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Міждисциплінарний науково-дослідний центр
складних систем

Dragomanov National Pedagogical University

Interdisciplinary research center
for complex systems

МІЖДИСЦИПЛІНАРНІ ДОСЛІДЖЕННЯ СКЛАДНИХ СИСТЕМ

INTERDISCIPLINARY STUDIES OF COMPLEX SYSTEMS

Номер 10–11 • Number 10–11

Київ • Kyiv
2017

УДК 001.5
ББК 72
М57

Свідоцтво про державну реєстрацію друкованого засобу масової інформації
серія КВ № 19094-7884Р від 29 травня 2012 року

Рекомендовано до друку Вченою радою Національного педагогічного університету
імені М. П. Драгоманова (протокол № 5 від 26 жовтня 2017 року)

М 57 Міждисциплінарні дослідження складних систем : [збірник наукових праць]. — Номер 10–11. — К. : Вид-во НПУ імені М. П. Драгоманова, 2017. — 124 с.

ISSN 2307-4515

УДК 001.5
ББК 72

Моделювання

Modeling

Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 4–34

Microscopic dynamics and kinetic description of spatial ecology models

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Abstract. We consider a method for the construction of Markov statistical dynamics for a class of birth-and-death ecological models in the continuum. Mesoscopic scaling limits for these dynamics lead to the kinetic equations for the density of a population. The resulting evolution equations are non-local and non-linear ones. We discuss properties of solutions to kinetic equations which strongly depend on characteristics of the models considered. The survey paper is devoted to giving an overview of our recent progress on the subject and it is not intended to be a complete review of the field.

1 Introduction

Dynamics of interacting particle systems appear in several areas of the complex systems theory. In particular, we observe a growing activity in the study of Markov dynamics for continuous systems. The latter fact is motivated, in particular, by modern problems of mathematical physics, ecology, mathematical biology, and genetics, see e.g. [16, 17, 20, 35] and literature cited therein. Moreover, Markov dynamics are used for the construction of social, economic and demographic models. Note that Markov processes for continuous systems are considering in the stochastic analysis as dynamical point processes [28, 29, 31] and they appear even in the representation theory of big groups [7, 8].

A mathematical formalization of the problem may be described as the following. As a phase space of the system we use the space $\Gamma(\mathbb{R}^d)$ of locally finite configurations in the Euclidean space $\mathbb{R}^d$. An heuristic Markov generator which describes considered model is given by its expression on a proper set of functions (observables) over $\Gamma(\mathbb{R}^d)$. With this operator we can relate two evolution equations. Namely, backward Kolmogorov equation for observables and Kolmogorov forward equation on probability measures on the phase space $\Gamma(\mathbb{R}^d)$ (macroscopic states of the system). The latter equation is a.k.a. Fokker–Planck equation in the mathematical physics terminology. Comparing with the usual situation in the stochastic analysis, there is an essential technical difficulty: corresponding Markov process in the configuration space may be

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constructed only in very special particular cases. As a result, a description of Markov dynamics in terms of random trajectories is absent for most of models under considerations.

As an alternative approach we use a concept of the statistical dynamics that substitutes the notion of a Markov stochastic process. A central object now is an evolution of states of the system that shall be defined by mean of the Fokker–Planck equation. This evolution equation with respect to probability measures on $\Gamma(\mathbb{R}^d)$ may be reformulated as a hierarchical chain of equations for correlation functions of considered measures. Such kind of evolution equations are well known in the study of Hamiltonian dynamics for classical gases as BBGKY chains but now they appear as a tool for construction and analysis of Markov dynamics. As an essential technical step, we consider related pre-dual evolution chains of equations on the so-called quasi-observables. As it will be shown in the paper, such hierarchical equations may be analyzed in the framework of semigroup theory with the use of powerful techniques of perturbation theory for the semigroup generators etc. Considering the dual evolution for the constructed semigroup on quasi-observables we introduce then the dynamics on correlation functions. Such a scheme of constructing the dynamics comes as a surprise because one cannot expect any perturbation techniques for the initial Kolmogorov evolution equations. The point is that states of infinite interacting particle systems are given by measures which are, in general, mutually orthogonal. As a result, we can not compare their evolutions or apply a perturbative approach. But under quite general assumptions they have correlation functions and corresponding dynamics may be considered in a common Banach space of correlation functions. Proper choice of this Banach space means, in fact, that we find an admissible class of initial states for which the statistical dynamics may be constructed. There we see again a crucial difference comparing with the framework of Markov stochastic processes, where the evolution is defined for any initial distribution.

Another interesting topic is related to the study of different scalings of the microscopic systems. Among others, the crucial role from the point of view of applications is played mesoscopic (Vlasov) description of the mentioned above microscopic systems. Originally, the notion of the Vlasov scaling was related to the Hamiltonian dynamics of interacting particle systems. This is a mean field scaling limit when the influence of weak long-range forces is taken into account. Rigorously, this limit was studied by W. Braun and K. Hepp in [5] for the Hamiltonian dynamics, and by R. L. Dobrushin [11] for more general deterministic dynamical systems. In [15], we proposed a general scheme for a Vlasov-type scaling of stochastic Markovian dynamics. Our approach is based on a proper scaling of the evolutions of correlation functions proposed by H. Spohn in [46] for the Hamiltonian dynamics. The present paper is meant to provide a comprehensive overview of our recent approaches to the birth and death stochastic dynamics. In particular, the approach proposed in [15] gives us a rigorous framework for the study of convergence of the scaled hierarchical equations to a solution of the limiting Vlasov hierarchy, and for the derivation of a resulting non-linear evolutional equation for the density of the limiting system. We consider some special birth-and-death models to show how the general conditions proposed in the paper may be verified in applications.

In the last section we study the kinetic (Vlasov) equation which corresponds to the birth-death Bolker–Pacala–Dieckman–Law (BDLP) model [9]. Namely, we consider a non-linear non-local evolution equation with non-local terms, which are convolutions with probability densities. We demonstrate that the long-time behavior of the solution depends on the asymptotic of the birth kernel and the initial condition, where either constant speed of the propagation or acceleration may be observed. Under additional assumptions, we also prove existence and uniqueness of traveling waves.

The results introduced in this article do not pretend to be novel. The present survey work provides a thorough summary of our papers [14–16, 18, 19, 21, 22, 24–26] as well as our understanding of fundamental ideas and results on the subject.

The structure of the paper is following. Section 2 contains a brief summary of the mathematical description of complex systems. In Section 3 we discuss general concept of statistical dynamics for Markov evolutions in the continuum and introduce necessary mathematical structures. Then, in Section 4, this concept is applied to an important class of Markov dynamics of continuous systems, namely, to birth-and-death models. Here general conditions for the existence of a semigroup evolution in a space of quasi-observables are obtained. Then we construct evolutions of correlation functions as dual objects. It is shown how to apply general results to the study of particular models of statistical dynamics coming from mathematical physics and ecology. In Section 5 we discuss the Vlasov-type scaling for birth-and-death stochastic dynamics. Finally, in Section 6 we study the kinetic (Vlasov) equation for the birth-death BDLP model.

2 Mathematical description of complex systems

We proceed to the mathematical realization of complex systems.

Let $\mathcal{B}(\mathbb{R}^d)$ be the family of all Borel sets in $\mathbb{R}^d$, $d \geq 1$; $\mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)$ denotes the system of all bounded sets from $\mathcal{B}(\mathbb{R}^d)$.

The configuration space over space $\mathbb{R}^d$ consists of all locally finite subsets (configurations) of $\mathbb{R}^d$. Namely,

$$\Gamma = \Gamma\big(\mathbb{R}^d\big) := \Big\{\gamma \subset \mathbb{R}^d \;\Big|\; |\gamma_\Lambda| < \infty, \text{ for all } \Lambda \in \mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)\Big\}.$$

Here $|\cdot|$ means the cardinality of a set, and $\gamma_\Lambda := \gamma \cap \Lambda$. We may identify each $\gamma \in \Gamma$ with the non-negative Radon measure $\sum_{x\in\gamma} \delta_x \in \mathcal{M}(\mathbb{R}^d)$, where δ_x is the Dirac measure with unit mass at x, $\sum_{x\in\emptyset} \delta_x$ is, by definition, the zero measure, and $\mathcal{M}(\mathbb{R}^d)$ denotes the space of all non-negative Radon measures on $\mathcal{B}(\mathbb{R}^d)$. This identification allows us to endow Γ with the topology induced by the vague topology on $\mathcal{M}(\mathbb{R}^d)$, i.e. the weakest topology on Γ with respect to which all mappings

$$\Gamma \ni \gamma \mapsto \sum_{x\in\gamma} f(x) \in \mathbb{R}$$

are continuous for any $f \in C_0(\mathbb{R}^d)$, the set of all continuous functions on

$\mathbb{R}^d$ with compact supports. It is worth noting the vague topology may be metrizable in such a way that Γ becomes a Polish space (see e.g. [33] and references therein).

Corresponding to the vague topology the Borel σ-algebra $\mathcal{B}(\Gamma)$ appears the smallest σ-algebra for which all mappings

$$\Gamma \ni \gamma \mapsto N_\Lambda(\gamma) := |\gamma_\Lambda| \in \mathbb{N}_0 := \mathbb{N} \cup \{0\} \tag{2.1}$$

are measurable for any $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$, see e.g. [3].

Among all measurable functions $F : \Gamma \to \bar{\mathbb{R}} := \mathbb{R} \cup \{\infty\}$ we mark out the set $\mathcal{F}_0(\Gamma)$ consisting of such of them for which $|F(\gamma)| < \infty$ at least for all $|\gamma| < \infty$. The important subset of $\mathcal{F}_0(\Gamma)$ formed by cylindric functions on Γ. Any such a function is characterized by a set $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$ such that $F(\gamma) = F(\gamma_\Lambda)$ for all $\gamma \in \Gamma$. The class of cylindric functions we denote by $\mathcal{F}_{\rm cyl}(\Gamma) \subset \mathcal{F}_0(\Gamma)$.

Functions on Γ are usually called *observables* . This notion is borrowed from statistical physics and means that typically in course of empirical investigation we may estimate, check, see only some quantities derived from the system as a whole rather then look into the system itself.

We denote the class of all probability measures on $\big(\Gamma, \mathcal{B}(\Gamma)\big)$ by $\mathcal{M}^1(\Gamma)$. Given a distribution $\mu \in \mathcal{M}^1(\Gamma)$ one can consider a collection of random variables $N_\Lambda(\cdot)$, $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$ defined in (2.1). They describe random numbers of elements inside bounded regions. The natural assumption is that these random variables should have finite moments. Thus, we consider the class $\mathcal{M}^1_{\rm fm}(\Gamma)$ of all measures from $\mathcal{M}^1(\Gamma)$ such that

$$\int_\Gamma |\gamma_\Lambda|^n \, {\rm d}\mu(\gamma) < \infty, \qquad \Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d), n \in \mathbb{N}.$$

Example 2.1. Let σ be a non-atomic Radon measure on $\big(\mathbb{R}^d, \mathcal{B}(\mathbb{R}^d)\big)$. Then the *Poisson measure* π_σ with intensity measure σ is defined on $\mathcal{B}(\Gamma)$ by

$$\pi_\sigma\big(\{\gamma \in \Gamma \big| N_\Lambda(\gamma) = |\gamma_\Lambda| = n\}\big) = \frac{\big(\sigma(\Lambda)\big)^n}{n!} \exp\big\{-\sigma(\Lambda)\big\}, \quad \Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d), n \in \mathbb{N}_0.$$

In the case of the Lebesgue measure $\sigma(dx) = dx$ one can say about the homogeneous Poisson distribution (measure) $\pi := \pi_{dx}$ with constant intensity 1.

The space of (finite) configuration which belong to a bounded domain $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$ will be denoted by $\Gamma(\Lambda)$. The σ-algebra $\mathcal{B}(\Gamma(\Lambda))$ may be generated by family of mappings $\Gamma(\Lambda) \ni \gamma \mapsto N_{\Lambda'}(\gamma) \in \mathbb{N}_0$, $\Lambda' \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$, $\Lambda' \subset \Lambda$. A measure $\mu \in \mathcal{M}^1_{\rm fm}(\Gamma)$ is called locally absolutely continuous with respect to the Poisson measure π if for any $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$ the projection of μ onto $\Gamma(\Lambda)$ is absolutely continuous with respect to (w.r.t.) the projection of π onto $\Gamma(\Lambda)$. More precisely, if we consider the projection mapping $p_\Lambda : \Gamma \to \Gamma(\Lambda)$, $p_\Lambda(\gamma) := \gamma_\Lambda$ then $\mu^\Lambda := \mu \circ p_\Lambda^{-1}$ is absolutely continuous w.r.t. $\pi_\Lambda := \pi \circ p_\Lambda^{-1}$.

By e.g. [32], for any $\mu \in \mathcal{M}^1_{\rm fm}(\Gamma)$ which is locally absolutely continuous w.r.t the Poisson measure, there exists the family of (symmetric) *correlation functions* $k_\mu^{(n)} : (\mathbb{R}^d)^n \to \mathbb{R}_+ := [0, \infty)$ which defined as follows. For any symmetric function $f^{(n)} : (\mathbb{R}^d)^n \to \mathbb{R}$ with finite support the following equality

holds

$$\int_\Gamma \sum_{\{x_1,\dots,x_n\}\subset\gamma} f^{(n)}(x_1,\dots,x_n)\,\mathrm{d}\mu(\gamma) = \frac{1}{n!}\int_{(\mathbb{R}^d)^n} f^{(n)}(x_1,\dots,x_n)k_\mu^{(n)}(x_1,\dots,x_n)\,\mathrm{d}x_1\dots\mathrm{d}x_n \quad (2.2)$$

for $n\in\mathbb{N}$, and $k_\mu^{(0)}:=1$.

The meaning of this notion is the following: the correlation function $k_\mu^{(n)}(x_1,\dots,x_n)$ describes the non-normalized density of probability to have points of our systems in the positions $x_1,\dots,x_n$.

The symmetric function of n variables from $\mathbb{R}^d$ can be considered as functions on n-point subsets from $\mathbb{R}^d$. We proceed now to the exact constructions.

The space of n-point configurations in $Y\in\mathcal{B}(\mathbb{R}^d)$ is defined by

$$\Gamma^{(n)}(Y):=\big\{\eta\subset Y\;\big|\;|\eta|=n\big\},\qquad n\in\mathbb{N}.$$

We put $\Gamma^{(0)}(Y):=\{\emptyset\}$. As a set, $\Gamma^{(n)}(Y)$ may be identified with the symmetrization of

$$\widetilde{Y^n}=\big\{(x_1,\dots,x_n)\in Y^n\;\big|\;x_k\neq x_l \text{ if } k\neq l\big\}.$$

Hence, one can introduce the corresponding Borel σ-algebra, which we denote by $\mathcal{B}\big(\Gamma^{(n)}(Y)\big)$. The space of finite configurations in $Y\in\mathcal{B}(\mathbb{R}^d)$ is defined as

$$\Gamma_0(Y):=\bigsqcup_{n\in\mathbb{N}_0}\Gamma^{(n)}(Y).$$

This space is equipped with the topology of the disjoint union. Let $\mathcal{B}\big(\Gamma_0(Y)\big)$ denote the corresponding Borel σ-algebra. In the case of $Y=\mathbb{R}^d$ we will omit the index Y in the previously defined notations. Namely,

$$\Gamma_0:=\Gamma_0(\mathbb{R}^d),\qquad \Gamma^{(n)}:=\Gamma^{(n)}(\mathbb{R}^d),\quad n\in\mathbb{N}_0.$$

The restriction of the Lebesgue product measure $(dx)^n$ to $\big(\Gamma^{(n)},\mathcal{B}(\Gamma^{(n)})\big)$ we denote by $m^{(n)}$. We set $m^{(0)}:=\delta_{\{\emptyset\}}$. The Lebesgue–Poisson measure λ on Γ_0 is defined by

$$\lambda:=\sum_{n=0}^{\infty}\frac{1}{n!}m^{(n)}. \quad (2.3)$$

For any $\Lambda\in\mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)$ the restriction of λ to $\Gamma_0(\Lambda)=\Gamma(\Lambda)$ will be also denoted by λ.

Remark 2.1. The space $\big(\Gamma,\mathcal{B}(\Gamma)\big)$ is the projective limit of the family of measurable spaces $\big\{\big(\Gamma(\Lambda),\mathcal{B}(\Gamma(\Lambda))\big)\big\}_{\Lambda\in\mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)}$. The Poisson measure π on $\big(\Gamma,\mathcal{B}(\Gamma)\big)$ from Example 2.1 may be defined as the projective limit of the family of measures $\{\pi^\Lambda\}_{\Lambda\in\mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)}$, where $\pi^\Lambda:=e^{-m(\Lambda)}\lambda$ is a probability measure on $\big(\Gamma(\Lambda),\mathcal{B}(\Gamma(\Lambda))\big)$ and $m(\Lambda)$ is the Lebesgue measure of $\Lambda\in\mathcal{B}_{\mathrm{b}}(\mathbb{R}^d)$ (see e.g. [3] for details).

Functions on Γ_0 will be called *quasi-observables* . Any $\mathcal{B}(\Gamma_0)$-measurable function G on Γ_0 is, in fact, defined by a sequence of functions $\{G^{(n)}\}_{n\in\mathbb{N}_0}$ where $G^{(n)}$ is a $\mathcal{B}(\Gamma^{(n)})$-measurable function on $\Gamma^{(n)}$. We preserve the same notation for the function $G^{(n)}$ considered as a symmetric function on $(\mathbb{R}^d)^n$. Note that $G^{(0)} \in \mathbb{R}$.

A set $M \in \mathcal{B}(\Gamma_0)$ is called bounded if there exists $\Lambda \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$ and $N \in \mathbb{N}$ such that

$$M \subset \bigsqcup_{n=0}^{N} \Gamma^{(n)}(\Lambda).$$

The set of bounded measurable functions on Γ_0 with bounded support we denote by $B_{\rm bs}(\Gamma_0)$, i.e., $G \in B_{\rm bs}(\Gamma_0)$ iff $G \restriction_{\Gamma_0\setminus M} = 0$ for some bounded $M \in \mathcal{B}(\Gamma_0)$. For any $G \in B_{\rm bs}(\Gamma_0)$ the functions $G^{(n)}$ have finite supports in $(\mathbb{R}^d)^n$ and may be substituted into (2.2). But, additionally, the sequence of $G^{(n)}$ vanishes for big n. Therefore, one can sum up equalities (2.2) over $n \in \mathbb{N}_0$. This requires the following definition.

Let $G \in B_{\rm bs}(\Gamma_0)$, then we define the function $KG : \Gamma \to \mathbb{R}$ by

$$\begin{aligned}(KG)(\gamma) &:= \sum_{\eta\Subset\gamma} G(\eta)\\ &= G^{(0)} + \sum_{n=1}^{\infty} \sum_{\{x_1,\dots,x_n\}\subset\gamma} G^{(n)}(x_1,\dots,x_n), \quad \gamma \in \Gamma, \end{aligned} \tag{2.4}$$

see e.g. [32, 37, 38]. The summation in (2.4) is taken over all finite subconfigurations $\eta \in \Gamma_0$ of the (infinite) configuration $\gamma \in \Gamma$; we denote this by the symbol, $\eta \Subset \gamma$. The mapping K is linear, positivity preserving, and invertible, with

$$(K^{-1}F)(\eta) := \sum_{\xi\subset\eta} (-1)^{|\eta\setminus\xi|} F(\xi), \quad \eta \in \Gamma_0. \tag{2.5}$$

By [32], for any $G \in B_{\rm bs}(\Gamma_0)$, we have $KG \in \mathcal{F}_{\rm cyl}(\Gamma)$, moreover, there exists $C = C(G) > 0$, $\Lambda = \Lambda(G) \in \mathcal{B}_{\rm b}(\mathbb{R}^d)$, and $N = N(G) \in \mathbb{N}$ such that

$$|KG(\gamma)| \le C\big(1 + |\gamma_\Lambda|\big)^N, \quad \gamma \in \Gamma.$$

The expression (2.4) can be extended to the class of all nonnegative measurable $G : \Gamma_0 \to \mathbb{R}_+$, in this case, evidently, $KG \in \mathcal{F}_0(\Gamma)$. Stress that the left hand side (l.h.s.) of (2.5) has a meaning for any $F \in \mathcal{F}_0(\Gamma)$, moreover, in this case $(KK^{-1}F)(\gamma) = F(\gamma)$ for any $\gamma \in \Gamma_0$.

For G as above we may sum up (2.2) over n and rewrite the result in a compact form:

$$\int_\Gamma (KG)(\gamma)\, {\rm d}\mu(\gamma) = \int_{\Gamma_0} G(\eta) k_\mu(\eta)\, {\rm d}\lambda(\eta). \tag{2.6}$$

As was shown in [32], the equality (2.4) may be extended on all functions G such that the l.h.s. of (2.6) is finite. In this case (2.4) holds for μ-a.a. $\gamma \in \Gamma$ and (2.6) holds, too.

3 Statistical descriptions of Markov evolutions

Spatial Markov processes in $\mathbb{R}^d$ may be described as stochastic evolutions of configurations $\gamma \subset \mathbb{R}^d$. In course of such evolutions points of configurations may disappear (die), move (continuously or with jumps from one position to another), or new particles may appear in a configuration (that is birth). The rates of these random events may depend on whole configuration that reflect an interaction between elements of the system.

The construction of a spatial Markov process in the continuum is a highly difficult question which is not solved in a full generality at present, see e.g. the review [44] and more detail references about birth-and-death processes in Section 3. Meanwhile, for discrete systems the corresponding processes have been constructed under quite general assumptions, see e.g. [39]. One of the main difficulties for continuous systems includes the necessity to control number of elements in a bounded region. Note that the construction of spatial processes on bounded sets from $\mathbb{R}^d$ is typically well understood, see e.g. [23].

The existing Markov process $\Gamma \ni \gamma \mapsto X_t^\gamma \in \Gamma$, $t > 0$ provides solution to the backward Kolmogorov equation for bounded continuous functions:

$$\frac{\mathrm{d}}{\mathrm{d}t} F_t = LF_t,$$

where L is the Markov generator of the process X_t. The question about existence for a Markov process with a generator L is still open. On the other hand, the evolution of a state in the course of a stochastic dynamics is an important question in its own right. A mathematical formulation of this question may be realized through the forward Kolmogorov equation for probability measures (states) on the configuration space Γ. Namely, we consider the pairing between functions and measures on Γ given by

$$\langle F, \mu \rangle := \int_\Gamma F(\gamma)\, \mathrm{d}\mu(\gamma). \tag{3.1}$$

Then we consider the initial value problem

$$\frac{\mathrm{d}}{\mathrm{d}t} \langle F, \mu_t \rangle = \langle LF, \mu_t \rangle, \quad t > 0, \quad \mu_t\big|_{t=0} = \mu_0, \tag{3.2}$$

where F is an arbitrary function from a proper set, e.g. $F \in K\big(B_{\mathrm{bs}}(\Gamma_0)\big) \subset \mathcal{F}_{\mathrm{cyl}}(\Gamma)$. In fact, the solution to (3.2) describes the time evolution of distributions instead of the evolution of initial points in the Markov process. We rewrite (3.2) in the heuristic form

$$\frac{\mathrm{d}}{\mathrm{d}t} \mu_t = L^* \mu_t, \tag{3.3}$$

where L^* is the (informally) adjoint operator of L with respect to the pairing (3.1).

In the physical literature, (3.3) is referred to the *Fokker–Planck equation*. The Markovian property of L yields that (3.3) might have a solution in the class of probability measures. However, the mere existence of the corresponding Markov process will not give us much information about properties

of the solution to (3.3), in particular, about its moments or correlation functions. To get it, we suppose now that a solution $\mu_t \in \mathcal{M}^1_{\rm fm}(\Gamma)$ to (3.2) exists and remains locally absolutely continuous with respect to the Poisson measure π for all $t > 0$ provided μ_0 has such a property. Then one can consider the correlation function $k_t := k_{\mu_t}$, $t \geq 0$. If we suppose that

$$LF \in \mathcal{F}_0(\Gamma) \qquad \text{for all } F \in \mathcal{F}_{\rm cyl}(\Gamma), \tag{3.4}$$

then, one can calculate $K^{-1}LF$ using (2.5), and, by (2.6), we may rewrite (3.2) as

$$\frac{\mathrm{d}}{\mathrm{d}t}\langle\!\langle K^{-1}F, k_t\rangle\!\rangle = \langle\!\langle K^{-1}LF, k_t\rangle\!\rangle, \quad t > 0, \quad k_t\big|_{t=0} = k_0, \tag{3.5}$$

for all $F \in K\big(B_{\rm bs}(\Gamma_0)\big) \subset \mathcal{F}_{\rm cyl}(\Gamma)$. Here the pairing between functions on Γ_0 is given by

$$\langle\!\langle G,\, k\rangle\!\rangle := \int_{\Gamma_0} G(\eta)k(\eta)\, \mathrm{d}\lambda(\eta). \tag{3.6}$$

Let us recall that then, by (2.3),

$$\langle\!\langle G, k\rangle\!\rangle = \sum_{n=0}^{\infty} \frac{1}{n!} \int_{(\mathbb{R}^d)^n} G^{(n)}(x_1, \dots, x_n)k^{(n)}(x_1, \dots, x_n)\, \mathrm{d}x_1 \dots \mathrm{d}x_n,$$

Next, if we substitute $F = KG$, $G \in B_{\rm bs}(\Gamma_0)$ in (3.5), we derive

$$\frac{\mathrm{d}}{\mathrm{d}t}\langle\!\langle G, k_t\rangle\!\rangle = \langle\!\langle \widehat{L}G, k_t\rangle\!\rangle, \quad t > 0, \quad k_t\big|_{t=0} = k_0, \tag{3.7}$$

for all $G \in B_{\rm bs}(\Gamma_0)$. Here the operator

$$(\widehat{L}G)(\eta) := (K^{-1}LKG)(\eta), \quad \eta \in \Gamma_0$$

is defined point-wise for all $G \in B_{\rm bs}(\Gamma_0)$ under conditions (3.4). Consequently, we are interested in a weak solution to the equation

$$\frac{\mathrm{d}}{\mathrm{d}t}k_t = \widehat{L}^* k_t, \quad t > 0, \quad k_t\big|_{t=0} = k_0, \tag{3.8}$$

where $\widehat{L}^*$ is dual operator to $\widehat{L}$ with respect to the duality (3.6), namely,

$$\int_{\Gamma_0} (\widehat{L}G)(\eta)k(\eta)\, \mathrm{d}\lambda(\eta) = \int_{\Gamma_0} G(\eta)(\widehat{L}^*k)(\eta)\, \mathrm{d}\lambda(\eta). \tag{3.9}$$

The procedure of deriving the operator $\widehat{L}$ for a given L is fully combinatorial meanwhile to obtain the expression for the operator $\widehat{L}^*$ we need an analog of integration by parts formula.

We recall that any function on Γ_0 may be identified with an infinite vector of symmetric functions of the growing number of variables. In this approach, the operator $\widehat{L}^*$ in (3.8) will be realized as an infinite matrix $\big(\widehat{L}^*_{n,m}\big)_{n,m\in\mathbb{N}_0}$, where $\widehat{L}^*_{n,m}$ is a mapping from the space of symmetric functions of n variables into the space of symmetric functions of m variables. As a result, instead of

equation (3.2) for infinite-dimensional objects we obtain an infinite system of equations for functions $k_t^{(n)}$ each of them is a function of a finite number of variables, namely

$$\begin{aligned} &\frac{\mathrm{d}}{\mathrm{d}t}k_t^{(m)}(x_1,\dots,x_m) = \sum_{n\in\mathbb{N}_0}\big(\widehat{L}^*_{n,m}k_t^{(n)}\big)(x_1,\dots,x_m), \quad t>0,\ m\in\mathbb{N}_0, \\ &k_t^{(m)}(x_1,\dots,x_m)\big|_{t=0} = k_0^{(m)}(x_1,\dots,x_m). \end{aligned} \tag{3.10}$$

Of course, in general, for a fixed n, any equation from (3.10) itself is not closed and includes functions $k_t^{(m)}$ of other orders $m \neq n$, nevertheless, the system (3.10) is a closed linear system. The chain evolution equations for $k_t^{(n)}$ consists the so-called *hierarchy* which is an analog of the BBGKY hierarchy for Hamiltonian systems, see e.g. [12].

In the present paper the restrict our attention to the so-called *sub-Poissonian* correlation functions. Namely, for a given $C>0$ we consider the following Banach space

$$\mathcal{K}_C := \big\{k:\Gamma_0\to\mathbb{R}\ \big|\ k\cdot C^{-|\cdot|}\in L^\infty(\Gamma_0,d\lambda)\big\} \tag{3.11}$$

with the norm

$$\|k\|_{\mathcal{K}_C} := \|C^{-|\cdot|}k(\cdot)\|_{L^\infty(\Gamma_0,d\lambda)}.$$

It is clear that $k\in\mathcal{K}_C$ implies,

$$\big|k(\eta)\big| \le \|k\|_{\mathcal{K}_C}\,C^{|\eta|} \qquad \text{for } \lambda\text{-a.a. } \eta\in\Gamma_0. \tag{3.12}$$

In the following we study the initial value problem (3.8) using the following scheme. We solve this equation in space $\mathcal{K}_C$. The well-posedness of the initial value problem in this case is equivalent with an existence of the strongly continuous semigroup (C_0-semigroup in the sequel) in the space $\mathcal{K}_C$ with a generator $\widehat{L}^*$. However, the space $\mathcal{K}_C$ is isometrically isomorphic to the space $L^\infty(\Gamma_0,C^{|\cdot|}d\lambda)$ whereas, by the H. Lotz theorem [40], [1], in a L^∞ space any C_0-semigroup is uniformly continuous, that is it has a bounded generator. Typically, for the operator L, any operator $\widehat{L}^*_{n,m}$, cf. (3.10), might be bounded as an operator between two spaces of bounded symmetric functions of n and m variables whereas the whole operator $\widehat{L}^*$ is unbounded in $\mathcal{K}_C$.

To avoid this difficulties we use a trick which goes back to R. Phillips [45]. The main idea is to consider the semigroup in L^∞ space not itself but as a dual semigroup $T^*(t)$ to a C_0-semigroup $T(t)$ with a generator A in the pre-dual L^1 space. In this case $T^*(t)$ appears strongly continuous semigroup not on the whole L^∞ but on the closure of the domain of A^* only.

In our case this leads to the following scheme. We consider the pre-dual Banach space to $\mathcal{K}_C$, namely, for $C>0$,

$$\mathfrak{L}_C := L^1\big(\Gamma_0,C^{|\cdot|}d\lambda\big). \tag{3.13}$$

The norm in $\mathfrak{L}_C$ is given by

$$\begin{aligned} \|G\|_C :&= \int_{\Gamma_0}\big|G(\eta)\big|C^{|\eta|}\ \mathrm{d}\lambda(\eta) \\ &= \sum_{n=0}^{\infty}\frac{C^n}{n!}\int_{(\mathbb{R}^d)^n}\big|G^{(n)}(x_1,\dots,x_n)\big|\ \mathrm{d}x_1\dots\mathrm{d}x_n. \end{aligned}$$

Consider the initial value problem, cf. (3.7), (3.8),

$$\frac{\mathrm{d}}{\mathrm{d}t}G_t = \widehat{L}G_t, \quad t > 0, \quad G_t\big|_{t=0} = G_0 \in \mathfrak{L}_C. \tag{3.14}$$

As long as (3.14) is well-posed in $\mathfrak{L}_C$ there exists a C_0-semigroup $\widehat{T}(t)$ in $\mathfrak{L}_C$. Then using Philips' result we see that the restriction of the dual semigroup $\widehat{T}^*(t)$ onto $\overline{\mathrm{Dom}(\widehat{L}^*)}$ will be C_0-semigroup with generator which is a part of $\widehat{L}^*$ (see Section 4 below for details). This provides a solution to (3.8) which continuously depends on an initial data from $\overline{\mathrm{Dom}(\widehat{L}^*)}$. And after we would like to find a more useful universal subspace of $\mathcal{K}_C$ which is not depend on the operator $\widehat{L}^*$. The realization of this scheme for a birth-and-death operator L is presented in Section 4 below. As a result, we obtain the classical solution to (3.8) for $t > 0$ in a class of sub-Poissonian functions which satisfy the Ruelle-type bound (3.12). Of course, after this we need to verify existence and uniqueness of measures whose correlation functions are solutions to (3.8). This usually can be done using proper approximation schemes, see e.g. Section 5.

4 Birth-and-death evolutions in the continuum

4.1 Microscopic description

One of the most important classes of Markov evolution in the continuum is given by the birth-and-death Markov processes in the space Γ of all configurations in $\mathbb{R}^d$. These are processes in which an infinite number of individuals exist at each instant, and the rates at which new individuals appear and some old ones disappear depend on the current configuration of existing individuals [31]. The corresponding Markov generators have a natural heuristic representation in terms of birth and death intensities. The birth intensity $b(x, \gamma) \geq 0$ characterizes the appearance of a new point at $x \in \mathbb{R}^d$ in the presence of a given configuration $\gamma \in \Gamma$. The death intensity $d(x, \gamma) \geq 0$ characterizes the probability of the event that the point x of the configuration γ disappears, depending on the location of the remaining points of the configuration $\gamma \setminus \{x\}$ (in the sequel $\gamma \setminus x$). Heuristically, the corresponding Markov generator is described by the following expression,

$$(LF)(\gamma) := \sum_{x\in\gamma} d(x, \gamma \setminus x)\,[F(\gamma \setminus x) - F(\gamma)] + \int_{\mathbb{R}^d} b(x, \gamma)\,[F(\gamma \cup x) - F(\gamma)]\,\mathrm{d}x, \tag{4.1}$$

for proper functions $F : \Gamma \to \mathbb{R}$.

4.2 Expressions for $\widehat{L}$ and $\widehat{L}^*$. Examples of rates b and d

We always suppose that rates $d, b : \mathbb{R}^d \times \Gamma \to [0; +\infty]$ from (4.1) satisfy the following assumptions

$$d(x, \eta), b(x, \eta) > 0, \qquad \eta \in \Gamma_0 \setminus \{\emptyset\},\ x \in \mathbb{R}^d \setminus \eta,$$

$$
\begin{aligned}
&d(x,\eta), b(x,\eta) < \infty, && \eta \in \Gamma_0,\ x \in \mathbb{R}^d \setminus \eta,\\
&\int_M \big(d(x,\eta) + b(x,\eta)\big)\,\mathrm{d}\lambda(\eta) < \infty, && M \in \mathcal{B}(\Gamma_0) \text{ bounded, a.a. } x \in \mathbb{R}^d,\\
&\int_\Lambda \big(d(x,\eta) + b(x,\eta)\big)\,\mathrm{d}x < \infty, && \eta \in \Gamma_0,\ \Lambda \in \mathcal{B}_{\mathrm{b}}(\mathbb{R}^d).
\end{aligned}
$$

We start with the expression for $\widehat{L} = K^{-1}LK$,

Proposition 4.1 ([20, Proposition 5]). *For any $G \in B_{\mathrm{bs}}(\Gamma_0)$ the following formula holds*

$$
\begin{aligned}
(\widehat{L}G)(\eta) = &-\sum_{\xi\subset\eta} G(\xi) \sum_{x\in\xi} \big(K^{-1}d(x,\cdot\cup\xi\setminus x)\big)(\eta\setminus\xi)\\
&+\sum_{\xi\subset\eta}\int_{\mathbb{R}^d} G(\xi\cup x)\big(K^{-1}b(x,\cdot\cup\xi)\big)(\eta\setminus\xi)\,\mathrm{d}x, \qquad \eta\in\Gamma_0.
\end{aligned}
\tag{4.2}
$$

Using this, one can derive the explicit form of $\widehat{L}^*$.

Proposition 4.2 ([20, Corollary 9]). *For any $k \in B_{\mathrm{bs}}(\Gamma_0)$ the following formula holds*

$$
\begin{aligned}
(\widehat{L}^*k)(\eta) = &-\sum_{x\in\eta}\int_{\Gamma_0} k(\zeta\cup\eta)\big(K^{-1}d(x,\cdot\cup\eta\setminus x)\big)(\zeta)\,\mathrm{d}\lambda(\zeta)\\
&+\sum_{x\in\eta}\int_{\Gamma_0} k(\zeta\cup(\eta\setminus x))\big(K^{-1}b(x,\cdot\cup\eta\setminus x)\big)(\zeta)\,\mathrm{d}\lambda(\zeta),
\end{aligned}
$$

where $\widehat{L}^*k$ is defined by (3.9).

4.3 Semigroup evolutions in the space of quasi-observables

We proceed now to the construction of a semigroup in the space $\mathfrak{L}_C$, $C > 0$, see (3.13), which has a generator, given by $\widehat{L}$, with a proper domain. To define such domain, let us set

$$
D(\eta) := \sum_{x\in\eta} d(x,\eta\setminus x) \geq 0, \quad \eta\in\Gamma_0; \tag{4.3}
$$

$$
D := \{G \in \mathfrak{L}_C \mid D(\cdot)\,G \in \mathfrak{L}_C\}. \tag{4.4}
$$

Note that $B_{\mathrm{bs}}(\Gamma_0) \subset D$ and $B_{\mathrm{bs}}(\Gamma_0)$ is a dense set in $\mathfrak{L}_C$. Therefore, D is also a dense set in $\mathfrak{L}_C$. We will show now that $(\widehat{L}, D)$ given by (4.2), (4.4) generates C_0-semigroup on $\mathfrak{L}_C$ if only 'the *full energy of death*', given by (4.3), is big enough.

Theorem 4.3 ([18, Theorem 3.2]). *Suppose that there exists $a_1 \geq 1$, $a_2 > 0$ such that for all $\xi \in \Gamma_0$ and a.a. $x \in \mathbb{R}^d$*

$$
\sum_{x\in\xi}\int_{\Gamma_0} \big|K^{-1}d(x,\cdot\cup\xi\setminus x)\big|(\eta)\,C^{|\eta|}\,\mathrm{d}\lambda(\eta) \leq a_1 D(\xi), \tag{4.5}
$$

$$\sum_{x\in\xi}\int_{\Gamma_0}\left|K^{-1}b\left(x,\cdot\cup\xi\setminus x\right)\right|(\eta)\,C^{|\eta|}\,\mathrm{d}\lambda\,(\eta)\leq a_2D(\xi) \tag{4.6}$$

and, moreover,

$$a_1+\frac{a_2}{C}<\frac{3}{2}. \tag{4.7}$$

Then $(\widehat{L},D)$ *is the generator of a holomorphic semigroup* $\widehat{T}\,(t)$ *on* $\mathfrak{L}_C$.

4.4 Evolutions in the space of correlation functions

In this Subsection we will use the semigroup $\widehat{T}(t)$ acting oh the space of quasi-observables for a construction of a solution to the evolution equation (3.8) on the space of correlation functions.

We denote $d\lambda_C:=C^{|\cdot|}d\lambda$; and the dual space $(\mathfrak{L}_C)'=\left(L^1(\Gamma_0,d\lambda_C)\right)'=L^\infty(\Gamma_0,d\lambda_C)$. As was mentioned before the space $(\mathfrak{L}_C)'$ is isometrically isomorphic to the Banach space $\mathcal{K}_C$ considered in (3.11)–(3.12). The isomorphism is given by the isometry R_C

$$(\mathfrak{L}_C)'\ni k\longmapsto R_Ck:=k\cdot C^{|\cdot|}\in\mathcal{K}_C. \tag{4.8}$$

Recall, one may consider the duality between the Banach spaces $\mathfrak{L}_C$ and $\mathcal{K}_C$ given by (3.6) with

$$|\langle\!\langle G,k\rangle\!\rangle|\leq\|G\|_C\cdot\|k\|_{\mathcal{K}_C}.$$

Let $\left(\widehat{L}',\mathrm{Dom}(\widehat{L}')\right)$ be an operator in $(\mathfrak{L}_C)'$ which is dual to the closed operator $\left(\widehat{L},D\right)$. We consider also its image on $\mathcal{K}_C$ under the isometry R_C. Namely, let $\widehat{L}^*=R_C\widehat{L}'R_{C^{-1}}$ with the domain $\mathrm{Dom}(\widehat{L}^*)=R_C\mathrm{Dom}(\widehat{L}')$. Similarly, one can consider the adjoint semigroup $\widehat{T}'(t)$ in $(\mathfrak{L}_C)'$ and its image $\widehat{T}^*(t)$ in $\mathcal{K}_C$.

The space $\mathfrak{L}_C$ is not reflexive, hence, $\widehat{T}^*(t)$ is not C_0-semigroup in whole $\mathcal{K}_C$. The last semigroup will be weak*-continuous, weak*-differentiable at 0 and $\widehat{L}^*$ will be weak*-generator of $\widehat{T}^*(t)$. Therefore, one has an evolution in the space of correlation functions. In fact, we have a solution to the evolution equation (3.8), in a weak*-sense. This subsection is devoted to the study of a classical solution to this equation. The restriction $\widehat{T}^{\odot}(t)$ of the semigroup $\widehat{T}^*(t)$ onto its invariant Banach subspace $\overline{\mathrm{Dom}(\widehat{L}^*)}$ (here and below all closures are in the norm of the space $\mathcal{K}_C$) is a strongly continuous semigroup. Moreover, its generator $\widehat{L}^{\odot}$ will be a part of $\widehat{L}^*$, namely,

$$\mathrm{Dom}(\widehat{L}^{\odot})=\left\{k\in\mathrm{Dom}(\widehat{L}^*)\;\middle|\;\widehat{L}^*k\in\overline{\mathrm{Dom}(\widehat{L}^*)}\right\} \tag{4.9}$$

and $\widehat{L}^{\odot}k=\widehat{L}^*k$ for any $k\in\mathrm{Dom}(\widehat{L}^{\odot})$.

One can consider the restriction $\widehat{T}^{\odot\alpha}(t)$ of the semigroup $\widehat{T}^{\odot}(t)$ onto $\overline{\mathcal{K}_{\alpha C}}$. It will be strongly continuous semigroup with the generator $\widehat{L}^{\odot\alpha}$ which is a restriction of $\widehat{L}^{\odot}$ onto $\overline{\mathcal{K}_{\alpha C}}$. Namely, cf. 4.9,

$$\mathrm{Dom}(\widehat{L}^{\odot\alpha})=\left\{k\in\overline{\mathcal{K}_{\alpha C}}\;\middle|\;\widehat{L}^*k\in\overline{\mathcal{K}_{\alpha C}}\right\},$$

and $\widehat{L}^{\odot\alpha}k = \widehat{L}^{\odot}k = \widehat{L}^{*}k$ for any $k \in \overline{\mathcal{K}_{\alpha C}}$. In the other words, $\widehat{L}^{\odot\alpha}$ is a part of $\widehat{L}^{*}$.

And now we may proceed to the main statement of this Subsection.

Theorem 4.4 ([19, Theorem 3.16])**.** *Let* (4.5), (4.6) *hold together with the following assumptions*

$$d\,(x,\xi) \le A(1+|\xi|)^N \nu^{|\xi|}, \tag{4.10}$$

$$1 \le \nu < \frac{C}{a_2}\Big(\frac{3}{2} - a_1\Big). \tag{4.11}$$

and let α *be chosen in the following way*

$$\frac{a_2}{C(\frac{3}{2} - a_1)} < \alpha < \frac{1}{\nu}.$$

Then for any $k_0 \in \overline{\mathcal{K}_{\alpha C}}$ *there exists a unique classical solution to* (3.8) *in the space* $\overline{\mathcal{K}_{\alpha C}}$*, and this solution is given by* $k_t = \widehat{T}^{\odot\alpha}(t)k_0$*. Moreover,* $k_0 \in \mathcal{K}_{\alpha C}$ *implies* $k_t \in \mathcal{K}_{\alpha C}$ *for* $t > 0$*.*

Example 4.1. (BDLP model) This example describes a generalization of the model of plant ecology (see [14] and references therein). Let L be given by (4.1) with

$$d(x,\gamma\setminus x) = m(x) + \varkappa^{-}(x)\sum_{y\in\gamma\setminus x} a^{-}(x-y), \qquad x\in\gamma,\ \gamma\in\Gamma,$$

$$b(x,\gamma) = \varkappa^{+}(x)\sum_{y\in\gamma} a^{+}(x-y), \qquad x\in\mathbb{R}^d\setminus\gamma,\ \gamma\in\Gamma,$$

where $0 < m \in L^\infty(\mathbb{R}^d)$, $0 \le \varkappa^{\pm} \in L^\infty(\mathbb{R}^d)$, $0 \le a^{\pm} \in L^1(\mathbb{R}^d, dx) \cap L^\infty(\mathbb{R}^d, dx)$, $\int_{\mathbb{R}^d} a^{\pm}(x)\,\mathrm{d}x = 1$. Let us suppose, cf. [14], that there exists $\delta > 0$ such that

$$(4+\delta)C\varkappa^{-}(x) \le m(x), \quad x\in\mathbb{R}^d, \tag{4.12}$$

$$(4+\delta)\varkappa^{+}(x) \le m(x), \quad x\in\mathbb{R}^d, \tag{4.13}$$

$$4\varkappa^{+}(x)a^{+}(x) \le C\varkappa^{-}(x)a^{-}(x). \quad x\in\mathbb{R}^d, \tag{4.14}$$

Then

$$d(x,\xi) + C\varkappa^{-}(x) \le d(x,\xi) + \frac{m(x)}{4+\delta} \le \Big(1+\frac{1}{4+\delta}\Big)d(x,\xi),$$

$$b(x,\xi) + C\varkappa^{+}(x) \le \frac{C}{4}\varkappa^{-}(x)\sum_{y\in\xi} a^{-}(x-y) + \frac{Cm(x)}{4+\delta} < \frac{C}{4}d(x,\xi),$$

Hence, (4.5), (4.6) hold with $a_1 = 1 + \dfrac{1}{4+\delta}, a_2 = \dfrac{C}{4}$, that fulfills (4.7). Next, under conditions (4.12), (4.14), we have

$$d(x,\xi) \le \|m\|_{L^\infty(\mathbb{R}^d)} + \|\varkappa^{-}\|_{L^\infty(\mathbb{R}^d)}\|a^{-}\|_{L^\infty(\mathbb{R}^d)}|\xi|, \quad \xi\in\Gamma_0,$$

and hence (4.10) holds with $\nu = 1$, which makes (4.11) obvious.

Remark 4.5. It was shown in [14] that, for the case of constant $m, \varkappa^{\pm}$, the condition like (4.12) is essential. Namely, if $m > 0$ is arbitrary small the operator $\widehat{L}$ will not even be accretive in $\mathfrak{L}_C$.

5 Vlasov-type scalings

For the reader convenience, we start from the idea of the Vlasov-type scaling. The general scheme for the birth-and-death dynamics as well as for the conservative ones may be found in [15]. The realizations of this approach for the Glauber dynamics (Example 1 with $s = 0$) and for the BDLP dynamics (Example 2) were considered in [16, 17], correspondingly. The idea of the Vlasov-type scaling consists in the following.

We would like to construct some scaling L_ε, $\varepsilon > 0$, of the generator L, such that the following scheme holds. Suppose that we have a semigroup $\hat{U}_\varepsilon(t)$ with the generator $\hat{L}_\varepsilon$ in some $\mathcal{L}_{C_\varepsilon}$, $\varepsilon > 0$. Consider the dual semigroup $\hat{U}^*_\varepsilon(t)$. Let us choose an initial function of the corresponding Cauchy problem with a singularity in ε. Namely, $\varepsilon^{|\eta|} k_0^{(\varepsilon)}(\eta) \sim r_0(\eta)$, $\varepsilon \to 0$, $\eta \in \Gamma_0$ for some function r_0, which is independent of ε. The scaling $L \mapsto L_\varepsilon$ should be chosen in such a way that first of all the corresponding semigroup $\hat{U}^*_\varepsilon(t)$ preserves the order of the singularity:

$$\varepsilon^{|\eta|}(\hat{U}^*_\varepsilon(t) k_0^{(\varepsilon)})(\eta) \sim r_t(\eta), \quad \varepsilon \to 0, \quad \eta \in \Gamma_0,$$

and, secondly, the dynamics $r_0 \mapsto r_t$ preserves the Lebesgue–Poisson exponents. There exists explicit (in general, nonlinear) differential equation for ρ_t:

$$\frac{\mathrm{d}}{\mathrm{d}t}\rho_t(x) = \upsilon(\rho_t)(x) \tag{5.1}$$

which will be called the Vlasov-type equation.

Now we explain an informal way to realize such a scheme. Let us consider for any $\varepsilon > 0$ the following mapping (cf. (4.8)) defined for functions on Γ_0

$$(R_\varepsilon r)(\eta) := \varepsilon^{|\eta|} r(\eta).$$

This mapping is "self-dual" with respect to the duality (3.6), moreover, $R_\varepsilon^{-1} = R_{\varepsilon^{-1}}$. Having $R_\varepsilon k_0^{(\varepsilon)} \sim r_0$, $\varepsilon \to 0$, we need $r_t \sim R_\varepsilon \hat{U}^*_\varepsilon(t) k_0^{(\varepsilon)} \sim R_\varepsilon \hat{U}^*_\varepsilon(t) R_{\varepsilon^{-1}} r_0$, $\varepsilon \to 0$. Therefore, we have to show that for any $t \geq 0$ the operator family $R_\varepsilon \hat{U}^*_\varepsilon(t) R_{\varepsilon^{-1}}$, $\varepsilon > 0$ has limiting (in a proper sense) operator $U(t)$ and

$$U(t) e_\lambda(\rho_0) = e_\lambda(\rho_t). \tag{5.2}$$

But, heuristically, $\hat{U}^*_\varepsilon(t) = \exp\{t\hat{L}^*_\varepsilon\}$ and $R_\varepsilon \hat{U}^*_\varepsilon(t) R_{\varepsilon^{-1}} = \exp\{t R_\varepsilon \hat{L}^*_\varepsilon R_{\varepsilon^{-1}}\}$. Let us consider the "renormalized" operator

$$\hat{L}^*_{\varepsilon,\,\mathrm{ren}} := R_\varepsilon \hat{L}^*_\varepsilon R_{\varepsilon^{-1}}. \tag{5.3}$$

In fact, we need that there exists an operator $\hat{L}^*_V$ such that $\exp\{t R_\varepsilon \hat{L}^*_\varepsilon R_{\varepsilon^{-1}}\} \to \exp\{t\hat{L}^*_V\} =: U(t)$ satisfying (5.2). Therefore, an heuristic way to produce scaling $L \mapsto L_\varepsilon$ is to demand that

$$\lim_{\varepsilon \to 0} \left(\frac{\mathrm{d}}{\mathrm{d}t} e_\lambda(\rho_t, \eta) - \hat{L}^*_{\varepsilon,\,\mathrm{ren}} e_\lambda(\rho_t, \eta) \right) = 0, \qquad \eta \in \Gamma_0$$

provided ρ_t satisfies (5.1). The point-wise limit of $\hat{L}^*_{\varepsilon,\,\mathrm{ren}}$ will be natural candidate for $\hat{L}^*_V$.

Note that (5.3) implies informally that $\hat{L}_{\varepsilon,\,\mathrm{ren}} = R_{\varepsilon^{-1}}\hat{L}_\varepsilon R_\varepsilon$. We propose below the scheme to give rigorous meaning to the idea introduced above. We consider, for a proper scaling L_ε, the "renormalized" operator $\hat{L}_{\varepsilon,\,\mathrm{ren}}$ and prove that it is a generator of a strongly continuous contraction semigroup $\hat{U}_{\varepsilon,\,\mathrm{ren}}(t)$ in $\mathcal{L}_C$. Next, we show that the formal limit $\hat{L}_V$ of $\hat{L}_{\varepsilon,\,\mathrm{ren}}$ is a generator of a strongly continuous contraction semigroup $\hat{U}_V(t)$ in $\mathcal{L}_C$. Finally, we prove that $\hat{U}_{\varepsilon,\,\mathrm{ren}}(t) \to \hat{U}_V(t)$ strongly in $\mathcal{L}_C$. This implies weak*-convergence of the dual semigroups $\hat{U}^*_{\varepsilon,\,\mathrm{ren}}(t)$ to $\hat{U}^*_V(t)$. We explain also in which sense $\hat{U}^*_V(t)$ satisfies the properties above.

Let us consider for any $\varepsilon \in (0;1]$ the following scaling of (4.1)

$$\begin{aligned}(L_\varepsilon F)(\gamma) :&= \sum_{x\in\gamma} d_\varepsilon(x,\gamma\setminus x)\,[F(\gamma\setminus x) - F(\gamma)]\\ &\quad + \varepsilon^{-1}\int_{\mathbb{R}^d} b_\varepsilon(x,\gamma)\,[F(\gamma\cup x) - F(\gamma)]\,\mathrm{d}x,\end{aligned}$$

and define the renormalized operator $\hat{L}_{\varepsilon,\mathrm{ren}} := R_{\varepsilon^{-1}}K^{-1}L_\varepsilon K R_\varepsilon$. Using the same arguments as in the proof of Proposition 4.1, we get

$$\begin{aligned}(\hat{L}_{\varepsilon,\mathrm{ren}}G)(\eta) = &-\sum_{\xi\subset\eta} G(\xi)\varepsilon^{-|\eta\setminus\xi|}\sum_{x\in\xi}\big(K_0^{-1}d_\varepsilon(x,\cdot\cup\xi\setminus x)\big)(\eta\setminus\xi)\\ &+\sum_{\xi\subset\eta}\int_{\mathbb{R}^d} G(\xi\cup x)\varepsilon^{-|\eta\setminus\xi|}\big(K_0^{-1}b_\varepsilon(x,\cdot\cup\xi)\big)(\eta\setminus\xi)\,\mathrm{d}x.\end{aligned}$$

$$\text{For } \varepsilon\in(0;1], \qquad D_\varepsilon(\eta) := \sum_{x\in\eta} d_\varepsilon(x,\eta\setminus x);$$

Suppose that there exists $a_1 \geq 1$, $a_2 > 0$, such that for all $\xi \in \Gamma_0$, for a.a. $x \in \mathbb{R}^d$, and for any $\varepsilon \in (0;1]$

$$\sum_{x\in\xi}\int_{\Gamma_0}\left|K_0^{-1}d_\varepsilon\left(x,\cdot\cup\xi\setminus x\right)\right|(\eta)\,\varepsilon^{-|\eta|}C^{|\eta|}\,\mathrm{d}\lambda(\eta) \leq a_1 D_\varepsilon(\xi), \tag{5.4}$$

$$\sum_{x\in\xi}\int_{\Gamma_0}\left|K_0^{-1}b_\varepsilon\left(x,\cdot\cup\xi\setminus x\right)\right|(\eta)\,\varepsilon^{-|\eta|}C^{|\eta|}\,\mathrm{d}\lambda(\eta) \leq a_2 D_\varepsilon(\xi), \tag{5.5}$$

$$a_1 + \frac{a_2}{C} < \frac{3}{2}. \tag{5.6}$$

For all $\eta,\xi\in\Gamma_0$ and a.a. $x\in\mathbb{R}^d$ the following limits exist and coincide:

$$\lim_{\varepsilon\to0}\varepsilon^{-|\eta|}\big(K_0^{-1}d_\varepsilon(x,\cdot\cup\xi)\big)(\eta) = \lim_{\varepsilon\to0}\varepsilon^{-|\eta|}\big(K_0^{-1}d_\varepsilon(x,\cdot)\big)(\eta) =: D_x^V(\eta); \tag{5.7}$$

$$\lim_{\varepsilon\to0}\varepsilon^{-|\eta|}\big(K_0^{-1}b_\varepsilon(x,\cdot\cup\xi)\big)(\eta) = \lim_{\varepsilon\to0}\varepsilon^{-|\eta|}\big(K_0^{-1}b_\varepsilon(x,\cdot)\big)(\eta) =: B_x^V(\eta). \tag{5.8}$$

We would like to emphasize, that above limits should not depend on ξ. The collection of examples for such d_ε, b_ε can be found in [15].

Now we are able to state result about convergence in $\mathcal{L}_C$.

Theorem 5.1 ([18, Theorem 4.4])**.** *Let conditions* (5.4), (5.5), *and* (5.6) *are satisfied. Suppose that convergences* (5.7), (5.8) *take place for all* $\eta \in \Gamma_0$ *as well as in the sense of* $\mathcal{L}_C$*. Assume also that there exists* $\sigma > 0$ *such that either*

$$d_\varepsilon(x,\xi) \le \sigma D_x^V(\emptyset) \qquad or \qquad d_\varepsilon(x,\xi) \ge \sigma D_x^V(\emptyset)$$

is satisfied for all $\xi \in \Gamma_0$ *and for a.a.* $x \in \mathbb{R}^d$*. Then* $\hat{U}_\varepsilon(t) \xrightarrow{s} \hat{U}_V(t)$ *in* $\mathcal{L}_C$ *uniformly on finite time intervals.*

Example 5.1 (BDLP model, revisited)**.** Let

$$d_\varepsilon(x,\gamma\setminus x) = m + \varepsilon\varkappa^- \sum_{y\in\gamma\setminus x} a^-(x-y),$$
$$b_\varepsilon(x,\gamma) = \varepsilon\varkappa^+ \sum_{y\in\gamma} a^+(x-y).$$

Comparing with the previous notations we have changed $\varkappa^\pm$ onto $\varepsilon\varkappa^\pm$. Clearly, conditions (4.12), (4.14) implies the same inequalities for $\varepsilon\varkappa^\pm$. Note also that d_ε is decreasing in $\varepsilon \to 0$. Therefore, to apply all results of this section to BDLP-model we should prove the convergence (5.7), (5.8) in $\mathcal{L}_C$. Note, that

$$\begin{aligned}\varepsilon^{-|\eta|}K_0^{-1}d_\varepsilon\left(x,\cdot\cup\xi\right)(\eta) &= d_\varepsilon(x,\xi)0^{|\eta|} + \mathbb{1}_{\Gamma^{(1)}}(\eta)\sum_{y\in\eta} a^-(x-y)\\ &\to m0^{|\eta|} + \mathbb{1}_{\Gamma^{(1)}}(\eta)\sum_{y\in\eta} a^-(x-y) =: D_x^V(\eta)\end{aligned}$$

and, analogously,

$$\begin{aligned}\varepsilon^{-|\eta|}K_0^{-1}b_\varepsilon\left(x,\cdot\cup\xi\right)(\eta) &= b_\varepsilon(x,\xi)0^{|\eta|} + \mathbb{1}_{\Gamma^{(1)}}(\eta)\sum_{y\in\eta} a^+(x-y)\\ &\to \mathbb{1}_{\Gamma^{(1)}}(\eta)\sum_{y\in\eta} a^+(x-y) =: B_x^V(\eta).\end{aligned}$$

The convergence in $\mathcal{L}_C$ is obvious now. The kinetic (Vlasov) equation has the following form

$$\frac{\mathrm{d}}{\mathrm{d}t}\rho_t(x) = \varkappa^+(a^+ * \rho_t)(x) - \varkappa^-\rho_t(x)(a^- * \rho_t)(x) - m\rho_t(x). \tag{5.9}$$

We study the obtained equation in the following section.

Remark 5.2. By duality (3.6), Theorem 5.1 yields weak*-convergence of the semigroups $\hat{U}_\varepsilon^{\odot\alpha}(t)$ to $\hat{U}_V^{\odot\alpha}(t)$ in $\overline{\mathcal{K}_{\alpha C}}$. To prove such convergence in the strong sense we need additional analysis of their generators. The problem concerns the fact that we have explicit expression for the generator $\hat{L}_V^{\odot\alpha} = \hat{L}_V^*$ only on the core $\left\{k \in \mathcal{K}_{\alpha C} \;\middle|\; \hat{L}_V^* k \in \overline{\mathcal{K}_{\alpha C}}\right\}$. However, we are able to show such convergence for the Glauber dynamics described in Example 1 for $s = 0$ using modified technique (see [16]).

6 Kinetic equation of a spatial ecology model

6.1 Introduction

In this section we study the mesoscopic equation of the BDLP model (5.9) from different perspectives. Namely we will deal with the following nonlinear nonlocal evolution equation, for $x \in \mathbb{R}^d$,

$$\begin{cases} \dfrac{\mathrm{d}u}{\mathrm{d}t}(x,t) = \varkappa^+(a^+ * u)(x,t) - mu(x,t) - \varkappa^- u(x,t)(a^- * u)(x,t), & t > 0, \\ u(x,0) = u_0(x), \end{cases} \tag{6.1}$$

which we will study in a class of bounded in x nonnegative functions.

The solution $u = u(x,t)$ to (6.1) describes approximately a density (at the moment of time t and at the position x of the space $\mathbb{R}^d$) for a particle system evolving in the continuum. In course of the evolution, particles might reproduce themselves, die, and compete (say, for resources). Namely, a particle located at a point $y \in \mathbb{R}^d$ may produce a 'child' at a point $x \in \mathbb{R}^d$ with the intensity $\varkappa^+$ and according to the dispersion kernel $a^+(x-y)$. Next, any particle may die with the constant intensity m. And additionally, a particle located at x may die according to the competition with the rest of particles; the intensity of the death because of a competitive particle located at y is equal to $\varkappa^-$ and the distribution of the competition is described by $a^-(x-y)$.

This model was originally proposed in mathematical ecology, see [9]. Rigorous mathematical constructions were done in [14, 23]. In [14], the mathematical approach was realized using the theory of Markov statistical dynamics on the so-called configuration spaces expressed in terms of evolution of time-dependent correlation functions of the system, see e.g. [20, 32, 34].

Here $m > 0$, $\varkappa^\pm > 0$ are constants, and functions $0 \le a^\pm \in L^1(\mathbb{R}^d)$ are probability densities:

$$\int_{\mathbb{R}^d} a^+(y)\,\mathrm{d}y = \int_{\mathbb{R}^d} a^-(y)\,\mathrm{d}y = 1.$$

Here and below, for a function $u = u(y,t)$, which is (essentially) bounded in $y \in \mathbb{R}^d$, and a function (a kernel) $a \in L^1(\mathbb{R}^d)$, we denote

$$(a * u)(x,t) := \int_{\mathbb{R}^d} a(x-y)u(y,t)\,\mathrm{d}y.$$

We assume that u_0 is a bounded function on $\mathbb{R}^d$. For technical reasons, we will consider two Banach spaces of bounded real-valued functions on $\mathbb{R}^d$: the space $C_{ub}(\mathbb{R}^d)$ of bounded uniformly continuous functions on $\mathbb{R}^d$ with sup-norm and the space $L^\infty(\mathbb{R}^d)$ of essentially bounded (with respect to the Lebesgue measure) functions on $\mathbb{R}^d$ with esssup-norm. Let also $C_b(\mathbb{R}^d)$ and $C_0(\mathbb{R}^d)$ denote the spaces of continuous functions on $\mathbb{R}^d$ which are bounded and have compact supports, correspondingly.

Let E be either $C_{ub}(\mathbb{R}^d)$ or $L^\infty(\mathbb{R}^d)$. Consider the equation (6.1) in E; in particular, u must be continuously differentiable in t, for $t > 0$, in the sense of the norm in E. Moreover, we consider u as an element from the space

$C_b(I \to E)$ of continuous bounded functions on I (including 0) with values in E and with the following norm

$$\|u\|_{C_b(I\to E)} = \sup_{t\in I} \|u(\cdot,t)\|_E.$$

Such a solution is said to be a classical solution to (6.1); in particular, u will continuously (in the sense of the norm in E) depend on the initial condition u_0.

We will also use the space $C_b(I \to E)$ with $I = [T_1, T_2]$, $T_1 > 0$. For simplicity of notations, we denote

$$\mathcal{X}_{T_1,T_2} := C_b\big([T_1,T_2] \to E\big), \qquad T_2 > T_1 \geq 0,$$

and the corresponding norm will be denoted by $\|\cdot\|_{T_1,T_2}$. We set also $\mathcal{X}_T := \mathcal{X}_{0,T}$, $\|\cdot\|_T := \|\cdot\|_{0,T}$, and

$$\mathcal{X}_\infty := C_b\big(\mathbb{R}_+ \to E\big)$$

with the corresponding norm $\|\cdot\|_\infty$. The upper index '+' will denote the cone of nonnegative functions in the corresponding space, namely,

$$\mathcal{X}_\sharp^+ := \{u \in \mathcal{X}_\sharp \mid u \geq 0\},$$

where $\sharp$ is one of the subscripts above.

We will also omit the subscript for the norm $\|\cdot\|_E$ in E, if it is clear whether we are working with sup- or esssup-norm.

6.2 Basic properties

The following theorem yields existence and uniqueness of a solution

Theorem 6.1. *Let $u_0 \in E$ and $u_0(x) \geq 0$, $x \in \mathbb{R}^d$. Then, for any $T > 0$, there exists a unique nonnegative solution u to the equation* (6.1) *in E, such that $u \in \mathcal{X}_T$.*

Proof. The proof is based on the fixed point argument applied to the map $u = \Phi_\tau v$, where, for a fixed $0 \leq v \in \mathcal{X}_T$, the function u solves the following equation

$$\begin{cases} \dfrac{\partial u}{\partial t}(x,t) = -mu(x,t) - \varkappa^- u(x,t)(a^- * v)(x,t) + \varkappa^+(a^+ * v)(x,t), \quad t \in (\tau, T], \\ u(x,\tau) = u_\tau(x). \end{cases}$$

One can show that, for $\tau = 0$, Φ_τ will be a contraction mapping on a time interval $[0, T_0]$. Hence a fixed point $u = \Phi u$ exists on $[0, T_0]$. There exists $T_1 > T_0$ such that, for $\tau = T_0$, Φ_τ is a contraction mapping on $[T_0, T_1]$ and the fixed point u may be extended to $[0, T_1]$. Iterating this scheme, we obtain a sequence $\{T_n\}_{n\in\mathbb{N}}$, such that $T_n \to \infty$ and $u = \Phi u$ on each $[0, T_n]$. Hence $u = \Phi u$ on $[0, \infty)$. It is left to note that u is a fixed point of Φ if and only if it satisfies (6.1).

For the details see [21, Theorem 2.2]. □

Below, $|\cdot| = |\cdot|_{\mathbb{R}^d}$ denotes the Euclidean norm in $\mathbb{R}^d$, $B_r(x)$ is a closed ball in $\mathbb{R}^d$ with the center at $x \in \mathbb{R}^d$ and the radius $r > 0$; and b_r is a volume of this ball.

The following theorem is an extension of Theorem 6.1 for $E = C_{ub}(\mathbb{R}^d)$, in which case the global boundedness of the solutions holds in both space and time under additional weak assumptions.

Theorem 6.2. *Suppose that there exists $r_0 > 0$ such that*

$$\alpha := \inf_{|x| \le r_0} a^-(x) > 0,$$

and, for some $\varepsilon, A > 0$, one have $a^+(x) \le \dfrac{A}{1+|x|^{d+\varepsilon}}$, for all $x \in \mathbb{R}^d$. Then, the solution $u \ge 0$ to (6.1), with $0 \le u_0 \in C_{ub}(\mathbb{R}^d)$, belongs to $C_{ub}(\mathbb{R}^d \times \mathbb{R}_+)$.

Proof. The idea of the proof goes back to [30, Theorem 1.3]. We consider

$$v(x,t) := (\mathbb{1}_{B_r(0)} * u)(x,t) = \int_{B_r(x)} u(y,t)\,dy.$$

It is possible to prove by contradiction that under conditions of the theorem v is globally bounded, which implies that u is bounded on $\mathbb{R}^d \times \mathbb{R}_+$. For the details see [21, Theorem 2.8]. □

The main difficulty in studying non-local monostable evolution equations is the lack of techniques for the class of equations. In particular, variational methods may be hardly applied here because of the type of the non-linear ('reaction') term, which is not a potential operator. Nevertheless, under restrictions on the kernels a^+, a^-, a version of the comparison principle may be proven. This result will be needed in the rest of the article. Let $T > 0$ be fixed. Define the sets $\mathcal{X}_T^1$ of functions from $\mathcal{X}_T$, which are continuously differentiable on $(0,T]$ in the sense of the norm in E. Here and below we consider the left derivative at $t = T$ only. For any u from $\mathcal{X}_T^1$ one can define the following function

$$\mathcal{F}u := \frac{\mathrm{d}u}{\mathrm{d}t} - \varkappa^+ a^+ * u + mu + \varkappa^- u(a^- * u), \qquad t \in (0,T],\ x \in \mathbb{R}^d. \tag{6.2}$$

Theorem 6.3. *Let there exist $c > 0$, such that*

$$\varkappa^+ a^+(x) \ge c\varkappa^- a^-(x), \quad \text{a.a. } x \in \mathbb{R}^d.$$

Let $T \in (0,\infty)$ be fixed and functions $u_1, u_2 \in \mathcal{X}_T^1$ be such that, for any $(x,t) \in \mathbb{R}^d \times (0,T]$,

$$\begin{gathered}(\mathcal{F}u_1)(x,t) \le (\mathcal{F}u_2)(x,t), \\ u_1(x,t) \ge 0, \qquad 0 \le u_2(x,t) \le c, \qquad u_1(x,0) \le u_2(x,0).\end{gathered} \tag{6.3}$$

Then $u_1(x,t) \le u_2(x,t)$, for all $(x,t) \in \mathbb{R}^d \times [0,T]$. In particular, $u_1 \le c$.

Proof. We consider

$$v(x,t) := e^{Kt}(u_2(x,t) - u_1(x,t)), \quad x \in \mathbb{R}^d,\ t \in [0,T].$$

By the fixed point method applied to the integral equation that is satisfied by v we can show that $v \geq 0$, provided $K > 0$ is sufficiently large. Hence $u_2 \geq u_1$. Also see [21, Theorem 3.1]. □

For $E = C_{ub}(\mathbb{R}^d)$ one can prove a refined version of Theorem 6.3 for non-differentiable in time functions. For any $T \in (0, \infty]$, define the set D_T of all functions $u : \mathbb{R}^d \times \mathbb{R}_+ \to \mathbb{R}$, such that, for all $t \in [0, T)$, $u(\cdot, t) \in C_{ub}(\mathbb{R}^d)$, and, for all $x \in \mathbb{R}^d$, the function $f(x, t)$ is absolutely continuous in t on $[0, T)$. Then, for any $u \in D_T$, one can define the function (6.2), for all $x \in \mathbb{R}^d$ and a.a. $t \in [0, T)$.

Proposition 6.4 ([21, Proposition 3.3])**.** *The statement of Theorem 6.3 remains true, if we assume that $u_1, u_2 \in D_T$ and, for any $x \in \mathbb{R}^d$, the inequality* (6.3) *holds for a.a. $t \in (0, T)$ only.*

We introduce a notation for the non-zero constant solution

$$\theta := \frac{\varkappa^+ - m}{\varkappa^-} \in \mathbb{R}. \tag{6.4}$$

It is easy to show using Duhamel's principle, that if $\varkappa^+ < m$, then the solutions to (6.1) converges to 0 exponentially fast and uniformly in space, as time tends to infinity. The case $\varkappa^+ = m$ was partially considered by Terra and Wolanski (see [48, 49]) and we omit it in the present article. Hence we make the following assumption in the rest of the article,

$$\varkappa^+ > m. \tag{A1}$$

It yields in particular that the constant solution θ is greater than zero. We will study solutions with initial conditions, that are non-negative and bounded by θ.

Definition 6.5. For $\theta > 0$, given by (6.4), consider the following sets

$$\begin{aligned} U_\theta &:= \{f \in C_{ub}(\mathbb{R}^d) \mid 0 \leq f(x) \leq \theta,\ x \in \mathbb{R}^d\}, \\ L_\theta &:= \{f \in L^\infty(\mathbb{R}^d) \mid 0 \leq f(x) \leq \theta,\ \text{for a.a. } x \in \mathbb{R}^d\}, \\ E_\theta &:= \{f \in E \mid 0 \leq f(x) \leq \theta,\ x \in \mathbb{R}^d\}. \end{aligned}$$

Hence E_θ is either U_θ or L_θ.

By virtue of Theorem 6.3, we assume,

$$\varkappa^+ a^+(x) \geq (\varkappa^+ - m) a^-(x), \quad \text{a.a. } x \in \mathbb{R}^d. \tag{A2}$$

Let us mention an important consequence of Theorem 6.3.

Proposition 6.6 ([21, Proposition 3.4])**.** *Suppose that* (A1) *and* (A2) *hold. Let $0 \leq u_0 \in E_\theta$ be an initial condition to* (6.1) *and $u \in \mathcal{X}_T$ be the corresponding solutions on any $[0, T]$, $T > 0$. Then $u \in \mathcal{X}_\infty$, with $\|u\|_\infty \leq \theta$.*

Let $v_0 \in E_\theta$ be another initial condition to (6.1) *such that $u_0(x) \leq v_0(x)$, $x \in \mathbb{R}^d$; and $v \in \mathcal{X}_\infty$ be the corresponding solution. Then*

$$u(x, t) \leq v(x, t), \quad x \in \mathbb{R}^d, t \geq 0.$$

Let us show that if $u_0 \not\equiv 0$, then the solutions to (6.1) are strictly positive; this is quite common feature of linear parabolic equations, however, in general, it may fail for nonlinear ones. It is required that

$$\text{there exists } \rho, \delta > 0 \text{ such that } a^+(x) \geq \rho, \text{ for a.a. } x \in B_\delta(0). \tag{A3}$$

Proposition 6.7 ([21, Proposition 3.8]). *Let* (A1), (A2), (A3) *hold. Let* $u_0 \in U_\theta$, $u_0 \not\equiv 0$, $u_0 \not\equiv \theta$, *be the initial condition to* (6.1), *and* $u \in \mathcal{X}_\infty$ *be the corresponding solution. Then*

$$u(x,t) > \inf_{\substack{y \in \mathbb{R}^d \\ s>0}} u(y,s) \geq 0, \qquad x \in \mathbb{R}^d, t > 0.$$

As a matter of fact, under (A4), a much stronger statement than unattainability of θ does hold. To show this we assume that

$$\begin{gathered} \text{there exists } \rho, \delta > 0, \text{ such that} \\ J_\theta(x) = \varkappa^+ a^+(x) - (\varkappa^+ - m)a^-(x) \geq \rho, \text{ for a.a. } x \in B_\delta(0). \end{gathered} \tag{A4}$$

Theorem 6.8 ([21, Theorem 3.9]). *Let* (A1), (A2), (A4) *hold. Let* $u_1, u_2 \in \mathcal{X}_\infty$ *be two solutions to* (6.1), *such that* $u_1(x,0) \leq u_2(x,0)$, $x \in \mathbb{R}^d$, *are from* U_θ. *Then either* $u_1(x,t) = u_2(x,t)$, $x \in \mathbb{R}^d$, $t \geq 0$ *or* $u_1(x,t) < u_2(x,t)$, $x \in \mathbb{R}^d$, $t > 0$.

By choosing $u_2 \equiv \theta$ in Theorem 6.8, we immediately get the following

Corollary 6.9 ([21, Corollary 3.10]). *Let* (A1), (A2), (A4) *hold. Let* $u_0 \in U_\theta$, $u_0 \not\equiv \theta$, *be the initial condition to* (6.1), *and* $u \in \mathcal{X}_\infty$ *be the corresponding solution. Then* $u(x,t) < \theta$, $x \in \mathbb{R}^d$, $t > 0$.

6.3 Traveling waves

For simplicity, we consider one-dimensional space ($d = 1$) in the following. For many-dimensional analogues of the statements, see [21, 22, 24–26].

Traveling waves were studied intensively for the original Fisher–KPP equation, see e.g. [4, 13, 36]; for locally nonlinear equation with nonlocal diffusion, see e.g. [10, 47, 51]; and for nonlocal nonlinear equation with local diffusion, see e.g. [2, 6, 30, 43].

Through this section we will mainly work in L^∞-setting. Recall that we will always assume that (A1) and (A2) hold, and $\theta > 0$ is given by (6.4).

Let us give a brief overview for the results of this Section. The existence and properties of the traveling wave solutions will be considered under the so-called Mollison condition (A5), cf. e.g. [41, 42]. Namely, in Theorem 6.12 we will prove that, for any $\xi \in S^{d-1}$, there exists $c_*(\xi) \in \mathbb{R}$, such that, for any $c \geq c_*(\xi)$, there exists a traveling wave with the speed c in the direction ξ, and, for any $c < c_*(\xi)$, such a traveling wave does not exist. Moreover, we will find an expression for $c_*(\xi)$, see (6.7). We will prove that the profile of a traveling wave with a non-zero speed is smooth, whereas the zero-speed traveling wave (provided it exists, i.e. if $c_*(\xi) \leq 0$) has a continuous profile (Proposition 6.13, Corollary 6.14). Next, we will demonstrate the uniqueness (up to shifts) of a traveling wave wave profile with a given speed $c \geq c_*(\xi)$ (Theorem 6.18).

Definition 6.10. Let $\mathcal{M}_\theta(\mathbb{R})$ denote the set of all decreasing and right-continuous functions $f : \mathbb{R} \to [0, \theta]$.

Definition 6.11. Let $\tilde{\mathcal{X}}^1_\infty := \tilde{\mathcal{X}}_\infty \cap C^1((0,\infty) \to L^\infty(\mathbb{R}^d))$. A function $u \in \tilde{\mathcal{X}}^1_\infty$ is said to be a traveling wave solution to the equation (6.1) with a speed $c \in \mathbb{R}$ and in a direction $\xi \in S^{d-1}$ if and only if (iff, in the sequel) there exists a function $\psi \in \mathcal{M}_\theta(\mathbb{R})$, such that for all $t \geq 0$, a.a. $x \in \mathbb{R}^d$,

$$u(x,t) = \psi(x \cdot \xi - ct), \quad \psi(-\infty) = \theta, \quad \psi(+\infty) = 0. \tag{6.5}$$

Here and below the function ψ is said to be the profile for the traveling wave, whereas c is its speed.

For a given $\xi \in S^{d-1}$, consider the following assumption on a^+:

$$\text{There exists } \mu = \mu(\xi) > 0 \text{ such that } \mathfrak{a}_\xi(\mu) := \int_{\mathbb{R}^d} a^+(x) e^{\mu \xi \cdot x} \, \mathrm{d}x < \infty. \tag{A5}$$

Theorem 6.12. *Let* (A1) *and* (A2) *hold and* $\xi \in S^{d-1}$ *be fixed. Suppose also that* (A5) *holds. Then there exists* $c_*(\xi) \in \mathbb{R}$ *such that*

1. *for any* $c \geq c_*(\xi)$*, there exists a traveling wave solution (in direction* ξ*), in the sense of Definition 6.11, with a profile* $\psi \in \mathcal{M}_\theta(\mathbb{R})$ *and the speed* c*,*
2. *for any* $c < c_*(\xi)$*, such a traveling wave does not exist.*

Proof. Since the semi-flow generated by (6.1) is commutative with the translation in $\mathbb{R}^d$, there is no loss of generality in considering the one-dimensional space ($d = 1$). Then one can show there exists $\mu > 0$ such that

$$\varphi(s) := \theta \min\{e^{-\mu s}, 1\}, \quad s \in \mathbb{R},$$

is a super-solution to (6.1). Now one can apply [51, Theorem 5]. Also see [21, Theorem 4.9]. □

Next statements describe the properties of a traveling wave solution.

Proposition 6.13 ([21, Proposition 4.11])**.** *Let* $\psi \in \mathcal{M}_\theta(\mathbb{R})$ *and* $c \in \mathbb{R}$ *be such that there exists a solution* $u \in \tilde{\mathcal{X}}^1_\infty$ *to the equation* (6.1) *such that* (6.5) *holds, for some* $\xi \in S^{d-1}$*. Then* $\psi \in C^1(\mathbb{R} \to [0,\theta])$*, for* $c \neq 0$*, and* $\psi \in C(\mathbb{R} \to [0,\theta])$*, otherwise.*

Corollary 6.14 ([21, Corollary 4.12, Proposition 4.13])**.** *In conditions and notations of Proposition 6.13,* ψ *is a strictly decaying function, for any speed* c*, and for any speed* $c \neq 0$*, the profile* $\psi \in C^\infty_b(\mathbb{R})$*.*

We assume that the first moment of a^+ in direction $\xi \in S^{d-1}$ exists, namely,

$$\int_{\mathbb{R}^d} |x \cdot \xi| \, a^+(x) \, \mathrm{d}x < \infty. \tag{A6}$$

The following assumption is a weaker form of (A3).

$$\begin{gathered}\text{There exist } r = r(\xi) \geq 0,\ \rho = \rho(\xi) > 0,\ \delta = \delta(\xi) > 0, \text{ such that} \\ a^+(x) \geq \rho, \text{ for a.a. } x \in B_\delta(r\xi).\end{gathered} \tag{A7}$$

We set,

$$\check{a}^{\pm}(s) := \begin{cases} \int_{\mathbb{R}^{d-1}} a^{\pm}(\tau_1\eta_1 + \ldots + \tau_{d-1}\eta_{d-1} + s\xi)\, d\tau_1 \ldots d\tau_{d-1}, & d \geq 2, \\ a^{\pm}(s\xi), & d = 1. \end{cases}$$

There exists a critical situation: when the abscissa of the traveling wave coincides with the abscissa of the kernel a^+. In this case, properties of the traveling waves may be different from the 'generic' case. To distinguish this cases and simplify the further statements, we introduce the following two classes of functions.

Definition 6.15. Let $m > 0$, $\varkappa^{\pm} > 0$, $0 \leq a^- \in L^1(\mathbb{R}^d)$ be fixed, and (A1) holds. For an arbitrary $\xi \in S^{d-1}$, we denote by $\mathcal{V}_\xi$ the the class of all kernels $0 \leq a^+ \in L^1(\mathbb{R}^d)$ such that (A2), (A5)–(A7) and one of the following assumptions does hold:

1. $\lambda_0 := \sup\{\lambda \in \mathbb{R} : \mathfrak{a}_\xi(\lambda) < \infty\} = \infty$;
2. $\lambda_0 < \infty$ and $\mathfrak{a}_\xi(\lambda_0) = \infty$;
3. $\lambda_0 < \infty$, $\mathfrak{a}_\xi(\lambda_0) < \infty$ and $\mathfrak{t}_\xi(\lambda_0) \in [-\infty, m)$, where $\mathfrak{t}_\xi(\lambda)$ is given by

$$\mathfrak{t}_\xi(\lambda) := \varkappa^+ \int_{\mathbb{R}} (1 - \lambda s)\check{a}^+(s) e^{\lambda s}\, \mathrm{d}s \in [-\infty, \varkappa^+), \qquad \lambda \in [0, \lambda).$$

Correspondingly, we denote by $\mathcal{W}_\xi$ the class of all kernels such that $\lambda_0 < \infty$, $\mathfrak{a}_\xi(\lambda_0) < \infty$, and $\mathfrak{t}_\xi(\lambda_0) \in [m, \varkappa^+)$ instead of $(1) - (3)$.

For $a^+ \in \mathcal{V}_\xi \cup \mathcal{W}_\xi$, denote the interval $I_\xi \subset (0, \infty)$ by

$$I_\xi := \begin{cases} (0, \infty), & \text{if } \lambda_0 = \infty, \\ \big(0, \lambda_0\big), & \text{if } \lambda_0 < \infty \text{ and } \big(\mathfrak{L}\check{a}^+\big)\big(\lambda_0\big) = \infty \\ \big(0, \lambda_0\big], & \text{if } \lambda_0 < \infty \text{ and } \big(\mathfrak{L}\check{a}^+\big)\big(\lambda_0\big) < \infty. \end{cases}$$

Consider the following complex-valued function

$$G_\xi(z) := \frac{\varkappa^+(\mathfrak{L}\check{a}^+)(z) - m}{z}, \quad \operatorname{Re} z > 0, \tag{6.6}$$

Proposition 6.16. *Let $\xi \in S^{d-1}$ be fixed and $a^+ \in \mathcal{V}_\xi \cup \mathcal{W}_\xi$. Then there exists a unique $\lambda_* = \lambda_*(\xi) \in I_\xi$ such that*

$$\inf_{\lambda > 0} G_\xi(\lambda) = \min_{\lambda \in I_\xi} G_\xi(\lambda) = G_\xi(\lambda_*) > \varkappa^+ \mathfrak{m}_\xi.$$

Moreover, G_ξ is strictly decreasing on $(0, \lambda_*]$ and G_ξ is strictly increasing on $I_\xi \setminus (0, \lambda_*]$ (the latter interval may be empty).

The following theorem provides expressions of for the minimal speed of traveling waves.

Theorem 6.17. *Let $\xi \in S^{d-1}$ be fixed and $a^+ \in \mathcal{V}_\xi \cup \mathcal{W}_\xi$. Let $c_*(\xi)$ be the minimal traveling wave speed according to Theorem 6.12, and let, for any $c \geq c_*(\xi)$, the function $\psi = \psi_c \in \mathcal{M}_\theta(\mathbb{R})$ be a traveling wave profile corresponding to the speed c. Let $\lambda_* \in I_\xi$ be the same as in Proposition 6.16.*

1. *The following relations hold*

$$c_*(\xi) = \min_{\lambda>0} \frac{\varkappa^+ \mathfrak{a}_\xi(\lambda) - m}{\lambda} = \frac{\varkappa^+ \mathfrak{a}_\xi(\lambda_*) - m}{\lambda_*} > \varkappa^+ \mathfrak{m}_\xi. \tag{6.7}$$

2. *For $a^+ \in \mathcal{V}_\xi$, there exists another representation for the minimal speed,*

$$c_*(\xi) = \varkappa^+ \int_{\mathbb{R}} x \cdot \xi \, a^+(x) e^{\lambda_* x \cdot \xi} \, \mathrm{d}x = \varkappa^+ \int_{\mathbb{R}} s \check{a}^+(s) e^{\lambda_* s} \, \mathrm{d}s > \varkappa^+ \mathfrak{m}_\xi.$$

Proof. First, we apply the Laplace transform to (6.1) with the traveling wave solution $u(x,t) = \psi(x \cdot \xi - ct)$. Then, analysis of the minimal speed $c_*(\xi)$ will be reduced to the analysis of the function G_ξ defined by (6.6). In particular, (6.7) follows from Proposition 6.16. For the details see [21, Theorem 4.23]. □

Now we will formulate the uniqueness (up to shifts) of a profile ψ for a traveling wave with the given speed $c \geq c_*(\xi)$, $c \neq 0$.

Theorem 6.18. *Let $\xi \in S^{d-1}$ be fixed and $a^+ \in \mathcal{V}_\xi \cup \mathcal{W}_\xi$. Suppose, additionally, that* (A4) *holds. Let $c_*(\xi)$ be the minimal traveling wave speed according to Theorem 6.12. For the case $a^+ \in \mathcal{W}_\xi$ with $m = \mathfrak{t}_\xi(\lambda_0)$, we will assume, additionally, that $\int_{\mathbb{R}} s^2 \check{a}^+(s) e^{\lambda_0 s} \, \mathrm{d}s < \infty$. Then, for any $c \geq c_*$, such that $c \neq 0$, there exists a unique, up to a shift, traveling wave profile ψ for* (6.1).

Proof. We will follow the sliding technique from [10]. Let $\psi_1, \psi_2 \in C^1(\mathbb{R}) \cap \mathcal{M}$ are traveling wave profiles with a speed $c \geq c_*$, $c \neq 0$. On can prove that, for any $\tau > 0$, there exists $T = T(\tau) > 0$, such that

$$\psi_1(s - \tau) > \psi_2(s), \quad s \geq T.$$

Then there exists $\nu > 0$, such that,

$$\psi_1(s - \nu) \geq \psi_2(s), \quad s \in \mathbb{R}.$$

Similarly, there exists $\tilde{\nu} > 0$, such that,

$$\psi_2(s - \tilde{\nu}) \geq \psi_1(s), \quad s \in \mathbb{R}.$$

We can shift ψ_1 and ψ_2 such that $\nu = \tilde{\nu} = 0$. As a result $\psi_1 = \psi_2$. See [21, Theorem 4.33] for the detailed proof. □

6.4 Propagation with a constant speed

We will study here the behavior of $u(tx, t)$, where u solves (6.1), for big $t \geq 0$. The results of Section 6.3 together with the comparison principle imply that if an initial condition $u_0(x)$ to (6.1) has a minorant/majorant which has a form $\psi(x \cdot \xi)$, $\xi \in S^{d-1}$, where $\psi \in \mathcal{M}_\theta(\mathbb{R})$ is a traveling wave profile in

the direction ξ with a speed $c \geq c_*(\xi)$, then for the corresponding solution u to (6.1), the function $u(tx,t)$ will have the minorant/majorant $\psi(t(x\cdot\xi - c))$, correspondingly. In particular, if the initial condition is "below" of any traveling wave in a given direction, then one can estimate the corresponding value of $u(tx,t)$ (Theorem 6.19). Considering such a behavior in different directions, one can obtain a (bounded) set, out of which the solution exponentially decays to 0 (Theorem 6.20). Inside of this set the solution will uniformly converge to θ (Theorem 6.21).

Here and below, for any measurable $A \subset \mathbb{R}$, we define $tA := \{tx \mid x \in A\} \subset \mathbb{R}$.

$$E_{\lambda,\xi}(\mathbb{R}^d) := \{f \in L^\infty(\mathbb{R}^d) \big| \|f\|_{\lambda,\xi} := \sup_{x\in\mathbb{R}^d} |f(x)|e^{\lambda x\cdot\xi} < \infty\}.$$

We are going to explain now how a solution $u(x,t)$ to (6.1) behaves outside of the sets

$$\Upsilon_{t,\xi} = \big\{x \in \mathbb{R}^d \mid x\cdot\xi \leq tc_*(\xi)\big\}, \quad \xi \in S^{d-1}.$$

Theorem 6.19. *Let $\xi \in S^{d-1}$ and $a^+ \in \mathcal{V}_\xi \cup \mathcal{W}_\xi$; i.e. all conditions of Definition 6.15 hold. Let $\lambda_* = \lambda_*(\xi) \in I_\xi$ be the same as in Proposition 6.16. Suppose that $u_0 \in E_{\lambda_*,\xi}(\mathbb{R}^d) \cap E_\theta$ and let $u \in \mathcal{X}_\infty$ be the corresponding solution to (6.1). Let $O_\xi \subset \mathbb{R}$ be an open set, such that $\Upsilon_{1,\xi} \subset O_\xi$ and $\delta := \operatorname{dist}(\Upsilon_{1,\xi}, \mathbb{R}^d \setminus O_\xi) > 0$. Then the following estimate holds*

$$\sup_{x\notin tO_\xi} u(x,t) \leq \|u_0\|_{\lambda_*,\xi} e^{-\lambda_*\delta t}, \quad t > 0.$$

Proof. is based on the proof of Theorem 6.1. We consider the map $\Phi(v)$ in the weighted L^∞-space $E_{\lambda,\xi}(\mathbb{R}^d)$. We can show there exists λ_* such that

$$0 \leq u(x,t) \leq \|u_0\|_{\lambda_*,\xi} \exp\big\{p_* t - \lambda_* x\cdot\xi\big\}, \quad \text{a.a. } x \in \mathbb{R}^d,$$

where $p_* = \varkappa^+ \int_{\mathbb{R}^d} a^+(x) e^{\lambda_* x\cdot\xi}\, dx - m$.

Also see [21, Theorem 5.4]. □

We are going to consider now the global long-time behavior along both directions $\xi \in S^{d-1}$ simultaneously. Define,

$$\Upsilon_T = \bigcap_{\xi\in S^{d-1}} \Upsilon_{T,\xi} = \bigcap_{\xi\in S^{d-1}} T\Upsilon_{1,\xi} = T\Upsilon_1, \quad T > 0.$$

We are ready now to state a result about the long-time behavior at infinity in space.

$$a^+ \in L^\infty(\mathbb{R}^d). \tag{A8}$$

$$\text{There exists } \mu_d > 0, \text{ such that } \int_{\mathbb{R}^d} a^+(x) e^{\mu_d|x|}\, \mathrm{d}x < \infty. \tag{A9}$$

Clearly, (A9) implies

$$\int_{\mathbb{R}^d} |x| a^+(x)\, \mathrm{d}x < \infty. \tag{6.8}$$

Theorem 6.20. *Let the conditions* (A1), (A2), (A3), (A8), (A9) *hold. Let* $u_0 \in E_\theta$ *be such that*

$$|||u_0||| := \max_{\xi \in S^{d-1}} \|u_0\|_{\lambda_*(\xi),\xi} < \infty,$$

and let $u \in \mathcal{X}_\infty$ *be the corresponding solution to* (6.1)*. Then, for any open set* $O \supset \Upsilon_1$*, there exists* $\nu = \nu(O) > 0$*, such that*

$$\sup_{x \notin tO} u(x,t) \le |||u_0|||e^{-\nu t}, \quad t > 0.$$

Proof. The proof follows from Theorem 6.19. See [21, Theorem 5.9] for details. □

Our second main result about the long-time behavior states that the solution $u \in \mathcal{X}_\infty$ uniformly converges to θ inside the set $t\Upsilon_1 = \Upsilon_t$.

For a closed set $A \subset \mathbb{R}^d$, we denote by $\mathrm{int}(A)$ the interior of A.

Theorem 6.21. *Let the conditions* (A1), (A2), (A4), (A8), (A9) *hold. Let* $u_0 \in U_\theta$*,* $u_0 \not\equiv 0$*, and* $u \in \mathcal{X}_\infty$ *be the corresponding solution to* (6.1)*. Then, for any compact set* $C \subset \mathrm{int}(\Upsilon_1)$*,*

$$\lim_{t\to\infty} \min_{x \in tC} u(x,t) = \theta. \tag{6.9}$$

Proof. The result of the theorem is a special case of the general result for dynamical systems on the space of bounded continuous functions by H. Weinberger [50]. See [21, Theorem 5.10] for the detailed proof. □

All result above about traveling waves and long-time behavior of the solutions were obtained under exponential integrability assumptions, cf. (A5) or (A9). In [27], it was proved, in the case of the local competition (e.g. $a^- = \delta_0$), on $\mathbb{R}$ with local nonlinear term, that the case with a^+ which does not satisfy such conditions leads to 'accelerating' solutions, i.e. in this case the equality like (6.9) holds for arbitrary big compact $C \subset \mathbb{R}$. The detailed analysis of the propagation for the slow decaying a^+ is done in the following section.

We will formulate an analog of the first statement in [27, Theorem 1].

Theorem 6.22 ([21, Theorem 5.21])**.** *Let the conditions* (A1), (A2), (A4), (A8)*, and* (6.8) *hold. Suppose also (cf.* (A9)*), that for any* $\lambda > 0$ *and for any* $\xi \in S^{d-1}$*,* $\mathfrak{a}_\xi(\lambda) = \infty$*. Let* $u_0 \in E_\theta$ *be such that there exist* $x_0 \in \mathbb{R}$*,* $\eta > 0$*,* $r > 0$*, with* $u_0 \ge \eta$*, for a.a.* $x \in B_r(x_0)$*. Let* $u \in \mathcal{X}_\infty$ *be the corresponding solution to* (6.1)*. Then, for any compact set* $\mathcal{K} \subset \mathbb{R}^d$*,*

$$\lim_{t\to\infty} \inf_{x \in t\mathcal{K}} u(x,t) = \theta.$$

6.5 Accelerating propagation

The main result of this subsection is Theorem 6.25, where we demonstrate the accelerated propagation of solutions to (6.1) in the case when either of the dispersion kernel or the initial condition has regularly heavy tails at ∞, perhaps different. We show that, in such case, the propagation is fully determined

by either the kernel or the initial condition. Our approach in this subsection is based, in particular, on the extension of the theory of sub-exponential distributions, which we introduced early in [25].

To formulate our main result, we start with the following definition.

Definition 6.23. A function $b : \mathbb{R} \to \mathbb{R}_+$ is said to be

– *(right-side) long-tailed*, if there exists $\rho = \rho_b \geq 0$, such that $b(s) > 0$ for all $s \geq \rho$; and, for any $\tau \geq 0$,

$$\lim_{s\to\infty} \frac{b(s+\tau)}{b(s)} = 1;$$

– *(right-side) tail-decreasing*, if there exists $\rho = \rho_b \geq 0$, such that $b = b(s)$ is strictly decreasing on $[\rho, \infty)$ to 0. In particular, $b(s) > 0$, $s \geq \rho$;

– *(right-side) tail-log-convex*, if there exists $\rho = \rho_b > 0$, such that $b(s) > 0$, $s \geq \rho$, and the function $\log b$ is convex (and hence continuous) on (ρ, ∞).

Definition 6.24. Let $\widetilde{\mathcal{S}}_{\mathrm{reg},d}$ be the set of all bounded functions $b : \mathbb{R} \to \mathbb{R}_+$ such that

1. b is tail-decreasing and tail-log-convex with the same $\rho = \rho_b > 1$, such that $b(\rho) \leq 1$ (without loss of generality); and

$$\int_{-\infty}^{\rho} b(s)\, ds + \int_{\rho}^{\infty} b(s) s^{d-1}\, ds < \infty$$

2. there exist $\delta = \delta_b \in (0,1)$ and an increasing function $h = h_b : (0,\infty) \to (0,\infty)$, with $h(s) < \dfrac{s}{2}$ and $\lim\limits_{s\to\infty} h(s) = \infty$, such that

$$\lim_{s\to\infty} \frac{b(s \pm h(s))}{b(s)} = 1,$$
$$\lim_{s\to\infty} b\big(h(s)\big) s^{1+\delta} = 0.$$

3. if $d > 1$, then we assume additionally that

   – either, for some $\mu, M > 0$,

$$b(s) = \frac{M}{(1+s)^{d+\mu}}, \quad s \in \mathbb{R}_+,$$

   – or, for all $\nu \geq 1$,

$$\lim_{s\to\infty} b(s) s^{\nu} = 0.$$

Any function which is asymptotically proportional at ∞ to either of

$$(\log s)^{\nu} s^{-(d+\delta)}, \quad s^{\nu} \exp\big(-D(\log s)^{q}\big), \quad s^{\nu} \exp\big(-s^{\alpha}\big), \quad s^{\nu} \exp\Big(-\frac{s}{(\log s)^{\gamma}}\Big),$$

belongs to the class $\widetilde{\mathcal{S}}_{\mathrm{reg},d}$, provided that $D, \delta > 0$, $q, \gamma > 1$, $\alpha \in (0,1)$, $\nu \in \mathbb{R}$.

We will choose an appropriate function $c : \mathbb{R}^d \to (0, \infty)$ and set

$$\Lambda(t, c) := \left\{ x \in \mathbb{R}^d \;\middle|\; c(x) \geq e^{-\beta t} \right\},$$

where $\beta := \varkappa^+ - m > 0$. Two model examples for us will be

$$c(x) = b(|x|) \quad \text{and} \quad c(x) = \int_{\Delta(x)} b(|y|)\, dy, \qquad x \in \mathbb{R}^d,$$

where $\Delta(x) := \left\{ y \in \mathbb{R}^d : y_j \geq x_j,\ 1 \leq j \leq d \right\}$.

We are aimed to show that, for a small enough $\varepsilon > 0$,

$$\lim_{t \to \infty} \operatorname*{ess\,inf}_{x \in \Lambda_\varepsilon^-(t,c)} u(x, t) = \theta, \tag{6.10a}$$

$$\lim_{t \to \infty} \operatorname*{ess\,sup}_{x \notin \Lambda_\varepsilon^+(t,c)} u(x, t) = 0. \tag{6.10b}$$

We formulate now our main result.

Theorem 6.25. *Let $b, q : \mathbb{R}_+ \to \mathbb{R}_+$ be bounded functions such that, for some $M, \mu, r, \delta > 0$,*

$$b(s) + q(s) \leq \frac{M}{(1+s)^{d+\mu}} \quad \text{for a.a. } s \geq r,$$

and $q(s) \geq \delta$ for a.a. $s \in [0, \rho]$. Let (A1)–(A4), (6.8) *hold. Suppose that $a^+(x) = b(|x|)$, $x \in \mathbb{R}^d$. Let either of the following conditions holds*

$$\sup_{s \in \mathbb{R}_+} \frac{q(s)}{b(s)} < \infty, \tag{6.11}$$

$$\sup_{s \in \mathbb{R}_+} \frac{b(s)}{q(s)} < \infty. \tag{6.12}$$

1. *Let $q : \mathbb{R} \to [0, \theta]$ and*

$$u_0(x) = q(|x|), \quad x \in \mathbb{R}^d.$$

Then

   (a) if $b \in \widetilde{\mathcal{S}}_{\mathrm{reg},d}$ and (6.11) *holds, then* (6.10) *holds with $c = a^+$;*

   (b) if $q \in \widetilde{\mathcal{S}}_{\mathrm{reg},d}$ and (6.12) *holds, then* (6.10) *holds with $c = u_0$.*

2. *Let $\displaystyle\int_0^\infty q(s) s^{d-1} ds \in (0, \theta]$ and*

$$u_0(x) = \int_{\Delta(x)} q(|y|) dy, \quad x \in \mathbb{R}^d.$$

Then

   (a) if $b \in \widetilde{\mathcal{S}}_{\mathrm{reg},d}$ and (6.11) *holds, then* (6.10) *holds with*

$$c(x) := \int_{\Delta(x)} a^+(y) dy, \quad x \in \mathbb{R}^d;$$

   (b) if $q \in \widetilde{\mathcal{S}}_{\mathrm{reg},d}$ and (6.12) *holds, then* (6.10) *holds with $c = u_0$.*

Proof. See [22, Theorem 1.5]. □

Note that in [22] the case when (6.8) does not hold was also covered.

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Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 35–42

View of mathematicians on biological data: Modeling axon growth using CTRW

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> In the theory of Brownian motion the first concern has always been the calculation of the mean square displacement of the particle, because this could be immediately observed.
>
> *George Uhlenbeck and Leonard Ornstein (1930)*

1 Description and analysis of the model

The main goal of this note is to propose a mathematical model that describes an ensemble of axon growth cones and shows the difference in the behavior of normal and mutant axons. We use here experimental microscopic data provided by the Morphem team (INRIA). An essential part of our analysis is to find the crucial characteristics of axon paths which indicates whether the family of axons is normal or mutant.

We introduce a probabilistic model for axon growing such that each family of axons is described as an ensemble of trajectories of a continuous time random walk (CTRW). We describe different regimes in the model and conclude how the behavior of axons depends on the parameters of the model. Biological observations of the axonal growth process show that axons are guided towards their targets by chemical signals from the cellular environment. To represent this control mechanism in mathematical terms we propose the CTRW model, where a random waiting time reflects a reaction time of the growth cones on the neighboring chemical environment. We observed that the distributions of the waiting time in the model for the normal axons and for the mutant ones differ a lot.

Continuous-time random walks (CTRW) are a natural generalization of a usual random walk. Mathematical analysis can be dated back to the pioneering work of Montroll and Weiss in the sixties [1]. At present they are extensively used in applications to physics, chemistry, and other sciences, see e.g. [2], [3].

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The work is made at IITP RAS and supported by the Russian Scientific Foundation grant 14-50-00150.

We are working with three families of (static) trajectories associated with the axon growth cones. One of the family is for normal axons, the other two are for two different axon mutations. We don't have dynamical data, and each trajectory presents positions of an axon tip during the observation time. The observation time is the same for all axons, but we don't have information about the intermediate stopping places for development of each axon. On figure 1 we present three sets of trajectories of axon growth cones. In fact, axons represented on real data images have different starting positions, but we shifted all of them to have the same starting point.

Now our main question is how to determine whether the family of axons on Fig. 1 is normal or mutant? We give the answer on this question below.

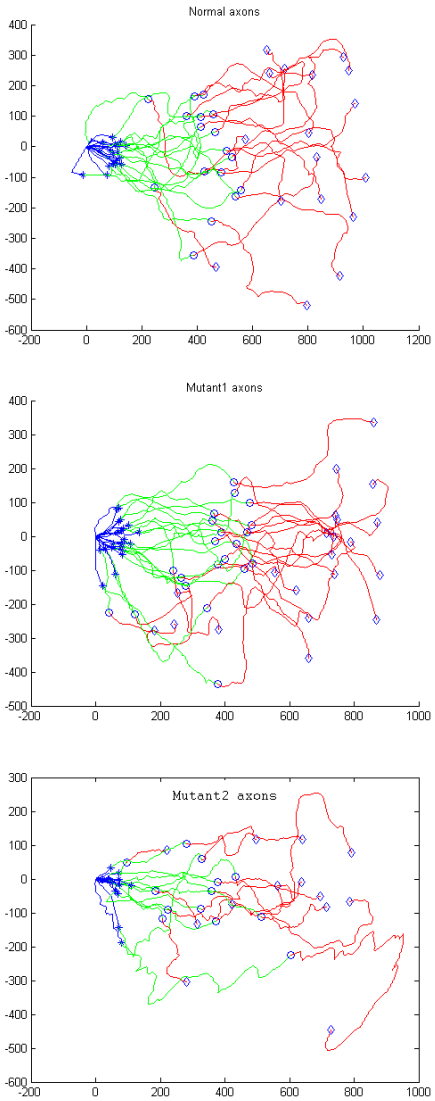

Fig. 1.1: Axonal trajectories

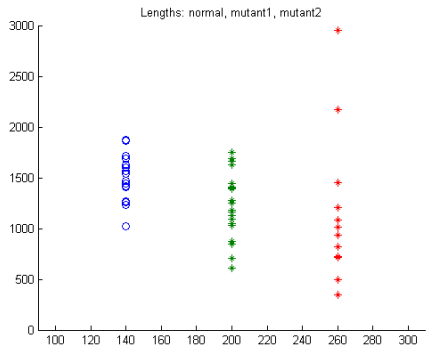

Fig. 1.2: Length distributions

The first observation is about length of axons. On fig. 2 we present the values of the lengths for the normal and mutant axons. One can see that the average length for the mutant axons is less than for the normal ones.

The second observation concerns the value of the average deviation of trajectories from the origin. We propose a model of axon growing based on a CTRW model. A CTRW model is a symmetrical random walk subordinated to a renewal process. It is defined by two probability distributions: a distribution $p(x \to y),\ x, y \in \mathbb{Z}^d$ for a spacial random walk and a distribution $f(t),\ t \geq 0$ for a waiting time. Then CTRW can be described as follows: a particle wait at position x a random time distributed by $f(t)$, then it jumps from x to y according to the distribution $p(x-y)$, and so on. Then a longer waiting time implies reducing of trajectories lengths.

Since we don't have any dynamical data for axon growing, we couldn't control absolute time and should introduce in our model an artificial time. We study here three cases, which are reasonable from our point of view.

The first case (A uniform partition). Assuming an equal absolute time T for growing of all axons and the existence of the average speed for any trajectory of the CTRW $X(t) \in \mathbb{Z}^d,\ t \in [0, T]$ (depending on the length of the trajectory) we can consider uniform partitions of trajectories proportional to the length L of axons: $X(0) = 0,\ X(T) = x_{end},\ X(\frac{k}{10}T) = x_k,\ k = 0, 1, \ldots, 10$, where x_{end} is a position of the end of the trajectory of the length L, and $x_k,\ k = 0, 1, \ldots, 10$ are points on the trajectory corresponding to the length $\frac{k}{10}L,\ k = 0, 1, \ldots, 10$.

The second case (A uniform partition after elongation). In this case we assume different time for axon growing but the same evolving time T for all axons. For long axons we consider again an equal absolute growing/evolving time as above, assuming different average speeds of the growth dependent on the length L. For short axons we say that the growing process stops at some moment of time, and after that the short axons just keep their final position in evolution process. Let L_n be an average length of trajectories of normal axons, then we put $L_n = T$ as the absolute evolving time and consider the following elongation in time for all short axons with a length L less than $L_n = T$: we take

the last part of the trajectory (from "time" L to time T) coinciding with the end point of axons. Thus we obtain that all short trajectories evolve during the same time $T = L_n$ with a constant speed 1, and we assume that it is the same absolute growing/evolving time $T = L_n$ for long trajectories. Finally, we construct the uniform partitions depending on the length of axons L, which is the same as in the first case.

The third case (A non uniform partition). Assuming again the same absolute time for growing of all axons and using observations from biological experiments that a speed of axon growing is decreasing in time (especially for mutant axons), we consider a non uniform partitions of trajectories corresponding to the following lengths $l(k)$:

$$l(k) \;=\; \frac{\alpha L}{1-e^{-\alpha}} \int_0^{t_k} e^{-\alpha t}\, dt, \quad t_k = \frac{k}{10}, \quad k \;= 0, 1, \dots 10$$

with $\alpha = 2$.

Since the axon growth cones in real growing processes develop along the main canal, we consider in our model a permanent drift along the X-axis, and study the deviation only along the Y-axis. Thus we can take the X direction as a direction of an artificial time. We formulate the following well-known result for the mean squared deviation $\langle Y^2(t)\rangle$, where $Y(t)$ is the position of the Y-coordinate of the 1-D CTRW when time t is large enough, see e.g. [1, 3].

Proposition 1.1. *Let $p(u) = p(-u)$ is a distribution of a symmetrical random walk on Z^1, and we consider two cases:*

1) *diffusive behaviour: $\langle\tau\rangle = \sum_0^\infty t\ f(t)dt < \infty$,*

2) *anomalous diffusion: $\langle\tau\rangle = \infty$ and $f(t) \sim \dfrac{1}{t^{\alpha+1}}$ as $t \to \infty$ with $\alpha \in (0,1)$.*

Then for large enough t we have for the mean squared displacement

$$\langle Y^2(t)\rangle \;\approx\; \frac{2a}{\langle\tau\rangle} t \quad \textit{in the first case} \tag{1.1}$$

and

$$\langle Y^2(t)\rangle \;\approx\; t^\alpha \quad \textit{in the second case with } \alpha \in (0,1). \tag{1.2}$$

Here a is the dispersion of the symmetrical random walk.

The proof of the Proposition is based on the Fourier–Laplace transform of the characteristic function of the random walk and on the formula

$$\hat{Y}^2(s) \;=\; \int \langle Y^2(t)\rangle\ e^{-st}\ dt \;=\; -\frac{\partial^2 \hat{\theta}(\lambda, s)}{\partial \lambda^2}\Big|_{\lambda=0},$$

where $\hat{\theta}(\lambda, s) \;=\; \int_0^\infty e^{-st} \langle e^{i\lambda Y(t)}\rangle\ dt$.

The main idea of our analysis is to compare statistical characteristics of the trajectories from different families (for normal and mutant axons separately) with the mean squared displacements for CTRW given by (1.1)–(1.2).

We use the empirical law for $\langle Y^2(t)\rangle$ to construct the graph of $\langle Y^2(t)\rangle$ as a function of t. Then we compare these functions with the linear or sub-linear growth given by (1.1)–(1.2) and conclude which parameters of the CTRW model imply the similar law for $\langle Y^2(t)\rangle$. For example, if $\langle Y^2(t)\rangle$ increases as a linear function: $y(t) = rt$, then by (1.1) we get that in this case the growth rate r of the function $y(t) = \langle Y^2(t)\rangle$ is connected with parameters a and $\langle\tau\rangle$ as follows:

$$r = \frac{2a}{\langle\tau\rangle}.$$

On Fig. 3–8 we present our calculations of $\langle Y^2(t)\rangle$ and $\big\langle (Y(t) - \langle Y(t)\rangle)^2 \big\rangle$ using the statistical data and construct corresponding interpolation curves in each of three cases under our consideration. Here $\langle\cdot\rangle$ is the empirical average.

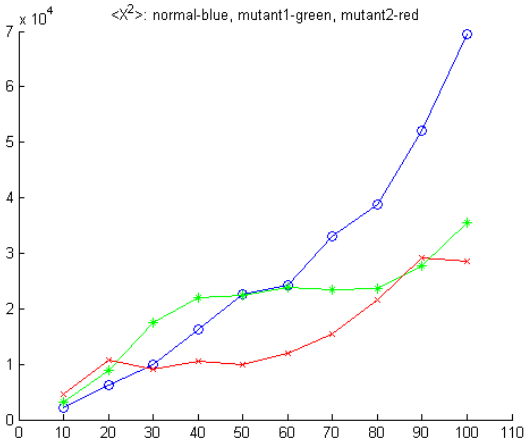

Fig. 1.3: The first case: second moments as a function of time (% of length)

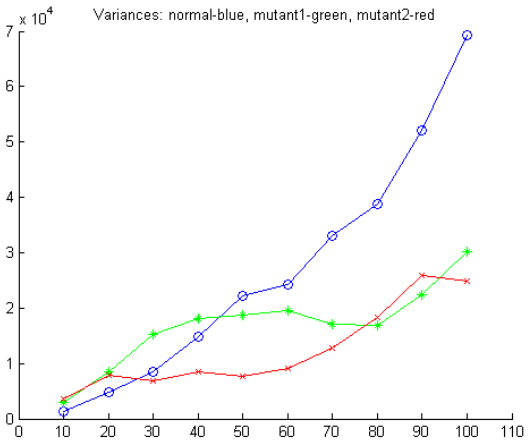

Fig. 1.4: The first case: variances as a function of time (% of length)

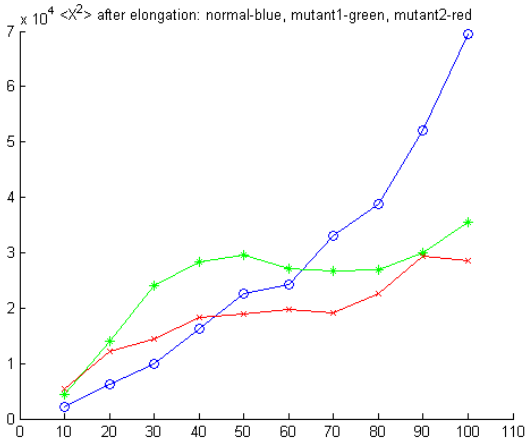

Fig. 1.5: The second case (elongation of short axons): second moments as a function of time (% of length)

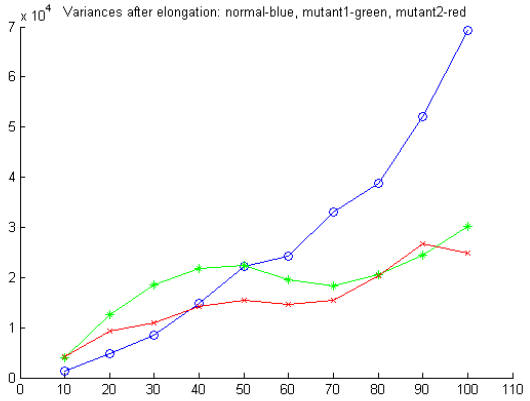

Fig. 1.6: The second case (elongation of short axons): variances as a function of time (% of length)

2 Conclusions

The analysis of the graph of the functions $y(t) = \langle Y^2(t)\rangle$ and $\big\langle (Y(t) - \langle Y(t)\rangle)^2\big\rangle$ allows one to conclude whether the family of corresponding axons is normal or mutant.

I. The difference in the behavior of the graph of $y(t) = \langle Y^2(t)\rangle$ and $\big\langle (Y(t) - \langle Y(t)\rangle)^2\big\rangle$ on Fig. 3–8 in the case of normal and mutant axons is evident: for normal axons the graph increases linearly whereas for mutant axons the increasing is sub-linear (or linear but with essentially smaller growth rate then in the normal case: $r_m < r_n$). Consequently, by the proposition the distributions of the waiting time $f(t)$ for normal and mutant axons are different, and by the formula (1.1) the average waiting time for mutant axons is longer

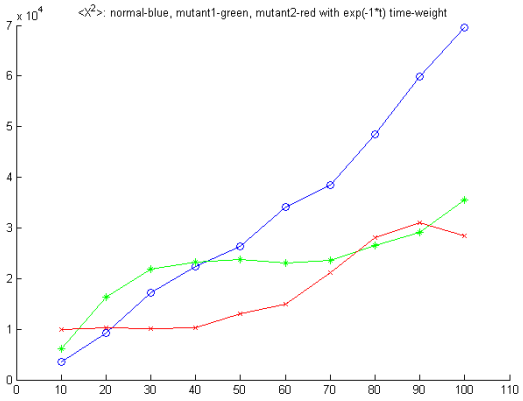

Fig. 1.7: The third case: second moments as a function of time (% of length with weights)

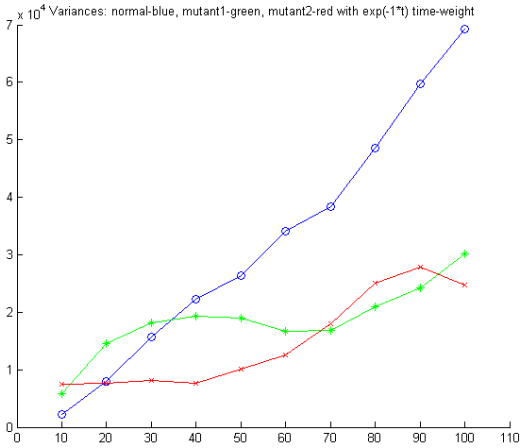

Fig. 1.8: The third case: variances as a function of time (% of length with weights)

(greater) than for normal axons:

$$\langle \tau_m \rangle \ > \ \langle \tau_n \rangle.$$

Using the constructions of the graphs of $\langle Y^2(t) \rangle$ and $\left\langle (Y(t) - \langle Y(t) \rangle)^2 \right\rangle$ for mutant axons we can formulate a hypothesis that for normal axons the time between renewals has a finite mean, whereas for mutant axons the time between renewals is greater in average or even can have an infinite mean. In the latter case, the scaling limit for the CTRW is an operator of the Levy motion subordinated to the hitting time process of a classical stable subordinator, see e.g. [4]. In this case, for large enough t we have $\langle Y^2(t) \rangle \ \approx \ t^\alpha$ with $0 < \alpha < 1$. That means that the hitting time for this CTRW to reach distant compact sets is much more greater for mutant axons than for normal ones.

II. We can observe two different regimes during evolution of axon growth cones. In the second regime, which is started approximately after 0.6 L, the coefficient $\dfrac{2a}{\langle\tau\rangle}$ increases, see formula (1.1). That can be the result of decreasing averaged waiting time $\langle\tau\rangle$ or increasing dispersion of the spacial random walk a on the second phase of the evolution.

We present in this note our observations on the statistical behavior of three families of axons, and the corresponding explanations of this behavior from a biological point of view is an open question.

We believe that modeling and analysis of the axon shape for different populations (normal/mutant) of axons is an important step of better understanding pathologies and degenerative diseases.

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Освіта

Education

Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 45–58

Interdisciplinary links as a didactic basis of the future teacher's professional training

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Abstract. In the article, the authors consider interdisciplinary links as an important factor in training students of higher pedagogical educational establishments for their future professional activities. As a result of the study and analysis of pedagogical experience, the researchers found that interdisciplinary links are the didactic principle and the basis for the formation of methodological knowledge. These connections are also considered as conditions for the formation of the outlook and the improvement of professional training of future specialists; they are means of increasing the efficiency of knowledge acquisition, activating cognitive activity, forming cognitive needs and developing a system type of thinking, etc. The attention is paid to the technology of implementation of interdisciplinary links in higher pedagogical education, which makes it possible to make the learning process of future teachers efficient. In the pedagogical practice, it became clear that the systematic nature of vocational and pedagogical knowledge involves an interdisciplinary synthesis of these knowledge. Students need to master the concepts, necessary skills and abilities within this knowledge system (system of philosophical knowledge, system of psychological knowledge, system of pedagogical knowledge, system of historical knowledge, system of knowledge in subjects that are profiling in the department, etc.). An analysis of the content of curricula, textbooks, manuals on a number of subjects enabled the authors to find out that interdisciplinary orientation in teaching philosophy, political science, sociology, economic theories, psychology, pedagogy and teaching methods of a particular discipline in the context of interdisciplinarity offers some extra opportunities for the formation of the system of professional and pedagogical knowledge of the future teachers, provides opportunities for mastering the methods of cognition, which prompts for a scientific understanding of the tasks of pedagogy, the issue of education and upbringing of the younger generation, understanding the state policy in the education area. As a result of the analysis and comparison of the contents of the curriculum, the sections, the topics and the separate questions that were adjacent to the indicated disciplines were identified. It allowed determining the content of interdisciplinary knowledge. Implementation of multifunctional interdisciplinary connections in the educational process affects the ideological orientation of a future teacher, the mastery of the dialectical method of cognition, the formation of a professional type of thinking and methodological culture.

Keywords: higher pedagogical education; system of knowledge; interdisciplinary links; interdisciplinary integration; training a future teacher.

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Introduction

In an age of globalization, any social and professional activity becomes intermediate. Under this circumstance, every person may find himself/herself in unpredictable communicative, professional and social situations. Modern education is guided by broad interdisciplinary training of specialists based on effective mechanisms of dynamic communicative and intercultural interaction. Acquiring a certain amount of knowledge remains an important function of the modern educational process. In the process of implementing this function, there are issues related to the assimilation of the future teachers' knowledge; mechanical memorization of basic knowledge sometimes prevails, which does not always have a positive influence on its comprehension and understanding of the level of their value both for the future specialist and in the process of professional educational activity. It is difficult to ignore the subtle understanding of basic knowledge if the scope of this knowledge is critically large. Therefore, the student must master this knowledge at the level of stereotypes, patterns, samples, and this is the reason why the value of such knowledge is reduced, the phenomena of pedagogical activity are ignored, the subject-subject relations acquire signs of a command-administrative system of governance that has already exhausted itself. Basic knowledge that is overloaded with unnecessary information becomes minor; it is leveled, loses value-sense content, and this issue negatively affects the cognitive activity and the development of a personality of a future teacher. Information overloads are also caused by rapid socio-cultural changes that are peculiar not only for education, but also for other branches of social development. Studying educational transformations contemporary didactics considers the fundamentalization of the content of education, which involves the study of the most important basic humanities and natural sciences, the mastering of interdisciplinary (and, consequently, inter-scientific) connections, the focus on ensuring the formation of a coherent picture of the world, the knowledge of its fundamental laws. Nowadays fundamentalization of the education content is an urgent problem. In the system of higher education, this subject is being discussed. However, it mainly concerns natural sciences and mathematics.

It is the interdisciplinary links that should be the foundation of the fundamentalization of the education content. The urgency of the problem of interdisciplinary connections in the educational process of higher education institutions is caused, firstly, by the peculiarities of the modern development of sciences, that is, their differentiation and integration; secondly, by the conceptual unity of scientific knowledge, which manifests itself, in particular, in the conceptual unity of professional knowledge; thirdly, the requirements that are currently put forward to the quality of training future specialists, as well as the necessary changes in the educational process.

Aims

The aim of the article is to characterize interdisciplinary links as a didactic basis for training a future teacher for effective professional activity, to consider the concept of "interdisciplinary links" and their role in this process.

Discussion

The problem of the relationship between educational disciplines and their consideration in the educational process has been realized by teachers for a long time, practically since there was a distinction in the process of teaching certain subjects. The problem of the implementation of interdisciplinary links was studied by J. Komensky, D. Locke, I. G. Pestalocci, K. Ushynskyi and others.

J. Komensky, unsurpassed specialist in didactics argued: "Everything that is in a mutual connection should be taught in the same connection" *(Komensky, 1955, p. 287).* Developing J. Komensky's insight, I. G. Pestalocci acknowledged that it is significant to "interconnect the objects in one's consciousness in the same connection in which they are indeed in nature" *(Pestalocci, 1963, p. 175).* The idea of generalized knowledge as a method of finding truth was put forward by D. Locke, who considered it necessary to fill one subject with the elements and facts of another, and to combine general education with the applied one. He advanced the idea of elemental knowledge and their relationship. The need to establish interdisciplinary links is mentioned in the papers of such German scholars as J. F. Herbart and A. Diesterweg.

K. D. Ushynskyi found interdisciplinary links fairly important and was the first scholar in pedagogy who expressed his opinion about their system-forming function. In his papers, an outstanding teacher developed an idea of forming a system of knowledge and the obligatory presence of links between its constituents, indicating the impossibility of the existence of such without interdisciplinary connections. His recommendations should be taken on the essence of the concept of "knowledge system" and filling it with certain content. It is no accident that K. D. Ushynskyi, who considered the mind as an organized system of knowledge, argued that "only a system, of course, intelligent one, which proceeds from the very nature of objects, gives us full control over our knowledge. A head filled with fragmentary, unconnected knowledge, resembles a barn where everything is in a mess and where the owner himself can find nothing; a head where there is only a system without any knowledge resembles a store where all the boxes have inscriptions, but there is nothing on the shelves" *(Ushynskyi, 1949, vol. 5, p. 355).*

In science, the term *discipline* means the historically formed branch of knowledge, which is characterized by the unity of a fixed subject of research, methods and language in each particular period of its existence. In universities there are disciplines in certain branches of scientific knowledge that are considerably different from school subjects, especially in structural terms. So, if it comes to the implementation of the links between disciplines that are taught at universities, it makes sense to use the term *interdisciplinary links*, thus emphasizing the difference between higher education and school.

The problem of links between school subjects and academic disciplines at the universities has attracted the attention of many researchers, as it is evidenced by a significant number of publications, in which the authors cover a particular way of solving it. In particular, the researchers point out that "the use of interdisciplinary links at the lessons makes it possible to understand and master the material better due to the timely restoration of knowledge in related disciplines, promotes the development of active mental activity of students to

restore previous knowledge and assimilate new material, affect their self-study, contribute to a comprehensive study of a subject *(Spivakovskiy, Petukhova, Kravcov, Voropay, Kotkova, 2016, p. 48).*

The results of researches were generalized, and it was found out that interdisciplinary links are considered as a didactic principle and basis for the formation of methodological knowledge, the condition for the formation of the worldview and improving professional training of future specialists, a means to increase the efficiency of knowledge acquisition, activating cognitive activity and the formation of cognitive needs, as well as the development of systemic thinking, one of the areas of developmental training and one of the criteria for the degree of readiness of graduates of higher educational institutions for professional activities, a way to implement the principles of learning with promoting their interaction, a factor in the formation of the content and structure of the discipline and the factor in the organization of cognitive activity by general scientific methods. However, the concept of *interdisciplinary links* is multifaceted. Therefore, it is quite clear that the essence of interdisciplinary connections can not be determined precisely. These relationships permeate the content, organizational forms of training, methods, educational and cognitive activities, promote the development of abilities and cognitive needs, provide effective formation of scientific concepts, in-depth learning of theories under investigation, etc. Modern Ukrainian scholars refer to the main types of innovative educational technologies as "interdisciplinary learning is the use of knowledge from different fields, their grouping and concentration in the context of the task being solved" *(Spivakovskiy, Petukhova, Kravcov, Voropay, Kotkova, 2016, p. 110).* Researchers from other countries interpret interdisciplinary learning as learning that combines teaching tasks and methods contained in more than one discipline and focuses on a central topic, section, problem, or work. Interdisciplinary learning is a teaching approach that combines curricular goals and methods from more than one discipline focusing on a central theme, issue, problem or work *(Interdisciplinary Learning, 2005).* According to the results of the analysis of dozens of sources, Ronald A. Styron, Jr., concludes that since knowledge is not acquired in isolation, interdisciplinarity is an important tool in creating new ways of thinking; it facilitates the integration of fragmented knowledge into a coherent whole, interdisciplinary learning contributes to critical thinking, creativity, skills of collaboration and communication *(Styron, 2013).*

Can we consider that interdisciplinary links are characterized by polyfunctionality, dynamism, synergy, and so on? Probably that is right, because having a thorough impact on the learning process and the educational process as a whole these links directly affect the mastery of students' professional and pedagogical knowledge. V. Kremen highlights that the stronger the interdisciplinary links are, the more effective is the process of forming the personality of a future teacher, who is ready to work under conditions when "the paradigm of education is changing, when there is a transition from the reproductive, authoritarian education to the formation of an innovative personally oriented type, the special structure of psycho-pedagogical, methodological and informational-technical preparation should be a subject to transformation" *(Kremen, 2009, p. 413).* The technology of implementing interdisciplinary links in higher pedagogical education enables the process of teaching future teachers to be effective.

The efficiency of this educational process lies in the fact that interdisciplinary links make it possible to identify relevant theoretical information in the area of pedagogical knowledge, and unnecessary information remains beyond the educational process. That is, the resources of a teacher and students are not allocated on the analysis and study of superfluous (obsolete, secondary) information, and the subject-subject interaction in general obeys the predicted educational outcome. The technology of the implementation of interdisciplinary links in higher pedagogical education makes it possible to work with key phenomena and laws, progressive forms and means of learning. In this way, the theory, which, according to I. Rau, "does not directly teach," but its knowledge should be used for the knowledge of reality *(Rau, 1985, p. 119).*

We find that in this context, the materials provided in the publication *Interdisciplinary Learning, 2012* are important; they analyze Scottish education that is undergoing significant and important changes: in the process of interdisciplinary education, links are used between different themes and / or disciplines to improve the education level, interdisciplinary training is the key to the effectiveness of education that meets the needs of students / pupils, effective interdisciplinary learning is always based on several general ideas concerning the multidisciplinary elements of curricula in several disciplines (knowledge sectors). Interdisciplinary training provides a stimulating and self-motivating context for learning and improves the integrity of understanding important educational (pedagogical) ideas, enhances competence in applying knowledge and skills of transferring knowledge from teacher to students; interdisciplinary training is effective when it is supported by an adequate self-assessment of the subjects of the educational process, and their cooperation forms teamwork where this very style leads to an effective dialogue that is the basis of development for all spheres of human activity.

Psychologists *theoretically proved and experimentally confirmed* that thinking is systemic by its nature and develops if system-forming links are present. The principle of systemicity in the work of the brain is common to the physiological and psychological processes; all mental functions are based on associative bonds and, in fact, the system of knowledge is formed on this basis.

At the level of intra-system associations, mental activity covers a range of knowledge of the subject and form internal subject links that combine the content of the course into the system. Activity at the level of inter-system associations is the highest degree of association. On the basis of the achievements of psychology, we note that inter-system associations become of paramount importance in the formation of the human mind. The associative nature of thinking defines (determines) the understanding of the process of learning knowledge only in close connection with their application, resulting in the formation of a complex system of associations that reflect the connection between objects and phenomena of reality. The formation of systemic knowledge affects the worldview, promotes the transformation of knowledge into beliefs.

System knowledge gained in the process of implementing interdisciplinary links not only encourages subjects to go beyond the typical content but also develops their critical thinking, creativity, communication skills; however, it is much more important that in the implementation of interdisciplinary links, learning satisfaction is ensured *(Benefits of Interdisciplinary Teaching and Learning).*

Hence, the methodology of teaching at a higher school should answer a series of interrelated questions: "How to form knowledge on the basis of various information in a rigorous and harmonious scientific system?", "How to teach quick and creative use of knowledge to expand, deepen and acquire new knowledge and solve various applied problems?", "How and in what way to solve the exact tasks, to establish the relations of the subject under study with other subjects and types of study?", "In what way is it the most efficient to apply knowledge from different x objects (subjects) in professional activity?" and so on.

Even in the content of these formulated questions, there is a definite (albeit curtailed) program of studying the knowledge system. On the other hand, we can admit the didactic approach to the fact that the problem of interdisciplinary connections is associated with a wide range of issues of gaining the new knowledge necessary for creative solution of various applied professional tasks. The current development of science is featured by a significant and rapid accumulation of information, and therefore, the higher school has to fulfill a very difficult task of selecting the most essential (basic) sciences, those very issues which constitute a system of orderly fundamental knowledge. Though the tendency for fundamentalization of knowledge in higher education arose long ago, it has not acquired a sufficient theoretical substantiation. Therefore, it is noteworthy to discuss the need to study the outlined problem.

In each particular branch and system of knowledge, in general, *a system of scientific knowledge* is characterized by a sufficient logical rigor, the mutual ordering of components. However, in the process of development of scientific knowledge, a number of theoretical positions, concepts, methods began to be operated by the relatively independent branches of science that were "adapting" these provisions, concepts, methods, etc for themselves. The further synthesis of these achievements should not be perceived as an artificial phenomenon; this is a result of a logical one, because in such a way, they are perfected; general principles, rules, methods are crystallized; common concepts are developed, which helps to systematize scientific knowledge, to deepen comprehension of the essence of various processes and phenomena, to find the best ways to use scientific knowledge in a practical plane.

The systemic nature of vocational and pedagogical knowledge also points to the need for interdisciplinary synthesis of knowledge. On the other hand, every academic discipline studied at an higher educational establishment has its own special subject of study and presents a special system of knowledge with a specific system of concepts, around which the facts are grouped. Students need to master the concepts, necessary skills and abilities within this knowledge system (system of philosophical knowledge, system of psychological knowledge, system of pedagogical knowledge, system of historical knowledge, system of knowledge on the subjects that are profiling in the department, etc.). Thus, for the fundamentalization of the content of vocational and pedagogical knowledge, a consistent reflection of the interpenetration of philosophical, historical, economic, psychological, pedagogical, methodological disciplines, subjects that are profiling in the department, etc. ensuring a broad outlook of a specialist, their professional competence are necessary. It is noteworthy to establish connections between the sciences of the same industry, different branches of knowledge.

In this regard, particular attention should be paid to interdisciplinary connections and the definition of their functions in the process of fundamentalizing the content of education.

At the same time, among the main areas of international education quality monitoring *(Spear, Mocker, 1984) problem solving competence* is characterized as an ability to apply cognitive skills that positively affects the identification, analysis, optimization of the processes of occurrence and implementation of interdisciplinary problems.

An analysis of the content of curricula, textbooks, and manuals on a number of disciplines made it possible to find out that the study of philosophy, political science, sociology, economic theories, psychology, pedagogy and teaching methods of a particular discipline provides constructive opportunities for the formation of the future professional system of vocational and pedagogical knowledge, oppportunities for mastering the methods of cognition, which prompts for a scientific understanding of the tasks of pedagogy, problems of education and upbringing of the younger generation, understanding the state education policy.

As a result of the analysis and comparison of the contents of the curriculum, sections, topics and separate questions that were adjacent to the indicated disciplines were identified. It allowed determining the content of interdisciplinary knowledge. Under such we consider knowledge; prior to the process of interdisciplinary synthesis (integration of the constituent elements (components), it belongs to different educational disciplines, and as a result of this synthesis (through the implementation of interpersonal relations) acquire in the minds of students integral integrative reflection. We adhere to this very point of view.

For example, for a number of subjects, the topic "Personality and processes of its formation" is contiguous. It is clear that in each discipline, the topic is revealed from certain positions, but knowledge of a future teacher must be integrated.

In pedagogy, the main factors influencing human development are considered. In philosophy, the following ones are given: "The concept of development, its relationship with the concepts of motion and change. Features of development in nature and society. Natural environment as a constant and necessary condition for the existence and development of society, etc.".

In the course of psychology, they comprise "...Man as a natural and social being. The concept of an individual... The concept of a personality", etc.

In the courses of political science, sociology and other social sciences, one way or another, issues that relate to this topic are raised.

In the course of pedagogy, consideration of such an important factor in the formation of personality as a social environment requires a philosophical reflection and understanding of the relationship between personality, social environment and the dialectics of the processes of their development. The depth of knowledge on this topic is also dependent on the quality of knowledge in psychology, which addresses the issues of the structure of an individual and the psychological mechanisms affecting it. At the same time, even more systematization and deepening of knowledge contributes to the consideration of the issues of the relationship between individuals and society, the role of education in pedagogy and sociology. Data obtained by the analysis of curricula and

manuals on specified disciplines allows to establish interdisciplinary knowledge, namely: "The natural and the social in human development. Personality. Individual. Personality as a product of socio-historical development. The social essence of a man. Ratio of parenting and development".

When studying the topic "The essence of the learning process", future teachers require knowledge of philosophy and psychology. In philosophy, the question of teaching as a process of cognition is considered. In psychology, the cognitive processes of a personality are revealed: perception, memory, thinking, imagination. The needs of pedagogical practice require students to comprehend and learn the following concepts: education, educational activity, content of discipline, thinking and knowledge, types of thinking, mental operations, techniques of mental activity, peculiarities of thinking of children of different age groups, and that learning achieves the developmental effect under the purposeful management of cognitive activity of students only. Development is closely linked to qualitative changes in mental activity, which is expressed not only in the accumulation of knowledge, skills, in the formation of skills, but also in the change and the emergence of new psychological properties (for example, in the formation of cognitive interests, in the activation of mental processes, etc.) In many cases, by the way, it is difficult to identify interdisciplinary knowledge, or it is even impossible, because there is a mismatch between the curriculum itself.

Analysis of training manuals for these disciplines provided similar results. It is evident that the content of manuals on various disciplines reflects the logic of a particular science. Being the specialists in a certain area, the authors sought to make them suitable for a wide range of professionals, which is fully justified. However, the analysis of textbooks on pedagogy, some textbooks and teaching aids on the methodology of teaching certain disciplines showed that in their content there is a problem of interdisciplinary connections, which has not received a sufficiently complete reflection yet so that these links are revealed at the level of individual examples illustrating those or other theoretical positions from other sciences. In fact, the artificial reduction of pedagogical knowledge to certain positions of other sciences is ensured. At the same time, it would be totally unfair to assert that there are no preconditions for the implementation of interdisciplinary links in the educational process in the curricula, manuals and textbooks. The task is to ensure that these objective prerequisites are most reflected in the content and methodology of studying at universities.

Analysis of curricula, manuals, and textbooks allowed revealing a number of concepts and a range of issues that are interdisciplinary in their essence. Thus, in the section "General Fundamentals of Pedagogy" they include: the subject and methodology of science, methods of research (theoretical analysis and synthesis, content, formalized research methods), laws, regularities, principles, process, development, formation, education, purpose, personality, individual, society, social relations, social environment, natural and social in the development of a personality, driving forces of education and upbringing, conditions, factors, education, self-education, outlook, career guidance, diagnosis, correction, forecasting, etc.In the section "Didactics", such concepts include a system, structure, element, form and content, age and individual characteristics of a person, knowledge, teaching as a process of cognition, psycholo-

gical properties of a person, sensation, perception, memory, attention, thinking, cognitive activity, mental ability, knowledge, skills, abilities, motivation of training, receptions of mental activity, management of cognitive activity, enhancing of cognitive activity, assimilation, educational problems, problem situation, direct and reverse interoperability, algorithm, test, information, dose of information, etc.

In the section "Theory of education", these notions are mental, labor, aesthetic, ethical, physical education, objective and subjective factors of education, form and content, the system of education, the group of people, development of an individual in a team, team structure, team activity, self-government, public body, public association, social movement, etc.

It cannot be argued that the abovementioned issues encompass all the content of interdisciplinary knowledge in the course of pedagogy. It should be notified that the development of sciences, the change in their content inevitably leads to a change in the interconnections between them, their mutual enrichment takes place, the tendency to increase knowledge and, consequently, to increase the volume of interdisciplinary knowledge. According to O. Abdullina, the content of training the students of a higher educational establishment should interconnect, coordinate, and balance the general (the core), the special (specificity of the faculty) and the individual (the differentiation and individualization of education and upbringing). The structure of the general nucleus is to a greater extent an invariant component such as knowledge of the laws, principles, methods of teaching and education, ways of organizing the educational process, as well as knowledge of a child as an object and subject of this process. The second (variational) component of the content of pedagogical training is optional courses, special courses, which take into account the peculiarities of future professional activities. The third component of the training of future teachers is self-study in the area the students are interested in; it is aimed at the development of individual cognitive and creative abilities that forms an individual style and approach to future professional activities *(Abdullina, OA (1990, p. 28).*

Taking into consideration the above-mentioned issues, it should be stated that the availability of educational disciplines in related subjects, issues, general concepts involves the need to identify objective prerequisites for the use of interdisciplinary links in the learning process, which will enable them to solve a number of urgent issues, which are related to the formation of the system of students' professional knowledge, namely:

- enhancing the professionalization of academic disciplines by selecting the content of educational material that is the basis for the acquisition of professional knowledge;
- eliminating unnecessary duplication of material, which may reduce the amount of time allocated to studying a particular section, and increase of the amount of information on a certain discipline;
- specification of tasks for students' self-study; since it is possible to determine the amount of information on a particular related discipline, there is an opportunity to establish in which scientific discipline it is more expedient to cover the issue more in depth, and in which it is possible to limit references to the previously studied material or to consider it from certain positions;

- students' awareness of the links between disciplines and facilitating the process of generalizing knowledge and expanding the scope of their application on this basis.

In the content of the educational material there are objective prerequisites for the development of cognitive interests; the full right to them can be attributed to the professionalization of disciplines, taught in universities.

From our point of view, first of all, professionalization of educational disciplines lies in defining subjects and selecting the content of lectures, workshops and practical classes. Following many researchers we take an orientation towards the formation of the following students' knowledge as a main criterion:

1) knowledge that constitutes theoretical basis for students to comprehend the ideas, concepts and theories of pedagogy;
2) knowledge that is directly applicable in the educational process;
3) knowledge and skills contributing to improving the methodological training of teachers.

This will be only possible by the implementation of interdisciplinary links. Thus, during the compilation and updating of curriculum for the subjects that are profiling in the department, we should take into account the content of the school subjects (direct connection with the teaching method of the subject). When students master the methods of scientific research, it is necessary to reveal the possibilities of their application in school practice, and so on. Establishment of interdisciplinary links will allow considering various pedagogical processes and phenomena in the interconnection and interdependence, unity and contradictory factors influencing them, as well as to differentiate and synthesize knowledge.

To a certain extent, a variety of forms, methods and means of learning intensifies students' cognitive activity and promotes increased interest in learning. An effective means of activation, which is very important in learning, are questions and tasks that can be informational and problematic. Even the most difficult issue is not always an active mental activity. To a large extent, this is facilitated by problem issues and challenges. Problem solving, creating problematic situations that cause intellectual difficulties to the student, stimulate their cognitive interest and create internal psychological conditions for the active learning of new knowledge, has its own peculiarities in a particular case. The problematic issue, the challenging task includes a problem that remains to be uncovered by a student, the area of the unknown, new knowledge, which requires a certain intellectual action, which is a deliberate intellectual process associated with the establishment of new relationships. The issue goes into the category of problems under the following conditions:

A) it must be complicated in such a way as to cause difficulties for students, and at the same time suitable for finding an answer on their own;
B) there should be a logical connection with already acquired knowledge;
C) it should contain a cognitive difficulty and visible limits of the known and the unknown;
D) a challenging issue should cause a sense of surprise when comparing new issues with the already known ones, dissatisfaction with the available storage of knowledge.

In our opinion, the materials of the Conference "Insights on Interdisciplinary Teaching and Learning" (Michigan State University, May 2012) are interesting and useful *(Augsburg, Bekken, Hovland, Klein, Luckie, Madison, Martin, et Al, 2013).* Based on the published results of the attendees of this conference, we formulated the main statements related to our problem: a) the specific disciplines are not ideally suited for interdisciplinary purposes, and interdisciplinary connections should be considered from the point of view of potential synergy and feedback between disciplinary and interdisciplinary training *(by Barbara Bekken and Marci Sortor);* interdisciplinarity manifests itself in a wide range of contexts, leads to radical transformations and changes in strategies, starting with improving comprehensive education; an educational mission should be considered through the prism of the interdisciplinary core of educational programs, and the solution to interdisciplinary problems will increase interdisciplinary capabilities *(by Julie T. Klein and Paula J. S. Martin)*; education should aim at developing a habit of developing interpersonal skills on a multidisciplinary basis that promotes knowledge integrity *(by William H. Newell and Douglas B. Luckie)*; The distinction between interdisciplinarity and integration must be clearly distinguished; the concept of integrated learning is a wider and more general term used for structures, strategies and activities characteristic of secondary schools, colleges, comprehensive education; integrated learning contributes to discipline and interdisciplinary communication *(by Bernard Madison and Tanya Augsburg);* the practice of learning should go beyond the disciplinary boundaries, which will enable a new and a creative approach to solving complex interdisciplinary problems *(by Aaron M. McCright);* the implementation of interdisciplinarity facilitates the application of knowledge in the context of real-world problems *(by Kevin Hovland and Richard Vaz).*

Another didactic aspect of the implementation of interdisciplinary links is the use of problem situations. Together with students, a teacher considers different pedagogical situations, mostly real-life ones. Modeling a challenging situation, students apply the knowledge acquired in general pedagogy, psychology, sociology, physiology and, of course, didactics. The most unexpected pedagogical situations will occur in the path of a teacher's set. The pedagogical skills and skillful use of the acquired interdisciplinary knowledge will help to solve them.

Creating problem situations and attracting students to active cognitive activity enable to reflect such a characteristic feature of modern scientific knowledge as the process of integration of different sciences and to promote the research aspects of various disciplines in the learning process, model their future professional activity. Such tasks require applying knowledge from different subjects, while the activity is directed at finding new unknown relationships, or the formation of generalized concepts based on specific interdisciplinary connections that determine the need for a broad transfer of knowledge. Transfer actions are transformed into interdisciplinary cognitive skills.

In the educational process, implementation of interdisciplinary connections (polyfunctionality) affects ideological orientation, mastering the methods of cognition, the formation of a professional type of thinking and its methodological culture. Students' awareness of the links between scientific disciplines,

their understanding of practical significance contributes to the activation of mental activity, the formation of cognitive needs and leads to the need for the further deepening of knowledge.

Based on this discussion, we can state that the solution of problem situations in the process of students' learning, involving students in active cognitive activity reveals relevant interdisciplinary links that enable to reflect such a characteristic feature of modern scientific knowledge as the integration process in learning different sciences and to promote the research aspect in the study of certain subjects, to model their future professional activities. Such tasks require applying knowledge from different disciplines, while the activity is directed at finding new unknown relationships, or the formation of generalized concepts based on specific interdisciplinary links that determine the need for a broad transfer of knowledge. Transfer actions are transformed into interdisciplinary cognitive skills. The students' ability to interdisciplinary generalizations characterizes the productivity of their cognitive activity, which ultimately leads to the formation of a knowledge system.

The analysis of scientific publications and practice of teaching subjects in the pedagogical university shows that it is possible to highlight the technology of Portfolio among the training technologies for the implementation of interdisciplinary links. In accordance with the tasks of a teacher, a student selects the works created at various lessons. Selection is carried out from several disciplines (for example, psychology, didactics, and methodology of educational work). Under these conditions, opportunities are created for the implementation of interdisciplinary connections, the use of knowledge of related disciplines. Portfolio may include all completed work for a certain period, namely, a term or an academic year. Portfolio can be presented at the final lesson, when passing the attestation modular control in order to demonstrate the ability to apply new knowledge of the subject in applied areas of activity.

Problem situations technologies and Portfolio can be effectively used in selective academic disciplines, which are usually taught in the form of special training courses in order to enhance general, fundamental and professional (theoretical and practical) training. One of such courses may be the interdisciplinary course "Humanities". Pedagogy is a science that studies human being. Consequently, it is necessary that the future teacher mastered the universal knowledge, because active creative pedagogical practice requires the teacher to apply knowledge in various branches of science.

Conclusions

Implementation of multifunctional interdisciplinary connections in the educational process affects ideological orientation, mastery of the dialectical method of cognition, the formation of a professional type of thinking and its methodological culture. Students' awareness of the links between scientific disciplines, their understanding of practical significance contributes to the activation of mental activity, the formation of cognitive needs and leads to the need for further deepening of knowledge.

Interdisciplinary links provide for the enhancement of the professionalization of educational disciplines through the selection of content (material), the

mastery of the dialectical method of cognition, generalized methods of cognitive activity, the formation of the ability to transfer knowledge in new situations, thus acting as a condition for the reader's readiness for the creative application of knowledge.

As it was discussed above, establishing links between subjects is the most important condition for the formation of systemic knowledge, as in the process of their study, inter-system associations are created, and even individual concepts can serve as their source. Inclusion in the content of lectures, workshops and other forms of academic lessons of the material, revealing the links between disciplines, becomes an urgent necessity. However, we should not include separate facts for illustrating certain provisions, but information in their interrelations. Effectively, those relationships will be established between phenomena, facts, concepts, and theories that are common to these disciplines.

The similarities between pedagogy and methodology of teaching a subject are well-known. We are going to consider this provision more specifically.

Methodology of teaching a subject is a pedagogical science, and its fruitful development is possible on the general pedagogical and especially on the didactic basis. The lack of a close relationship between methodology and didactics depletes in general both the one and another science. Scientific disciplines, relations between which are considered, have their own subjects and investigate certain areas of reality. If in general, a subject of didactics is the content and organization of the learning process leading to the mastery of this content, the subject of the method is the social process of teaching the younger generation the basics of science. In general, didactics reveals the patterns of education and training, the method reveals the peculiarity of teaching a particular subject. Consequently, the commonality of these disciplines lies primarily in the fact that they have the same object of research. At the same time, in contrast to the methodology, specifics of didactics is the fact that it takes into account the logic of the science itself, develops the optimal directions of teaching the fundamentals of this science.

At the present stage of development of higher pedagogical education, implementation of interdisciplinary relations is one of the most important problems. It is possible to solve this problem comprehensively, provided modernization and upgrading of the education system, updating of educational standards and curricula, the creation of interdisciplinary training plans and the corresponding variational content, etc. In such circumstances, the personality of a teacher will play a very important role, since it is entrusted with responsible tasks for improving the educational process, increasing its efficiency and quality. A modern teacher of a higher educational institution should ensure the most efficient use of academic time, scientific and consistent presentation of the content of discipline so that students can not only perceive, comprehend and analyze pedagogical phenomena and facts, but could make pedagogically appropriate conclusions and act in any situation adequately.

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Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 59–70

Citizenship education as basis of educational work in modern PR China

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Abstract. In modern world through education children and adults are supposed to learn how to be active and effective citizens. Citizenship education is about enabling people to make their own decisions and to take responsibility for their own lives and communities. Educators all over the world supporting the idea of directed and controlled citizenship education as the new area of education use as an argument that citizenship education is an ideal tool for exploring national and human values. China throughout centuries made a complex original system of educational activity which always aimed to make a Citizen of China and a Chinese from a human being. In different historical periods this process belonged to sphere of ethics, state service, philosophy, education etc.
The aim of this article is to represent the experiences of China as to organization of citizenship education and its dominant position in the whole educational system of the country today. Modern China is one of 15 countries of the worlds where citizenship education (in forms of political and patriotic education) is an official part and subject of the state educational program.

Keywords: P.R.China, citizenship education, patriotic education, political education, deliberated citizenship, directed education

Introduction

A child is born just as a human being. At the time of birth, he\she is only a candidate to become a person. He\she cannot become a person and a personality in isolation: it needs to be learned how to become a person and a personality. It is the society that introduces him\her to the world of people; it regulates and fills its behavior with social content. In other words, a child is born as a human, but he\she is not born a person, but becomes it. A man acts as a person when he\she becomes able to make independent decisions and take responsibility for them to society, he\she is a relatively autonomous, free and independent subject of activity that is responsible for decisions and actions made, as well as for the community where he\she lives and feels as a part of it. Nowadays the processes have place in modern world need active, informed and responsible citizens; citizens who are willing and able to take responsibility for themselves and their communities and contribute to the state and worldwide process as well.

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In 2002 the UK officially became the first country in the world to introduce Citizenship education as a statutory subject in the National Curriculum, following the recommendations of the Crick Report of 1998. By now already 15 countries of the world have this subject as a part of educational programs to get people ready to live in the society (among them are Poland, France, China, Norway etc.) (Kalashnyk, 2017). But in fact the Chinese educational system can be seen as the first one to make citizenship education as the method and aim of educational work. In any historical period in this country education in all it forms (socialization, social education, formal and informal education, postponing knowledge by the means of schooling, training etc.) aimed to make a person to be a patriot of China, a worthy member of local community, a part of the society whose physical and moral qualities fit the general idea and social requirements of the Chinese state. In other words citizenship education was and is basis of educational work in China.

Theoretical framework

Terminological issues

In different historical periods the process of making a human child to become a Chinese whose aim of being was serving the state belonged to different spheres of ethics, state service, philosophy, education etc. That's why in Chinese pedagogical literature there are several terms for this educational process which can be used in parallel. The most common parallel used twoes are "citizenship education" and "patriotic education". In "Xi han jiaoxue cidian" (*Xihan pedagogical dictionary*, 1988) the term "patriotic education" and the term "citizenship education" presented at "Zhongguo zhongxue jiaoxue baike quanshu" (*Encyclopedia on Chinese Middle School education*, 2015) have the same definition as to the general idea and aims of this kind of education.

This phenomenon also can be explained in one hand by the specifics of the Chinese language and characters used for depicting the words "patriotism" (爱国 — loving the state/country) and "citizenship" (国籍 — being a part of the state/country). In the other hand it can be explained by the tradition of the Chinese society to have all the spheres of a person's life to be regulated by the state through ideology, religion, local community, educational system, traditions etc. According to the Chinese state ideology in any time of Chinese society's development a Chinese had a strict set of duties and rules for him \her to follow and fulfill. The state regulated and appreciated only the social deeds of a person and in time the characteristics, ideas, likes and dislikes of a person himself lost their value. A person became be charged and seen by his fitting or not the social ideal regulated by the state. That's why at a certain period social and personal parts of life of a Chinese became spliced and traditional for other cultures personal feeling of patriotism became a social requirement and "obligatory to be produced set of rituals" in China.

Citizenship education of young people is also considered in China as the introduction of the new generation into the system of values of the Chinese democratic (civil) society, that envisages the formation of the foundations of its civic culture (Liu, 2014). Civic culture is a deep awareness of a person of

his / her belonging to a certain state, a sense of civil dignity, social responsibility, and the ability to defend social and state interests in difficult situations. The defining characteristics of civil culture are: patriotism, legal consciousness, political education, morality, and labor activity (Liu, 2010). The term "civic culture" in the Chinese professional literature is also not widely used, but can be seen in the researches which are translated from other languages or are made together with the abroad scientists.

Also in modern pedagogical literature of China the term "citizenship education" is not commonly used. More often they use traditional for the Chinese science term "patriotic education" if it concerns history, culture, economics, ecology and other humanitarian spheres of life and the term "civil education" or "political education" if it turns to law or politics.

Historical and social issues

The tradition of loving own country, awareness of its exclusivity are inherent in Chinese society for a long time. The great merit in this field belongs to the Chinese state authorities. For example, back in the Qin Dynasty (221-207 BC), the territories that surround China, were officially declared to be unfit for life due to the lack of oxygen there and the settling of bizarre creatures that are not related to the human beings. And it was the Qin Dynasty to begin the construction of Great Wall to separate China from the rest of the world. Throughout history, love for the Motherland, the Emperor as the personification of the State, father as the personification of the Emperor was considered to be the greatest virtue in the Chinese society.

The ancient Chinese philosopher and thinker Confucius (551-479 BC) created a system of ethical norms and rules that include: honesty, modesty, thrift, loyalty to duty, humanity and charity, respect for parents and elders, rejection of denunciations, striving for compromise, stability, order and discipline. As for respect and veneration ruling class, the thinker made it necessary if the representatives of the upper class are honest with the Emperor and follow their duties as to the state. Confucius considered education and moral self-improvement of a person to be an essential factor of human existence, a condition for the prosperity of the entire nation and country (he did not share these concepts). Confucius tried to raise a new type of a person who could eventually turn into a "perfect person" or "noble man" — a person with high moral qualities, educated and brought up within the spirit of observing rituals and devotion to the country. It was during the period of active Confucianism as a state ethical-political doctrine that under the Emperor was made a state "Committee on Morals and Ethics". This Committee even had the right to remove the emperor from the throne if it recognizes that his actions are "harmful for China". For the sake of justice, however, it should be noted that for almost 600 years of such a body's existence the Committee has never used the given right (Maliavin, 2000).

The task of elaborating a clear concept of patriotic / citizenship education came to the forefront of the PRC in the very first years of its existence. General impoverishment of the state and nation, political turmoil, invasion of foreign troops, civil war, faced China with general apathy. In such a situation

the government under the leadership of Mao Zedong also needed to solve the problem of the economic development of the county which could have guaranteed the very existence of the country and the state. The problem was solved thanks to the program of citizenship / patriotic education, which became the basis of the "Big Leap Policy" (an assessment of its economic, cultural and social consequences is not the task of the article). The patriotic / citizenship concept of that period resulted in introduction to the Constitution of the PR China of the statement that "every Chinese, firstly and foremost, should be a worthy citizen of the PR China, contribute to its development and be the creator of its achievements" (Article 4) (*Constitution of the People 's Republic of China*, 2014).

Later on this Constitutional provision was expanded in Constitutional Fundamental Rights and Duties of Citizens of China; in particular:

1) Citizens of the People's Republic of China have the right as well as the duty to work. Work is the glorious duty of every able-bodied citizen (Article 42);
2) The exercise by citizens of the People's Republic of China of their freedoms and rights may not infringe upon the interests of the state, of society and of the collective (Article 51);
3) It is the duty of citizens of the People's Republic of China to safeguard the unity of the country and the unity of all its nationalities (Article 52);
4) Citizens of the People's Republic of China must abide by the constitution and the law, keep state secrets, protect public property and observe labor discipline and public order and respect social ethics (Article 53);
5) It is the duty of citizens of the People's Republic of China to safeguard the security, honor and interests of the motherland; they must not commit acts detrimental to the security, honor and interests of the motherland. (Article 54);
6) It is the duty of citizens of the People's Republic of China to pay taxes in accordance with the law. (Article 56) (*Constitution of the People 's Republic of China*, 2014).

It is also worth noting that the social orientation of the Chinese economic reforms is also of a civil character (buying Chinese, traveling in China, promoting Chinese goods etc.) ensures their success: makes each Chinese an active supporter and participant of the process having place. The educational policy of the Chinese state also contributes to the effectiveness of the work over the coordinated feeling of citizenship by all means cultivated in the Chinese nation. The very purpose of this policy is understandable and close to all segments of the Chinese population, it addresses the patriotic / citizenship and national feelings of the Chinese in their desire to develop the country and revive its greatness.

Results

Citizenship education can be seen as the most important idea of Chinese pedagogical theory and educational practice. It is, to the greatest extent, based on the concept of "Chinacentrism" which was proclaimed by the Secretary-General of the CPC Central Committee Hu Yaobang in 1982 when he noted that "patriotism is the best tradition and highest moral quality of the Chinese nation, the main criterion for individuals, classes, parties, doctrines, theories and ideological trends" (Wu, 2000). In modern China, citizenship education solves very practical problems of nowadays Chinese nation as a union and forces people to follow such values as reunification of the Motherland (this aspect aims to reduce the level of hidden and overt sepretism in certain regions of the PRC, introduces the official state position towards Taiwan, adjoining and disputed territories), proves the ratio of "socialism with the Chinese tradition" as the political system, harmonizes it with the capitalist democracy trends of the West; forms the attitude of the Chinese towards the world, China, its leading position in the world, human rights etc.

In the middle of the XX century Chinese educational and pedagogical science adopted the Foremer Soviet Union's idea of 9 types of educational work (moral (ideological), labor, physical, patriotic citizenship, aesthetical, religious, legal, environmental and intellectual). At the same period the Chinese science itself (basising over the works of Mao Zedong, in particular, the article "How to educate people properly") from above mentioned nine types of education isolated four which were called "Great Four". The "The Great Four" forms the basis of Chinese educational theory till now and includes moral, labor, physical and patriotic / citizenship education with the leading role belongs to the patriotical / citizenship one. All the other kinds of educational work (the list of it was expanded since 1950s) in China are to be seen through the citizenship education and the idea of "Chinacentrizm". Table 1 shows some kinds of education and their tasks seen through prizma of citizenship education in China.

Today, the whole system of values, beliefs, world outlook of the Chinese people, as well as the social structure of the country is based on citizenship education. It also includes issues of the spiritual state of the Chinese nation. Using the experience of generations, the Chinese government plays a great role in the forming of conscious citizenship among the inhabitants of the country.

In China, patriotism and citizenship is seen as the basis and prerequisite for the normal and natural development of a child. Lou Shizhen (an expert over citizenship education, Beijing Normal University) mentions that citizenship education of a child should start from the family, which from the very first days should form a child's attitude towards the Motherland, people in order to eliminate negative behavior and promote a healthy lifestyle. This attitude should be positive, emotional and rational at the same time. The family should be fully aware of the content and means of citizenship education create a special family environment for the education of a new Chinese, taking into account age characteristics and needs of the child. It is also important to apply all situations and various sides of family life form conscious citizenship at every stage of a child's development. Lou Shizhen gives a number of recommendations on citizenship education for a family.

Type of educational activity	Task of the educational activity
Ecological Education	People are to take care of nature and avoid pollution because all the natural recourses belong to the state and polluting makes harm to the common proper of the Country
Religious Education	China is a multicultural nation and being a part of the culture religion and beliefs of other co-citizens are to respected if their beliefs and religious values do not pay harm to the Country and Chinese society
Labor Education	People are to work well and do as much as they can on their working place to have an opportunity to be useful for their country. Any work or labor is appreciated by the Country.
Health Education	People are to take care of their health because they are to work well. Any person in China is seen as property of the Country and that's why not taking care of health is seen as making harm to the common property of the State.
Physical / Sport education	The Chinese are to go in for sports because they are to be healthy workers and sports achievements make good image of the Country.
Aesthetical Education	Chinese material and non-material culture heritage makes an integral part of world cultural heritage. A lot of traditional Chinese cultural achievements are unique and cannot be seen elsewhere but China. That's why from year to year more and more foreigners come to China.
Hygienic Education	People are to take care of their hygiene because it is a part of your health education and today a low level of hygiene in some parts of China makes harm to the image of the country in general.
Sexual Education	People are to be well educated in sexual sphere, be responsible for their sexual relationships, adhere the idea of responsible parentship because in one hand it is a part of the health program of the Country and in the other not controlled childbirth pays harm to the economics and social sphere of China as a state.
Mental education	People of China re to study well and adhere the idea of life-long education because economics of China needs well-qualified workers for the state to be one of the economical leaders of the world.

Table 1. Task of the educational activity through prizma of citizenship education in China

According to them, parents should:

1) understand what is "patriotism" and "citizenship";
2) pay attention to their own moral attitudes, determine the meaning and direction of personal citizenship development;
3) understand the importance of citizenship education and produce it their everyday life focusing the child over this particular issue;
4) pay attention to forming and development of patriotic and citizenship emotions in the child;
5) direct the child to show citizenship in day-by-day life;
6) give children a personal example of citizenship and patriotism;
7) use different motivations to educate the child with proper citizenship position (Ouyang, 2011).

In the educational institutions of the PRC, spirituality, citizenship and morality are proclaimed as the fundamental basis of education. It is believed that society as a social union of people can function and develop only with directed, systematic and organized educational work over each individual. Today, the Chinese society and educational institutions face the task of developing the personality as a conscious citizen, who combines the universal values with the specific features of the Chinese nation (Dzhgun, 2012).

Systematic citizenship education in modern China starts with a kindergarten through ethical conversations with children, in the process of playing and learning of Chinese language, in the course of general elementary knowledge, aesthetical education and physical culture. In elementary school, a special subject is studied - moral and ideological education; in the middle - - political and ideological education. In high school "Politics" is an obligatory course for all the students (Boyenko, 2006).

For the needs of moral, ideological and political education the Chinese educational system uses singing and music lessons. The State Education Committee of the People's Republic of China recommends about 100 different songs and musical works to be learnt at primary and secondary schools, including: National Anthem, Songs About Motherland, "Without the Communist Party, there is no China", "In union we are strong", etc. The Department of Moral Education of the State Committee for Education of the People's Republic of China published and recommended for use by all schools of the country a teaching manual entitled "The ceremony of raising the national flag - moral and patriotic / citizenship education" (Boyenko, 2006). All the methods mentioned aim to implement the strategic task to educate the Chinese youth according to the state order, in particular - to focus all the educational tools to form at the students the citizenship spirit.

In the primary school, the patriotic / citizenship education is carried out in the spirit of "five points of love: for Motherland, people, labor, science and socialism": It aims to acquire such students' qualities as patriotism, collectivism, sense of responsibility and duty, teach children to be organized and disciplined, to give necessary knowledge about the Chinese society, Constitution and the basic laws of the PR China; centers on studying of Chinese history, culture and traditions, as well as the history of the Chinese Revolution.

In secondary school, the content of citizenship education includes the following components: patriotic education, education in the spirit of collectivism, socialist education for socialist modernization and creating of socialism with the Chinese specifics, social morality and Chinese moral and ethical traditions, labor ethics, Chinese culture and traditions, labor education, religious education, hygienic education, socialist democracy and the foundations of legal education, basic rights and duties of a citizen, Constitution and other laws of the PR China, forming the habit and taste for work, being organized, reliable, truthful and honesty, following healthy lifestyle (Li, 2007).

In high school, the content of citizenship education has a more political and ideological character. It includes the following programs and courses:

1) patriotic education (revolutionary struggle of the Chinese people, unity of the Chinese people and the unity of the Chinese state);
2) education in the spirit of collectivism (Marxism-Leninism and modern citizenship education, Deng Xiaoping's theory of building socialism with the Chinese specifics, a course of knowledge on dialectical and historical materialism);
3) political education and traditional Chinese morals;
4) labor education (education for socially useful work and practical activities);
5) socialist democracy, legal education and education of a builder of a socialist society;
6) moral and psychological education (self-education and self-motivation; healthy lifestyle, psychological and physical health, family relationship education, sexual education, team and society, education of a sense of friendship and good attitude towards people).

If at secondary school, the compulsory subject "Politics" accounts for 8.5% of the school time released for compulsory subjects. At high school the time for this discipline goes up to 15 % (Luo, 2005).

The leading role in the implementation of the official state policy towards education (state order) to school belongs to teacher. As part of the professional training of teachers in China it was created a special program of citizenship education of teachers-to-be nowadays used in all the Normal (Pedagogical) universities of the country. Mainly it's issues are closely related politics and ideology and are as following:

1) theory of Marxism-Leninism, the ideas of Mao Zedong, Deng Xiaoping's theory of building socialism with Chinese specifics;
2) patriotic education, education of the Chinese spirit, Chinese traditions, Chinese history and culture;
3) domestic and foreign policies of the Communist Party of china and the state government of the PR China;
4) legislative system of China and socialist democracy, the development of discipline and responsibility;
5) general education of a person, ideals, forming of the social position and correct relationship with the other people;
6) socialist ethics, social and professional ethics;

7) development of the correct style of study, life and work, forming taste and need of self-education and self-improvement;
8) labor education;
9) aesthetic education on the basis of Chinese culture inheritages;
10) psychological, spiritual and physical health of a person (Lu, 2011).

Start September 2001, in China, the third Saturday of September is declared to be a national day of patriotic \citizenship and defense education as a part of citizenship education state concept. This decision was adopted at the 23rd session of the Standing Committee of the National Congress of the PR China according to Article 55 of the Constitution of the PR China "It is the sacred obligation of every citizen of the People's Republic of China to defend the motherland and resist aggression" (*Constitution of the People's Republic of China*, 2014). According to this article in April 2001 the National Congress of the People's Republic of China adopted the National Law of the PR China "On Patriotic / Citizenship and Military Education". Start then in the programs of primary and secondary schools in China, as well as of colleges and universities, there appeared the obligatory theoretical discipline "National Defense" that aims to develop national, patriotic / citizenship and defense thinking of students. Practical component of this subject contains different activities, that teach children and youths to take care of themselves in wild nature, get them acquainted with fauna and flora of their native region and China in general (special attention is paid to edible plants), give initial medical training courses, work in teams, follow the orders, help each other, cherish the national flag, be engaged in strategic planning process etc.

Discussion

Patriotism and a national idea are considered to be two main conceptual ideas of citizenship education in China today. Patriotism is seen as a set of practical actions and the sum of theoretical knowledge that leads to the formation of national consciousness and self-consciousness of the Chinese people. In practice, patriotism manifests itself as love for China, hope and faith in better future of the country, readiness for practical activities for the benefit of China and the Chinese people. The national idea is viewed as the orientation of the individual to the interests of the state and society, and the corresponding system of relations of the individual with others in the conditions of the state, the formation of the ideal of a progressive democratic, legal, social, state (*20 details about moral education in modern China*, 2007).

Citizenship reflects the world outlook and attitudes of a person as a citizen, focuses him / her on the identification of personal, civil, professional and family development. One of the most important tasks of citizenship education in China today is to provide young people with following practical skills: critical consciousness, ability to make conscious decisions, implementation of free choice, understanding and following of norms and rules of behavior, knowledge of laws, basic human rights, joint work for the benefit of society, personal social responsibility, mutual understanding and mutual respect for each individual, ethnic group, people and their cultures.

For recent 8–10 years the Chinese official educational science began to revive the Concept of Consciousness Patriotism / Citizenship which was quite

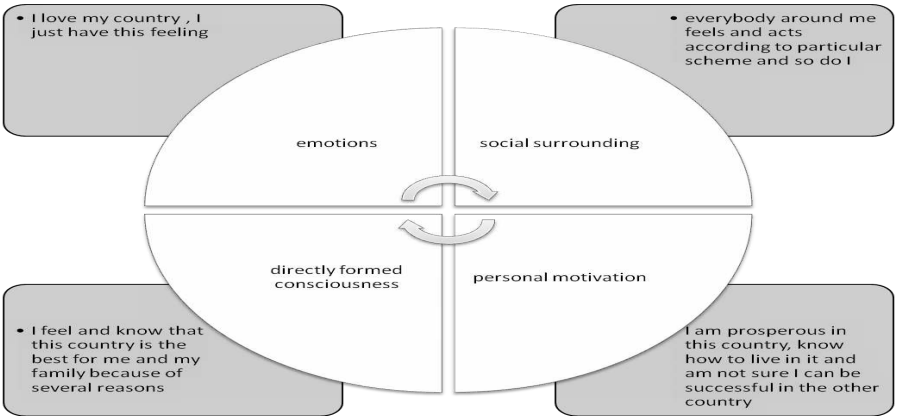

Figure 1. Types of citizenship motivators

popular in the Chinese historical genesis. Modern Chinese Pedagogical science following the Western trends also allocates 4 types of underground that force a person and make him / her to feel himself as a citizen of the country, a part of a particular social or national union. Figure 1 shows the types of undergrounds according to the Chinese contemporary pedagogical and sociological theory[1].

If the Western sociology and education science pays much attention to forming the emotional component of citizenship of a person, the Chinese focus their attention over the more practical ones, using "Social surrounding" as a method of citizenship education. And defining it as directed process, the Chinese traditionally delegate all the powers to the state and to the educational system as the state's authorized body. This phenomena also has the ideological and historical background and basis upon the requirement of Han Yu (philosopher, educator, state servant; 768–824) who obliged teachers to persuade theit students that China is the most progressive, economically developed and logically organized state using concrete examples, but not limiting to the classic postulate, that "behind the Great Wall there is no air and life is not possible there" (*History of the Chinese education*, 2001)

From a substantive point of view, the directed consciousness citizenship education of young people in Modern China is, first of all, "the formation of a national consciousness, the feeling of belonging to the native land, the people" (Pan, 2010). This process has two stages, which respectively indicate different levels of assimilation of national values. At the first stage, ethnic self-consciousness is realized on the basis of assimilation of the native language, family customs, traditions, national mythology, art; folklore, convictions, ideals, generally accepted norms of behavior and so on. At the second stage, social and patriotic self-consciousness is formed in the process of a person being included in practical activities directed on the development of the state, its ordering and strengthening; studying the history of China, its cultural heritage; introducing of various elements of Chinese culture into one's own life and world perception; establishing of friendly and partner relationship with representatives of other

[1]Western sociology quits "Directly formed consciousness" as a motivator for citizenship and uses "Philosophical motivators" to define the process of self-motivation of a person over some social issues

countries and nations, cultivating of the best features of the Chinese mentality and national character, developing of self-identity as the Chinese etc.

The Chinese Government assigns the school the most important role in this process and has prepared a whole package of documents specifying the peculiarities of forming the patriotic and citizenship consciousness of the Chinese youth: "The CPC Central Committee's resolution on work over moral and citizenship / patriotic education in primary and secondary schools", "The CPC Central Committee's resolution on the implementation of citizenship / patriotic education and strengthening work on moral education of schoolchildren", "The CPC Central Committee's resolution on citizenship / patriotic and political education of students and young workers" etc.

Conclusion

Citizenship education in China is based on modern principles of economic, democratic and information society, demands of the Chinese state taking into account the process of globalization of the world economy as well as the interests of the particular country. The task of citizenship education is defined as strengthening the collective spirit; forming the mass consciousness of the nation; assisting to rational, open, calm, confident authority of the state and state leaders; realizing the importance of collective work over the implementation of innovations; increasing the level of social responsibility of all citizens of the country. That's why following the historic and educational traditions of their own country the Chinese till now make the citizenship \patriotic education the main part and the task of the educational work in the country. All the other directions of the pedagogical influence over children, youth and just any citizen of China are to follow the "Chinacentrizm Concept" and go through the prism of citizenship education to check out their expediency, usefulness and simply vitality in Modern China's social and educational space.

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Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 71–87

Methodological aspects of exclusion and inclusion at the stage of entry into the issue of diversity

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Abstract. This article reflects the current understanding of the processes of exclusion and inclusion of the national higher school, the results of a sociological study of students' heterogeneous groups of Berdiansk State Pedagogical University in the framework of the joint European project "Initial and further education and training for educationalists and managers in education in the field of diversity", design of resources, conditions for teachers' training. Empirical data form the basis for the development of inclusive educational space a model of the University and the Strategic plan for the development of inclusive education in the region.

The conceptual idea of the study: in contrast to the traditional ideas prevalent in the national and foreign pedagogy, which limit the inclusive education only to the integration of persons with disabilities into the cultural and educational environment of an institution, we propose a vision of inclusive education as providing equal participation in the educational space of various heterogeneous groups: individuals with disabilities, gifted persons, migrants, socially vulnerable groups of population, representatives of national and religious communities, etc.

The research methodology involves the analysis of scientific literature, legislative and normative documents; sociological research; qualitative and quantitative processing of empirical data; modeling of inclusive educational space of a University.

Key words: exclusion, inclusion, diversity, inclusive educational space of a University, strategic plan for the development of inclusive education in a region.

Introduction

The relevance of study. Actual problems of modern higher school include problems resulting from socio-political, socio-economic processes, the emergence and escalation of inter-ethnic and international conflicts, problems of representatives of heterogeneous groups' integration.

Education, as an integral part and necessary condition of human life, is the most sensitive to the effects of globalization and modernization. Globali-

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zation nature of the world led to the merger of life and value meanings both of individuals and civilizations.

It is the civilizational dimension where problems of communication of various social groups and communities, including the problems of their coexistence in the educational space gain a special status. It is therefore important to understand the different processes and phenomena in a single continuum of the education system's functioning of objectively existing social, ideological, material, and psychological conditions influencing processes of identity formation and professional development. Global changes in the modern world reveal serious contradictions in all spheres of social life, strengthening mutual confrontation with global trends of integration and disintegration, unity and diversity. They appear quite clearly in the marginalized and socially unprotected groups of the population.

In the conditions of a globalized world the civilization, as well as its carriers must be protected from leveling and even disappearance. For this, the society has developed special protection mechanisms, primarily supporting the trends of localization and identification. In the context of identity formation there are two main ways of identifying it: protection, aimed at isolation from the influence of negative processes, and social design as an adaptation to new and quickly changing realities (Balcerowicz L., 2005).

The issues of social diversity, inclusion and tolerance have become extremely acute for different countries of the world; they touch the fundamental components of a human: health, labor, the intellectual and social capital. A special place among them belongs to education, as it is the appropriate level of education and culture that can provide self-affirmation and self-realization of personality, a decent job, successful socialization. One of the urgent problems of education in Ukraine with a complex structure of stratification is the development and improvement of the system of quality education provision at all levels for the population, including persons with disabilities, migrants, refugees, socially vulnerable groups, representatives of ethnic and religious minorities that has claimed the search of ways and resources for their solution, the development of international cooperation forms in this area.

The current situation requires the development and implementation of alternative models of the through education system, awareness of a diversity issue as a given one, as an important socio-political and educational issue which must be solved in a wider philosophical and pedagogical vision of inclusive education.

And as the answer to this question is the implementation of a joint European project TEMPUS-IV "Initial and further education and training for educationalists and managers in education in the field of diversity" (2013–2016), for realization of which 20 universities of Western and Eastern Europe were involved.

From the point of view of ideology of the project the concept of "inclusion" is interpreted much broader and beyond the scope of inclusive education in relation to persons with "disabilities" and is defined as "the process of seeking and responding to the needs' diversity of all learners through increasing participation in teaching, cultures, communities, and reducing *exclusivity* in their learning" (Певзнер М. Н., Петряков П. А., Ширин А. Г., 2014, с. 27).

Purpose of the study: to design inclusive educational space of a University and the Strategic plan for the development of inclusive education in the region based on the analysis of social nature of the exclusion phenomena and of inclusion in the context of diversity, generalization of sociological researches results of students' special educational needs, that is of different heterogeneous groups' representatives.

The research methodology involves the analysis of scientific literature, legislative and normative documents in the context of diversity, inclusive education, higher education; a sociological study of special educational needs of students — representatives of different heterogeneous groups; qualitative and quantitative processing of empirical data; modeling of inclusive educational space of a University.

1. Social exclusion and inclusion in the context of diversity: terminology field of study

A significant part of people in different periods of life is faced with physical, mechanical, social, psychological and other barriers that exclude them from social functioning. This phenomenon in the scientific lexicon is defined by the term "social exclusion" and is often used in relation to the process of marginalization, causes and consequences of access limitations to basic social institutions of society.

In scientific and political discourse social exclusion (lat. exclusio — exception) is the process of the social objects deprivation from the prestigious, socially-accepted values. The terms "social exclusion", "victims of exclusion" were introduced into scientific discussion in 1974 in France to refer to socially vulnerable layers of the population. Above all, mentally and physically dependent people, disabled people, single parents, orphans, deviants, maladaptive people, marginalized, and marginal persons were meant (Бородкин Ф., 2000, с. 5-16).

The analysis of scientific articles devoted to the problem allows allocating two basic approaches to the interpretation of the social exclusion concept:

1 French approach that focuses on social solidarity, integration (inclusion), which requires recognition and respect for the rights of all minorities, that do not violate the integrity of the community;

2 Anglo-Saxon approach, declaring individual freedom, equal rights for all citizens and is understood as a free choice both between individuals and between an individual and society (Колупаєва А. А., 2006, с. 39-45).

During the second half of the twentieth century, the term "social exclusion" was widely distributed in the Humanities in most European countries, encouraging the creation of a number of international documents, concepts: the European Social Charter (1965), the European Concept of Social Exclusion (1984). The European Parliament has also authorized special programs to combat social exclusion in Europe, with clearly defined conditions, because of which people are suffering exclusion. Among the priority factors of exclusion in

the European concept are: disadvantage in terms of education, skills, employment, housing, financial resources, etc. (Європейська політика і соціальне партнерство в ЄС, 2012).

In the context of modern concepts of alienation in education the social exclusion is understood as "diploma exclusion" which means the process of exclusion of children, teenagers and even adults from the education system and socially preferred forms of adaptation to life. A personality, marginalized or not included in the socio-cultural process of development and formation for a variety of reasons, feels the constriction, limitation in time, in procedural and communicative aspects (Шмидт В. Р., 2006).

We'd like to represent our own view about the relationship between social exclusion and educational space, representing the subjective-objective picture of social reality through abstract and formal requirements, norms that exist in social reality. In accordance with the classical definition of exclusion, society is a certain social space, in the center of which there are members of the society, forming a "mainstream" (confident, adaptable, recognized, outsiders). In the next concentric circle there are the ones who were discriminated for different reasons from the viewpoint of implementation of these rights (unconfident, inadaptable, not enjoying their rights or not knowing how to defend them). And finally, on the periphery of social space there are those who are the object of multiple discrimination (disadaptants, insiders, personalities excluded from social groups). In fact, it is this part of social space that will correspond to a state of social exclusion and falling out of the educational environment.

Teaching experience allows us to speak about the social exclusion situation in the student's environment when, for various reasons, there's no motivation for studies and acquisition of a profession, participation in student activities, extracurricular activities, volunteer movement, and where the missing classes multiply, etc. As common reasons for this situation is the mismatch between expectations and perceptions with the real picture of learning process, the misalignment of needs: the needs that are relevant to the student are not satisfied or they are not satisfied at all. An alternative to the situation of exclusion is inclusion in the new understanding as a modern and realistic way of solving this problem.

2. Sociological research in the framework of the project TEMPUS-IV

With the aim of identifying the priority needs of students-representatives of various heterogeneous groups and their satisfaction, minimization of the conditions, causes of social exclusion, exclusion from the educational space in the framework of joint European project TEMPUS-IV "Initial and further education and training for educationalists and managers in education in the field of diversity", the sociological study was conducted by the working team of the project in 2016.

The *aim* of the study was to obtain analytical information about the number of heterogeneous groups of students and their specific needs in the partner universities of the project to develop software and other educational resour-

ces in the field of preparation and further training of teachers and educational managers to work with heterogeneous groups and organizations.

Tasks of the study: 1) determination of the number of the following groups of students: young people — inophones (migrants), gifted young people (3 subgroups: intellectually gifted, artistically gifted and gifted in sports), young people — representatives of socially vulnerable groups, young people with disabilities (persons with disabilities); 2) development of diagnostic tools to determine the educational needs of special groups of students for the above mentioned heterogeneous groups: selection and justification of the parameters and indicators of the research, development of a tool for indicators' measuring; 3) collecting survey data, identifying the specific educational needs of the study subjects; 4) analysis and synthesis of the research results.

The main problem of the research was to investigate what features of the educational needs of students' special groups were, and to what extent the subjects of the educational process are oriented to satisfy these needs for inclusive education, appropriate services and conditions of education.

Research methods: collection of statistical data on the number of special groups of students, questionnaires, quantitative and qualitative analysis of the results.

Research tool — a specially designed questionnaire.

Subject of research: educational and social needs of students' special groups; ideas of students' special groups about opportunities to meet their educational needs (attitude to mutual learning, awareness about inclusive education, educational needs of students, social needs, types of possible educational support, organizational and pedagogical requirements, educational and methodological needs, logistics needs, expectations related to future education).

Let's reveal the results of the survey in Berdiansk State Pedagogical University (Ukraine), which was an official participant of the project TEMPUS-IV. The study included 860 students from different faculties, 486 of which were identified as representatives of the diagnosed heterogeneous groups. Quantitative analysis of the respondents is represented by the following types of samples: 40% — gifted young people; 27% — young people with disabilities; 22% — inophones; 11% — young people — representatives of socially vulnerable groups of the population.

The conducted analysis of the study results on the scales of needs' denominations of student youth confirms the diversity of the educational and social needs of students' different groups. The needs in recreation, in health preservation, in considering religious beliefs, maintaining relations with national culture, and overcoming the language barrier have the least preferences among the students. This choice is interpreted as a predictable and happy one.

The method of ranking the educational and social needs of students in heterogeneous groups let identify the following priority training needs and conduct the qualitative analysis: the need for pedagogical support in special learning environments, quality education, organizational and informational support. The priority social needs include: the need for social contact, approval, recognition, and social status.

The comparative analysis of the educational needs of heterogeneous groups has shown that the following groups need satisfaction in pedagogical support:

young people — representatives of socially vulnerable groups of the population (37%), gifted young people (23%), inophones (21%), young people with disabilities (19%). The category of gifted young people has the greatest need in special education (48%), it's followed after the degree of preference by young people — representatives of socially vulnerable groups of the population (19%), inophones (17%), young people with disabilities (16%). The following groups have a priority need to obtain a quality education: inophones (50%), gifted young people (22%) young people — representatives of socially vulnerable groups of the population (20%), young people with disabilities (8%). Organizational and informational support is needed by young people with disabilities (48%) young people — representatives of socially vulnerable groups of the population (34%), inophones (18%).

Thus, the priority educational needs among all respondents, as well as after the degree of importance of this need among the other needs' sets of this category of students is as follows: inophones — the need for quality education, talented young people — the priority is given to the need for special learning environments, for groups of young people-representatives of socially vulnerable groups and for those with disabilities among the priority educational needs is satisfaction of the need for pedagogical support.

A comparative analysis of the social needs of heterogeneous groups has shown that in the satisfaction of needs in social communication gifted young people are more in need (36%), later on after the degree of preference are inophones (29%) young people- representatives of socially vulnerable groups of the population (28%), young people with disabilities (7%). The approval and recognition is needed in the first place by gifted young people (60%), by young people-representatives of socially vulnerable groups of the population (38%) and by inophones (2%). Satisfaction of the need for social status is experienced by the representatives of the category of gifted young people (49%), young people with disabilities (24%) young people-representatives of socially vulnerable groups of the population (27%).

Thus, the matching, the comparison of empirical material obtained during the sociological research allowed to perform more precisely the preferences, values of heterogeneous groups representatives of Berdiansk State Pedagogical University, to test the research hypothesis and to make sure about the need to design and develop inclusive educational environment, the corporate culture of a heterogeneous community, intensify teachers' and educational managers' training to work with heterogeneous groups and organizations.

The results of the sociological research allow us to design inclusive educational environment of the University (on the example of Berdiansk State Pedagogical University), the strategic plan for the development of inclusive education in the region, the strategies for networking in territorial educational community, they are as well put in the basis for the development of educational modules, courses, oriented to the priority needs of these groups of student's community, suggesting the formation of a new pedagogical vision of the nature and organization of inclusive education to meet the current needs of pluralistic society.

3. The inclusive educational environment of the University

Modern life places special demands on the quality of educational services in a higher education institution and while training competitive specialist, which is largely ensured by the minimization of conditions of exclusivity, adaptation, and inclusion of the student in the educational process. Successful adaptation depends on the ability of educational systems to be more flexible and responsive to the needs of students. In terms of implementation of such approaches the role of a teacher changes — from the source of ready-made knowledge to an educational manager, consultant, proofreader, editor, and of a student, from receiving knowledge to creating something new, to a realizer of personal ideas, inclinations. In this context it is important to choose such a pedagogical approach that would best satisfy the needs of students in self-realization, creativity, quality of pedagogical support, approval, recognition, overcoming language barriers, etc., to create conditions that are optimal for achieving not only academic success but personal success as well.

We believe that one of the conditions of solving the problem of special needs, self-actualization of a student-representative of any heterogeneous group is the development of inclusive educational space of a University.

The problem of the definition of "educational space" in the last decade has become more and more interesting for scientists and researchers in different fields of science. In one research, this phenomenon is considered at the level of the territory, which often leads to the identification of the concepts "educational environment" and "education system" (A. Liferov, E. Dneprov); in others, it is about the interaction between a child and an adult (I. Frumin, D. El'konin); thirdly, it is seen as the educational environment (T. Borisova, P. Ponomarev); fourthly as an event, as a phenomenon, a development situation (N. Borytko), as the educational system (O. Gugolenko).

M. Gromkova believes that "educational space — a space in which educational processes occur, i.e. the interaction with the surrounding world is implemented and realized. In the pedagogical processes it is specially narrowed, restricted, directed in a certain direction in time (present and history) and event (depending on the content of studies) aspects". The author proposes to consider two planes of the educational space: the external (sociocultural) and internal (personal). Quantitative and qualitative characteristics of the educational space in the educational process largely depend on a teacher, his or her internal culture, outlook, worldview, as well as readiness to implement the interactive, perceptual and communicative functions (Громкова М. Т., 2003, с. 65).

According to M. Korbut, "educational environment" is directly linked to the concept of "educational experience" because the environment is posited as the totality of organizations experience's conditions in education. Environment in this case is not the material conditions but the symbolic field. It is born and functions where there is a communicative interaction between different senses or modes of activity and as a result accumulates this diversity so that each of the participants in the environment is able to change his or her own position and own vision of the situation and to formulate possible new draft of the

description and, therefore, a new design of the situation (Korbut, A. M. , 2004, p. 106).

The willingness of the participants in the educational process to adequately respond to the challenges depends largely on the understanding of the processes, factors and their control mechanisms, as processes of globalization lead to rapid social, economic, political upheavals and issues of social stratification, social inequality are beyond the range of interest not only of sociologists, philosophers, and economists.

The diversity of the social environment is stated in the field of sociology (M. Weber, T. Parsons, P. Sorokin and others) in the framework of social stratification theories. The diversity is the basic characteristic of the social structure of society and represents a set of indicators that show the degree of variegation, diversity of society; accentuate the richness of this society's shades.

Education is a process of gradual development and maturation of a person, formation of his personality; in other words, this is a special socio-cultural process of development and formation of personality. The education system enables people to enter the world of contacts with different social parties, thereby creating and accumulating socio-cultural baggage in their life (Инклюзивное образование : проблемы и перспективы, 2014, с. 65-67).

Realization of the goal of inclusive education will claim, in our view, resolving a number of tasks: improvement of regulatory-legal, scientific-methodical, financial-economic support, focused on implementation and support of inclusive education; introduction of innovative educational technologies, models of providing special educational services to persons with special educational needs; formation of the educational-developing environment through the provision of psycho-medical and socio-pedagogical support; ensuring access to social environment, educational space; development and use of special didactic resource and rehabilitation facilities; improving the system of training and retraining of teachers working in inclusive education; communicative function as the main mechanism of the educational environment functioning; the involvement of students' parents with special needs to participate in the training and socialization process.

In numerous international documents the key human rights standards are formulated, including the right to education. The General Declaration of Human Rights, proclaimed by the United Nations on 10 December 1948, focuses on the fact that every person has the right to education, which should be available for him or her.

In the Declaration on the Rights of Persons with Disabilities, proclaimed by the United Nations on 9 December 1975, it's stated that people with disabilities should enjoy all the rights set forth in this Declaration.

The standard rules on the equalization of opportunities for persons with disabilities were adopted by General Assembly Resolution 48/96 of 20 December 1993, proclaimed that States-parties should recognize the principles of equal opportunity in primary, secondary and higher education for children and young people with disabilities.

In the Salamanca Declaration of 1994, adopted at the World Conference on Education of Persons with Disabilities, it's told about the principles of policies and practices in education. The Declaration stated that persons with

special needs in education should have access to education in ordinary schools where conditions must be created on the basis of pedagogical methods and techniques focused on this category of children and their needs. Regular schools with inclusive orientation are the most effective means of combating discriminatory attitudes, creating a favourable atmosphere in society, building an inclusive society and providing education for all. It is also mentioned that it's necessary to support the education of persons with special needs as an integral part of all educational programmes.

Thus, the right to education is a fundamental human right; the right to education of persons with special needs must be guaranteed without discrimination and any restrictions. States should recognize the principle of equal opportunities in the field of primary, secondary and higher education for children, youth and people with individual characteristics. Integrated educational structures, special educational system should develop in the direction of inclusive model of education.

Legislative recognition of the right to education of Ukrainian citizens, including those with mental and physical disabilities, is displayed in the current legislation guaranteeing the right to education without discrimination and on the basis of opportunity's equality, provides education at all levels. But the real situation of inclusive education implementation requires a qualitative change both in the existing Special education and in General one as well. Legal regulation of integrated or inclusive education will call for specific changes in legislation.

The policy of inclusion is based on the basic principles: a person's value does not depend on his or her abilities and achievements; everyone is able to feel and think; every person has the right to communicate and to be heard; all people need each other; the true education can only be provided in the context of real relationships; all people need friendship and support; diversity enriches all the aspects of human life.

Based on the above mentioned universally accepted principles of inclusion we formulate the following principles of functioning of the University inclusive orientation: continuity and multi-level; training orientation on the development of a wide range of graduates' competencies, including perception and generation of new knowledge; development of creative thinking, ability to find creative solutions to problems; leadership and social responsibility; interaction and interpenetration of scientific and educational activities of teachers; openness and availability of the University; integration principle of scientifically-educational environment of a University into the state and the international system; principle of compactness, unity of a campus.

Solution of educational tasks of the institutions of an inclusive orientation is based on implementation and adherence to the principles of inclusive education development (*author's vision*): the science that involves the development of theoretical and methodological foundations of inclusive education; program-methodical tools, monitoring and analysis of the results of inclusive education implementation, assessment of technologies' effectiveness used to achieve learning outcomes, conduct of an independent examination; consistency that ensures equal access to quality education for persons with special educational needs, early diagnosis and aid, continuity between levels of educa-

tion: preschool — General secondary education — vocational — higher education; variability that provides the correction orientation, the organization of personality-oriented educational process in the complex developmental work to meet the socio-educational needs, creation of conditions for social, labour rehabilitation, integration into society; the principle of social responsibility in the family provides training, education and development of children; creating conditions for the development of natural abilities; participation in the educational and rehabilitation process; the principle of social partnership with the aim of the process optimization of educational integration of persons with special needs.

Based on the above mentioned, we define the essential characteristics of approaches to the inclusive environment of the University. To build an inclusive society it's necessary to undertake a number of sequential steps: 1) recognition of diversity as spiritual values; 2) to learn how to interact with it; 3) to use diversity as a development resource.

For the educational environment to act as a developing educational environment, during the interaction of its components, it has to acquire *specific properties*: flexibility, meaning the ability of educational institutions to rapid restructuring in accordance with the changing needs of an individual, environment and society; continuity, expressed through the interaction and the continuity of its constituent elements; variation, implying a change of educational environment in accordance with the needs in educational services of the population; integration, providing solutions to educational problems by strengthening cooperation between its member institutions; openness, providing the participation of all subjects of education in management and democratization of training forms, education and interaction; policy on the active communication of all subjects of educational process, carried out on the basis of pedagogical support of a teacher's special position.

Taking as a basis a common definition of "space — many objects that have relationships" educational space is specified as a really existing space-time continuum of educational events' functioning system, a certain objectively existing body of interrelated material, political, ideological, socio-psychological factors and conditions that directly and indirectly interact with a person in the process of formation and development of his or her qualities, skills, attitudes, behavioral orientations (Инклюзивное образование : проблемы и перспективы, 2014, с. 67).

Educational space represents, on the one hand, subjective and abstract, on the other one an objective picture of social reality. It is created on the basis of subjective factuality, that is, subjective values, and also objective (formal) requirements and norms, existing in social reality (I. Surina).

Based on the definition of educational space, peculiarities of its relationship with social space, it can be argued that the educational environment has the following *characteristics*: multidimensionality that includes many indicators that determine the existence of agents, such as: life-world environment, the environment of stay, educational practice, educational and developmental technologies, etc.; diversity — association (on the basis of educational activities) in the same space-time zones of heterogeneous, even dissimilar elements; temporality — organization of time, ability to differentiate time zones: age and regional; relative continuity — existence in a certain time interval; the length is

manifested in a number of educational institutions and the repetition of events, in their zonal prevalence of personal, group and institutional level within the common space; saturation is caused by many events ordered in time and space in the life of the agent related to education, latently containing the value that determines his or her life's path; asymmetry — it is impossible to identify two symmetric subspaces containing similar structural organization and the same exchange networks, which correspond to interactions; assimilativity — acceptance of the minority by the majority in which the minority accepts the values and norms of the majority (dominant culture); complexity — the large number of different elements, orientations for educational, cultural systems, values and appropriate types of social behavior underlying the relations between agents; openness — the presence of permeable, movable, probabilistic boundaries (primarily in the temporal dimension), as well as the ability to exchange information with the public system; nonlinearity — social reality — social space — social life — educational space — the living world.

Based on the analysis of the scientific literature on the problem under consideration we define the inclusive educational environment of the University as a space in which there are social and educational relationships and the relationships of educational process subjects, social phenomenon, educational policy, values, etc., which determine the specificity of the implementation of education purpose, upbringing and comprehensive development of an individual in the heterogeneous society.

In the structure of inclusive educational space of the University we distinguish the following elements: subjects of the educational process (students, teachers, representatives of medical institutions, public organizations, rehabilitation centers, cultural centers of national communities, etc.), regulatory and material support.

The relationship between the subjects of the educational process is aimed not only at meeting the educational needs of inclusive people, but also to promote the formation of active civil position in science, education, culture, sports, skills to adequate broadcast of information and socio-positive communication in an inclusive society, and socialization.

Regulatory support includes, primarily, the implementation of government documents regulating educational process of the University in terms of inclusion (laws, orders, standards, regulations, recommendations, etc.), guidance documents, allowing teachers and staff to work with inclusive people in the special conditions, and internal documents concerning the organization of inclusive education taking into account the conditions and possibilities of each specific University.

Material support involves the segment of material-technical and informational-consulting infrastructure of the University, allowing realizing in practice the idea of inclusive education, for example, special equipment for teaching the hearing impaired, visually impaired, hard traveling, language laboratories, mobile consulting stations, etc.

Let's comment on the project of the inclusive educational environment of the University, for example, the representatives group of gifted young people in the field of literature. By giving priority to the educational and social needs of this students group of Berdiansk State Pedagogical University, namely in quality education, in special education, pedagogical support, social

contact, approval and recognition, social status by a project working group and philologists-volunteers, as one of the areas focused on inclusive education, related services, and support of creative talent it is supposed to use and improve the experience of extracurricular classes, creating the conditions for self-realization in the literary field. In the form of a cultural project, students will have the opportunity to self-realize, for example, in the writing of works in various literary genres in Ukrainian, Russian, English, German, etc. languages, gain the skills of tolerant behavior and communication with writers and poets of the region, country and abroad. It is on the basis of the capability-oriented approach (Capability Approach) that this project will be joined by students from different institutes and faculties of the University: Institute of Social Pedagogical and Correctional Education, Primary Education, Faculty of Computer and Energy Saving Technologies, Physical Education, Physics, Mathematics and Technological Education with different creative abilities and preferences.

Students of different nationalities from different regions of Ukraine are involved in bilingual communication, are attached to the values of the world and national culture by means of the Ukrainian, Russian, English, German, Bulgarian languages and cultures. A student of Computer Technology Faculty can write poetry in Russian, a future social teacher — in English, a primary school teacher composes a fairy tale in German; a student-Bulgarian — in Ukrainian, etc. As a result of participation in this project of teachers-philologists' professional support, approval and recognition after the publication in the student newspaper "University word", the literary almanac, the local press, performances of their works at student parties, and at different events we expect that students' self-esteem will increase, values will be changed, a positive motivation for learning, acquisition of teaching profession, social status of an active individual activity will be formed.

A modern qualified teacher, regardless of involvement in any heterogeneous group, is formed through the development of specific skills, optimal use of personal potential, the ability to manage a diversity of student's composition in his or her future professional activities. This task cannot be solved in one project, so we need a holistic system of logical, thoughtful activities at the level of network interaction of the University with educational, cultural, social institutions, organization of dialogue and cooperation with civil society, formation of regional communities of the social partners on matters of integration in society, the development design of inclusive education in regional communities.

4. Strategic plan for the development of inclusive education in the region

The need for the development and implementation of the Strategic plan of inclusive education development in the region is due to the information and statistical data. According to the Central psycho-medical-pedagogical consultations among children in Ukraine (10.5 percent) 837315 children have disorders of psychophysical development: 246308 (violations of the musculoskeletal device), 240033 (visual impairment), 212704 (speech disorders), 60400 (impaired mental function), 52266 (mental retardation), 22467 (hearing impairment), 3120 (autism), 17 (deaf-blindness).

The development of inclusive education in Ukraine — a complex, multifaceted process, involving scientific, methodological and administrative resources. The implementation of inclusive education requires the creation of appropriate educational space, creation of training programs, providing scientific-methodological and socio-pedagogical support. Pedagogical collectives of educational institutions of all educational levels are in dire need of assistance in the organization of pedagogical process, the establishment of cooperation of all participants in an inclusive process, where the Central figure is a child.

The conceptual ideas of the Strategic plan of inclusive education development in the region is actualized with the following provision: Ukraine, having ratified international legal instruments (UN Declaration on human rights, Declaration on the rights of persons with disabilities, the UN Convention on the rights of the child, UN Declaration on the rights of persons belonging to national or ethnic, religious and linguistic minorities, etc.), declared to the global community about its liabilities in the area of human rights, including children and young people of different heterogeneous groups.

The formation of mechanisms system for the integration of persons with special needs, migrants, refugees, members of ethnic and religious communities into the society affects the fundamental components of a human: health, labour and intellectual capital. A special place among them belongs to education, as it is the appropriate level of education that can provide a decent workplace, self-assertion and self-realization, successful socialization.

The right to education for citizens of Ukraine, including from among the heterogeneous groups are reflected in the current legislation, based on universally recognized international human rights standards, as articulated in the Universal Declaration of Human Rights (1948), Declaration on the Rights of Disabled Persons (1975), General Assembly Resolution "Standard Rules on the Equalization of Opportunities for Persons with Disabilities" (1993), the Salamanca Declaration (1994).

In Ukraine the right to education without discrimination on the basis of equal opportunities at all educational levels is guaranteed by the laws and normative legal documents: the Constitution of Ukraine, laws of Ukraine "On education" (2014), "About social protection of disabled persons in Ukraine" (1991), "On rehabilitation of disabled persons in Ukraine" (2005), "On protection of childhood" (2001) and others. To implement public policies towards certain categories of children and young people, representatives of heterogeneous groups the Ministry of Education and Science of Ukraine in 2009 created the Concept of development of inclusive education and the following documents were approved: "Action plan regarding the implementation of inclusive education of children with special needs in secondary schools for 2009-2015", "On approval of action plan concerning the introduction of inclusive and integrated education in General schools for the period up to 2020" and so on.

However, the existing system of education in Ukraine at present does not fully provide the accessibility and equality of rights to education by children — representatives of various heterogeneous groups, their socialization. There is an urgent need to reorganize the government policy on the provision of educational services, creation of equal conditions and opportunities for all without exception. This requires the development and implementation of alternative

policies, models of education systems through education and socio-pedagogical support, creating conditions for upbringing and education of these children among their peers, from preschool level until they receive professional training. Inclusion, in the new understanding, is a modern and realistic way of solving this problem.

Despite the difficulties and the ambiguity of the acceptance of this issue by the society, inclusion broadens the circle, opens wide opportunities for adaptation of children in society, their realization and affirmation.

Goal of the Strategic plan of inclusive education development in the region:

- support and promotion of the state policy implementation in the sphere of inclusive education and social acceptance of the problem;
- meeting the needs in basic education for all marginalized groups, the expansion of forms and types of educational institutions, improvement of the conditions of learning, types of support, training;
- involvement of all the individuals into the educational and socializing processes, regardless of age, gender, ethnic and religious affiliation, social status, health, level of intellectual and physical development, educational achievements;
- ensuring equal treatment of all people and the creation of necessary conditions for persons with special educational needs.

Implementation of the goals of the Strategic plan of inclusive education development in the region would require the solution of several ***tasks***:

- improvement of normative-legal, scientific-methodical, financial-economic support, focused on the implementation of inclusive education in the region;
- introduction of innovative educational technologies, models of providing special education services to persons with special educational needs;
- formation of the educational-developing environment through the provision of psycho-medical and socio-pedagogical support;
- provision of barrier-free access to the social environment, educational premises;
- development and use of special educational and didactic support, rehabilitation training tools;
- improvement of training or retraining system of teachers working in inclusive education, intercultural communication.

Expected results:

- the formation of a new philosophy of thinking in society; respect and tolerance toward all people with developmental disabilities and behavior based on the ideology of non-discrimination on any grounds;
- organization of cooperation and constructive engagement of all subjects of the educational and developmental process of the region in the field of inclusive education;
- initiation of children, teenagers, young people with special educational needs and their families to social and educational institutions, involvement in an inclusive process;
- de-institutionalization of the institutions of segregation and social integration of people with disabilities.

Key partners: regional state administration; district state administrations; municipal councils; universities; departments of education (district, city), primary, secondary, non-formal institutions; social and cultural institutions (Centre of social services for family, children and youth, Centre for social rehabilitation of the disabled persons, Center for children and youth creativity; cultural-educational centers of national communities; public organization: international organization "Red cross, Religious mission of the Roman Catholic Church in Ukraine "Caritas-Spes", youth organizations; volunteer organizations; mass media.

Business strategies. Directions for the development and implementation of the Strategic plan of inclusive education development in the region have identified the following strategies:

Strategy of concentrated growth involves the strengthening of positions of state policy in the sphere of inclusive education, support, and encourage of its implementation at the level of regional legislative and executive authorities. *Planned activities:* promotion of inclusive education in the region; making suggestions about the implementation of inclusive education in the system of educational establishments (preschool, General education, extra-curricular, vocational, higher); initiating the development and implementation of regional social program "Available environment"; creation in higher educational institutions of the region preparatory departments for students with disabilities; the initiation of training and retraining of specialists in inclusive education at the regional courses of teachers' improvement of qualification; assistance to minimize regulatory and bureaucratic barriers to innovations related to the practical implementation of inclusive education in the region.

Strategy of integrated development: increase, merging of structures, organizations working in the field of inclusion. *Planned activities*: establishment of special Funds of the literature on the problem of inclusion in a book (libraries) and electronic (library) format; creation of a regional network of institutions of the inclusive profile (regional methodological center for targeted assistance, the centre of the playing customer support, a lekotek, center for language adaptation, centre for intercultural communication, support laboratory of talented youth; development of socio-pedagogical project "Distance learning of children, students with limited functional abilities" (distance school in Berdiansk, regional resource center for distance learning at the Competence centre for inclusive education of Berdiansk State Pedagogical University).

Strategy of diversification growth: development and introduction of new services for members of heterogeneous groups. *Planned activities*: assisting students with limited functional abilities in learning; training of children with disabilities, parents, teachers to distance learning; provision of relevant literature from the library and electronic funds for teachers, parents, volunteers on the problem of inclusion; organization of summer rest and recreation in an inclusive environment.

Strategy of corporate development: formation of corporate culture, intercultural communication. *Planned activities:* training of teachers implementing inclusive education; development of scientific and methodological materials to support inclusive education: individual plans, didactic material for children with disabilities, recommendations for tutors, teachers; introduction of increa-

sing forms of pedagogical skills in the context of inclusive education: scientific-practical conferences, round tables, seminars; a series of pedagogical workshops on inclusive education; the organization of regional scientific-methodological forum "Equal rights — equal opportunities"; the Days of national cultures of the Ukrainian Northern Azov; the initiation of exhibitions for pupils and students of creative collectives; personal exhibitions of gifted youth; holding webinars and online lectures on the problems of inclusive education.

Strategy of management of educational services involves providing effective management of the implementation of the Strategic plan for the development of inclusive education in the region. *Planned activities:* provision of psycho-pedagogical, socio-pedagogical support of students, students with disabilities, their families; development and implementation of programmes on inclusive education and intercultural communication on the basis of training courses; provision of information and methodological services to clients with disabilities.

Monitoring of educational services in the field of inclusive education. Conduct intermediate and final monitoring of the Strategic plan implementation for the development of inclusive education in the region using the methods of mathematical statistics, publication, factographic; parametric, independent expert evaluation.

On the basis of quantitative and qualitative analysis of the results of the Strategic plan implementation for the development of inclusive education in the region to form proposals for improvement of normative legal and methodical bases of inclusion and offer them to the Department of education and science of Zaporizhzhya Regional Administration for consideration and making necessary decisions.

Conclusions

1. Diversity — the differences between people regarding sex, age, ethnicity, religion, health or disability, the specific characteristics of the individual, etc.

The diversity is manifested not only in social differences but also in the individual psychological characteristics of subjects of the educational environment, which is not an obstacle for its successful operation, but on the contrary fills it with various meanings and strengthens the educational effect.

2. Inclusive education — the process of ensuring equitable participation in the educational space of educational institutions of various heterogeneous groups: individuals with disabilities, gifted, migrants, socially vulnerable groups, ethnic and religious communities, etc.

3. The inclusive educational environment of the University — a space in which there are social and educational relationships and the interrelationships of subjects of educational process, social phenomena, educational policy, values, etc., which determine the specificity of the purpose of education implementation, upbringing and comprehensive development of an individual in the heterogeneous society.

In the structure of inclusive educational space of the University there are the following elements: subjects of the educational process (students, teachers,

representatives of medical institutions, public organizations, rehabilitation centers, cultural centers, national communities, etc.), normative and material support.

4. One of the conditions of inclusive education implementation is the adoption and implementation of the leading ideas of inclusion, inclusive education at the state level, at the level of regions, territorial communities, and micro-societies.

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Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 88–95

Людина у освітньому просторі smart-суспільства

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Анотація. Представлена концептуалізація smart-суспільства в антропологічному та соціоаксіологічному вимірах, де smart-людина розглядається як суб'єктом smart-суспільства в контексті вивчення особливостей її життєдіяльності в освітньому просторі.

Ключові слова: інформаційне суспільство, smart-суспільство, smart-людина, «суспільство знань та інновацій», інноваційна освіта.

Abstract. The conceptualization of smart-society at anthropological and social-axiological dimensions is represented at the article. The smart-individual is considered at the context of discovering one's life-sustaining activity at the educational space.

Keywords: informational society, smart-society, smart-individual, society of knowledge and innovations, innovative education.

Вступ

Актуальність дослідження особливостей людини і освіти у smart-суспільстві розгортається в двох паралельних площинах еволюції суспільства від індустріального до постіндустріального та від інформаційного до smart-суспільства, що потребує виявлення у контексті даної еволюції цих взаємовідносин. Матриця smart-суспільства актуалізує увагу на осмисленні взаємовідносин «людина-освіта», що є центральною складовою у багатьох дослідженнях сучасної науки, яку можна було б охарактеризувати як міждисциплінарну. Епістемологічний характер постановки даної проблеми та праксеологічне вирішення даної проблеми на користь людини свідчить, що соціум повинен володіти необхідними і достатніми ресурсами для свого відтворення та ефективного розвитку. З середини 80-х рр. минулого століття соціогуманітарна наука формується як прикладна наука, яка інтенціонує свої дослідження на вивченні особистості людини та її взаємовідношення з освітою.

Мета статті — розкрити концептуалізацію smart-суспільства, його понятєво-категорійний апарат та еволюцію основних його категорій в ан-

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тропологічному та соціоаксіологічному вимірах, де smart-людина розглядається як креатора інноваційного середовища в контексті вивчення особливостей її життєдіяльності в освітньому просторі.

Стан наукового опрацювання проблеми. Соціальний феномен смарт-суспільства, що з'явився в контексті історичної еволюції наукової картини світи (інформаційної революції), сьогодні є актуальним з точки зору мультикультурності та міждисциплінарності сучасної науки. Вивчення особливостей взаємодії людини і освіти у smart-суспільстві розпочалося з появи теорій технократичної культури як синтезу раціональних методів і процедур технічного знання у поєднанні з соціокультурними особливостями, суспільно необхідними для управління інформаційно-високотехнологічним науково-технічним прогресом, що характеризуються диференціацією і спеціалізацією соціальних інститутів, високим рівнем промисловості, науки і техніки, економіки, урбанізації, відкритою системою соціальної мобільності [11]. Аналіз особливостей взаємодії людини і освіти у smart-суспільстві свідчить, що людина смарт-суспільства — це образ, що використовується для фіксації всієї багатоманітності історико-культурних традицій та новацій, діяльнісних факторів та духовних прагнень, світоглядних парадигм, задіяних в активних процесах екзистенції у кореляції з соціокультурною діяльністю людини. В сучасних умовах українського суспільства та науки ми знаходимо лише окремі статті [1; 2; 3; 4] щодо розгляду проблем смарт-освіти, які свідчать, що концептуалізація смарт-суспільства знаходиться лише на початковому етапі свого становлення [2, с. 13–27]. Нами використана концептуальна парадигма О. Тоффлера про «суспільство третьої хвилі», в якому відбулися парадигмальні зміни про розвиток суспільства та взаємовідносини людини у форматі «людина-освіта» [10]. Серед робіт які спонукали нас до наукового пошуку є доробки з інформаційного суспільства та інноваційної освіти таких авторів, як Р. Арона, Д. Белла, Е. Гідденса, Л. Берталанфі, З. Бжезинського, І. Валлерстайна, М. Кастельса, Ю. Лотмана, Н. Лумана, У. Матурана, Дж. Нейсбіта, О.Тоффлера, Ф.Фукуями, на основі яких розгорталася еволюція інформаційного суспільства в постінформаційне, а потім і у smart-суспільство.

Наукова новизна дослідження виражається в тому, що вперше представлено концептуалізацію smart-суспільства у соціо-гуманітарному вимірі і розроблено понятєво-категоріальний апарат теми як результат розвитку інформаційно-високотехнологічного науково-технічного прогресу. В контексті системного та антропологічного аналізу ми намагаємося розглянути еволюцію інформаційного суспільства в smart-суспільство в умовах сучасних цивілізаційних змін та довести, що для появи даного виду суспільства величезне значення відіграли такі феномени, як інформація, інформаційно-комунікативні технології, інформаційно-комунікативний менеджмент, що сприяли розвитку smart-суспільства [3, с. 43–51]. Ми виходимо з того, що smart-людина є суб'єктом smart-суспільства, в основі якого розвиток суспільства — високотехнологічного, інноваційного, інформаційного, що потребує когнітивних здібностей і компетентностей людини, націленої на удосконалення технологій цифрової економіки як результату високотехнологічного розвитку соціуму та викликів інформаційно-технологічної революції.

Методологічні підходи дослідження особливостей взаємодії людини і освіти у smart-суспільстві розкривають передумови формування smart-людини і smart-світогляду людини постінформаційного суспільства. Новий smart-світогляд осмислює умови створення соціуму як розумного та інноваційного, націленого на визначення способів задоволення потреб людини у контексті виявлення сутності людського життя, що формується в умовах smart-освіти. Методологічні засади моделі smart-суспільства зводяться до використання таких методів і принципів, як культурно-історичного підходу та доцільності, цілісності та культурного плюралізму для аналізу проблем смарт-суспільства, що зберігають свою специфіку в духовно-інформаційному житті. Визначення smart-суспільства імплікується у контексті конкретних теорій адаптації людини до оточуючого середовища. У цьому контексті можуть бути використані антропологічний та соціоаксіологічний методи та підходи, що дозволяють проаналізувати проблеми людини, освіти, знання, руху до «суспільства знань» та інновацій.

Характеристика терміну Smart

Smart — це властивість об'єкта, що характеризує інтеграцію у даному об'єкті елементів, раніше не поєднуваних, що здійснюються за допомогою використання Інтернет. Наприклад: Smart-TV, Smart-Home, Smart-Phone Smart-технології, що в цілому приводить до розширення трудової мобільності — в освіті, на державній службі і в багатьох інших сферах зайнятості, особливо у середовищі молоді. Останнім часом стали виникати світові тренди у розвитку smart: smart-міста, smart-країни, smart-мобільності, smart-екології, smart-освіта, smart-життя.

Відмітимо, що вперше термін «SMART-суспільство» ввів П. Друкер ще у 1954 р., перші літери якого означали: S — Self-Directed; M — Motivated; A — Adaptive; R — Resourceenriched; T — Technology. SMART-критерії, яким повинні відповідати цілі: 1) specific — конкретний (що необхідно досягнути); 2) measurable — вимірюваний (у чому буде вимірюватися результат); 3) attainable — досягнутий (за рахунок чого можливо досягнути цілі); 4) relevant — актуальний (визначення істинності цілі); 5) time-bounded — співвіднесення з конкретним строком (визначення часового проміжку, по закінченню якого ціль має бути досягнута). Правильна постановка цілей означає їх конкретність, вимірювальність, досягнутість, значущість і співвіднесеність з конкретним строком, що й означають перші літери даного терміну [9, с. 4–10]. Слово «Smart» у перекладі на українську означає розумний, тобто такий, що сприяє розвитку розумних технологій в контексті освітянського простору. Ключовим у властивості «смарт» є здатність взаємодіяти з оточуючим середовищем, тому Smart — це властивість системи чи процесу, яке проявляється у взаємодії з оточуючим середовищем і наділяє систему здатністю: 1) адаптації до умов, що трансформуються; 2) самостійного розвитку і самоконтролю; 3) ефективного досягнення результату, що й повинна культивувати інноваційна освіта.

Платформа Smart networks («розумних мереж») передбачає використання комунікаційних мереж для управління освітою. Розумна мережа виражається через три складових розвитку Інтернет: 1) міжмашинна вза-

ємодія (M2M), тобто технології, що дозволяють машинам отримати якісне упорядкування інформації, її упорядкування, що протистоїть ентропії; 2) хмарові обчислювання (CC); 3) аналіз великих даних (Big Data). Тому логічним продовженням еволюції інформаційного суспільства є смарт-суспільство (smart-society), що розвивається на основі смарт-технологій.

Smart-суспільство — це нова сукупність свідчень, характеристик, що представляють певний об'єкт у його якісній визначеності, нова культурно-освітня динаміка суспільства, що дозволяє отримати нові ефекти — економічні, політичні, соціальні, духовні, освітянські.

Концепції (парадигми, теорії) розвитку smart-суспільства: зарубіжний досвід

Саме сьогодні необхідно розвивати смарт-культуру і смарт-освіту, з точки зору якої вони представляють певний рівень відтворення суспільного життя, що залежить від техніко-економічних показників розвитку суспільства, технологій, параметрів його розвитку, що вимагає підтримки пріоритетних напрямків, що сприяють оптимізації інформаційно-пізнавальної культури особистості та створення духовно насиченого інформаційного простору smar-суспільства. «Інформаційні процеси, які зростають в геометричній прогресії не тільки надають необмежені можливості, щодо використання інформаційних ресурсів, а й призводять до нових стилів життя, поведінки, комунікації особистості» [5, с. 225].

Не випадково передові країни вже давно сформували концепції (парадигми, теорії) смарт-суспільства, що представляють новий етап у розвитку постінформаційного суспільства [4, с. 38–41], а саме — розумного суспільства, розумного уряду, розумної освіти, розумного міста, що пов'язано з формуванням «економіки знань». Концепція смарт-суспільства знаходиться в основі сучасних державних програм розвитку країн Південної Кореї та Японії, зокрема, в Південній Кореї Національним соціальним агентством розроблена «Стратегія смарт-суспільства», що є надзвичайно актуальною. Smart-суспільство трансформує бізнес, роблячи управління більш інтелектуальним (гнучким, розумним), а людину — розумною, діяльність якої направлена на використання знань та інновацій. В контексті еволюції інформаційного суспільства на його зміну в багатьох розвинутих країнах світу йде «суспільство знань», яке називають наступною стадією розвитку («Towards Knowledge Societies», доповідь ЮНЕСКО) з його найважливішим ресурсом знання. Розвиток смарт-суспільства сприяє розвитку людини, тому що пов'язаний з початком ери становлення розуму, тобто ноосферного суспільства. В основі Smart-суспільства лежить розвиток «суспільства знань», цифрових технологій, цифрового суспільства, всього того, що зветься «цифровою ерою» розвитку цивілізації. Smart-суспільство побудоване таким чином, що «розумна» робота, яка сформована «розумним» життям, державою і бізнесом, базується на «розумній» інфраструктурі і «розумних» громадянах, які відіграють центральну роль у створенні smart– культури [7].

Інноваційна Smart-освіта

Smart-інновації породжують нову парадигму розвитку суспільства, яка вважається найважливішим фактором становлення Smart-суспільства. Не випадково це зростання зафіксоване у документі «Європа — 2020: Стратегія розумного стійкого та інклюзивного розвитку» (Smart growth) — стратегія, що включає розвиток економіки, що базується на знаннях та інноваціях, та сприяє стійкому розвитку (Sustainable growth), більш ефективному використанню ресурсів, що включає інклюзивне зростання (Inclusive growth) та укріплення високої зайнятості населення [8].

Освіта, за рахунок використання електронних і колективних технологій, стає більш масовою та ефективною, відповідно, смарт-держава формує смарт-громадян (розумних), які є високоосвіченими, так як використовують сучасні технології, діють колективно і приймають участь в управлінні. Зарубіжні вчені вважають, що розвиток таких галузей, як Smart-транспорт, Smart-охорона здоров'я, Smart-енергетика, Smart–суспільство приведе до появи Smart-світу, детермінованого цифровими технологіями.

Необхідною умовою формування smart-суспільства є smart–освіта, в основі якої формування смарт-компетентності суб'єктів як складової частини їх інформаційної компетентності: знання про smart-середовище і порядок формування взаємодії з ним; вміння пошуку і використання smart-ресурсів, smart-технологій. Взаємодія у smart-середовищі повинна здійснюватися у контексті взаємодії з медіасередовищем і кіберпростором, що передбачає реалізацію багатомовної модальної логіки. Формування і розвиток smart-культури передбачає формування культури — smart-взаємодії у smart-середовищі, smart-безпеки, комп'ютерної та інформаційної етики. Як і smart-суспільство, smart-культура не є самостійною сутністю: вона є складовою частиною інформаційної культури, медіакультури, базується на них і розвиває їх, сприяючи розвитку людини як креатора інноваційного середовища. В умовах розвитку збільшення об'єму інформаційних потоків, скорочення життєвого циклу знань, підвищення вимог до професійних характеристик особистості, швидкоплинності соціальних змін і т.д. освіта втрачає свій базовий одноразовий характер і набуває властивостей послідовного, системного, безперервного процесу. Інноваційна освіта як фактор інтелектуального розвитку суспільства та його сталого розвитку представляє його як основний ресурс: для економіки знань уміння та інтелект є основою виробничою силою, яка дозволяє створити додаткову вартість, що є основною метою нової економіки Інноваційна освіта як потенційний інтелектуальний ресурс суспільства орієнтується на пріоритети інноваційного економічного розвитку.

Інноваційна освіта — це одна із найважливіших галузей людської діяльності; охоплює буквально все суспільство і витрати на неї постійно зростають. В розвинених країнах в цю сферу вкладаються 5–8% валового національного продукту. В суспільстві склалося розуміння того, що саме в сфері освіти і науки формуються основи стратегії розвитку для кожної країни, пріоритети розвитку інноваційної освіти набувають першочергового значення. Хоча кожна країна вирішує свої проблеми з врахуванням економічних можливостей і культурних традицій, в цілому слід виокремити основні напрямки сучасних реформ в сфері освіти:

1) реалізація швидкого розвитку системи безперервної освіти з широким використанням сучасних комп'ютерних технологій;
2) демократизація, фундаменталізація, гуманізація і гуманітаризація освіти;
3) забезпечення високого рівня природничо-наукової, математичної і комп'ютерної грамотності;
4) введення державних стандартів для всіх рівнів освіти;
5) здійснення органічного зв'язку системи освіти з суспільними структурами, що являють собою найважливіші джерела неформальної освіти громадян;
6) інтернаціоналізація освіти.

Вирішення цих проблем повинно забезпечити країні входження в світовий економічний, політичний і культурний простір.

Інноваційна освіта виконує нові суспільні функції. Так, освіта в умовах глобального світу стає економічним фактором. Для глобального світу характерними є процеси міграції людей, культур, руйнуються культурні зразки, традиційні цінності, втрачається ідентичність народу, зростає етнічна напруга між етнічними групами. Силою, яка здатна подолати ці суперечності, привести людей до взаєморозуміння, вирівнювання культурних відмінностей, може стати освіта як фактор соціальної згуртованості. Задачею освіти є підготовка людини до роботи в нових організаційних структурах і широкого розповсюдження інформаційних технологій, які змінюють організацію праці. Метою освіти повинно стати вироблення навиків роботи в команді; освіта і самоосвіта стають засобами самореалізації особистості. Однією з найважливіших залишається проблема забезпечення рівних можливостей отримання освіти різними соціальними групами.

Освіта виступає механізмом забезпечення історичної спадковості, формування трансляції і наслідування «соціального генофонду». Спочатку через звичаї і традиції, а пізніше через знання транслюються найбільш ефективні моделі життя і поведінки, історично вироблені даною спільнотою. Як такий механізм, освіта має дві істотні функції:

1) спадкова, чи соціально-відтворювальна функція, що наділяє молодь зразками досвіду і навичками соціально-організованого життя. Молодь, соціалізуючись, вписується в життя конкретного суспільства, цим забезпечує виробництво благ, дотримання норм життєдіяльності, суспільного укладу і порядку даного суспільства;

2) розвиваюча, чи адаптивно-змінна функція, яка формує у нового покоління здатність до розвитку, творчості, інновацій і забезпечує її інтелектуальним ресурсом. Істотні функції освіти, протилежні одна до одної, знаходяться в протиріччях — соціальних, економічних, духовно-ідеологічних.

Якщо функція збереження здатна законсервувати суспільство, то функція розвитку направлена проти «історичного спадку» і здатна привести суспільство до втрати своєї ідентичності. Функція розвитку в освіті повинна бути підпорядкована функції збереження стійкості суспільства, і тільки в єдності двох функцій освіта повинна стати механізмом соціального наслідування і соціального відтворення суспільства. Освіта уявляється основним засобом відтворення соціального порядку, коли останній зруйнований чи йому властиві недоліки. Не обмежуючись феноменом передачі знань, освіта в широкому смислі слова є основним засобом, за допомогою яко-

го країна повинна сприяти формуванню інформаційного суспільства. Цінність освіти, заснована на багатому історичному досвіді міжкультурного обміну, стала в сучасному світі особливо актуальною. Основними напрямками протиріч у сфері освіти є:

1) інвестування в людський капітал (human capital);
2) пошук збалансованого співвідношення навчальних програм, направлених на підготовку працівників для ринку праці, і програми, що забезпечують всебічний розвиток особистості.

Як результат дослідження, виокремимо антропологічні засади розвитку сучасного світу, що привели до появи smart-суспільства [6]. В контексті виявлення антропологічних засад взаємодії людини і суспільства на новому етапі розвитку Smart-суспільства має велике значення виявлення нових типів взаємодії людини і суспільства, що привело до появи нових проблем соціокомунікації-соціотрансляції мультипроцесів інформації, що включає синтез інформатики, кібернетики електронно-обчислювального програмування, антропології, соціології. На інформаційні процеси здійснюють вплив індивідуально-психологічні стани-феномени учасників інформаційного обміну, їх індивідуально–праксеологічний досвід, компетентність в адитивності з соціокультурно-екзистенційними процесами індивіда у суспільстві. Смарт-суспільство включає в себе «розумні технології», освіту, управління містом, все, що пов'язане з Інтернетом, новою роллю інформаційних технологій, що виступають у якості єдиної інфраструктури нового суспільства, яка пов'язує в єдину інтелектуальну мережу людей, що створюють середовище для розповсюдження знань та сприяють ефективному смарт-управлінню.

Отже, виявлення особливостей взаємодії людини і освіти у smart- суспільстві актуалізує увагу на дискурсосмисленні соціуму-людини і засвідчує той факт, що сучасний світ знаходиться у стані системних глобальних змін та глобальної трансформації людства. Антропологічний аспект соціальних відносин, що формуються у Smart-суспільстві, свідчить, що трудова діяльність організована на основі колективного інтелекту та «смарт-роботи», що сприяє подоланню ентропійних (хаотичних) тенденцій і поверненню традиційним інститутам стабільності. У якості ключової цінності виникає поняття «суспільство мрії» як високодуховне, що реалізує принципи соціальної відповідальності та справедливості. У результаті зміни потреб суспільства з'являються нові вимоги до трудових ресурсів, витребуваним виступає володіння колективною мережевою компетенцією. Інноваційна освіта нині набуває основних значень в контексті того, що вона: 1) складова частина соціалізації особистості, в процесі освіти людина набуває знання, навички, цінності, норми; 2) система інформації, яка включається в освітні програми різних шкіл і навчальних закладів і здійснюється в процесі навчання; 3) інституціонально організована діяльність, яка забезпечується системою освітянських закладів; 4) характеристика (чи якість) інтелектуального розвитку населення; 5) рівень освіти різних соціальних груп, що визначають економічний і культурний потенціал суспільства. Таким чином, здійснено концептуалізацію smart-суспільства, його понятєво-категорійний апарат, еволюцію основних його категорій у вимірі «smart» та затребуваність людини як креатора інноваційного середовища, в основі якого новий рівень взаємодії «людина-суспільство».

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Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 96–104

Сучасна інженерно-педагогічна освіта: інтегровано розвивальний підхід

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Анотація. У статті висвітлено проблему міждисплінарного дослідження інженерної та педагогічної освіти, необхідності розроблення методологічних основ для підвищення нетрадиційного професійного розвитку студентів інженерно-педагогічних спеціальностей під час їхньої професійної підготовки у педагогічному університеті. У зв'язку з цим досліджено сучасний інтегровано розвивальний підхід для впровадження інноваційних технологій у навчально-виховний процес вищих навчальних закладів інженерно-педагогічного спрямування. Акцентовано увагу на: введенні поняття «інтегровано розвивальний підхід», «міждисциплінарна методика інтегровано розвивального навчання», «інтегровано розвивальне навчання»; чинниках, що забезпечують вдосконалення підготовки майбутніх фахівців з урахуванням принципів, методів і прийомів, що спонукають до творчості, розвитку особистісних якостей, використання інноваційних педагогічних технологій, пов'язаних із винахідництвом, раціоналізацією.
У статті приділено увагу компетентностям, що можуть бути сформовані у студентів педагогічного університету завдяки впровадженню у професійну підготовку взаємопов'язаних специфічних принципів інженерно-педагогічної культури — інженерного та педагогічного мислення, здатності викладати і виконувати роботу на рівні сучасних досягнень техніки і технології, ефективно застосовувати теоретичні знання для розв'язання практичних завдань.

Ключові слова: інженерно-педагогічна освіта, інтегровано розвивальний підхід, принцип, студентами, професійна підготовка, чинники.

Abstract.
The article highlights the problem engineering studies and teacher education, the need to develop a methodology to enhance professional development of non-traditional students of engineering and pedagogical skills during their training at Pedagogical University. In this regard studied modern efficient integrated scientific approach for developing innovative technologies in the educational process of higher educational institutions of engineering and pedagogical direction. The attention is focused on the introduction of the concept of "integrated developmental approach", "integrated interdisciplinary method of developing education", "integrated developing education"; factors that ensure the improvement of training of future specialists with the principles, methods and techniques that encourage creativity, development of personal qualities, the use of innovative educational technologies related inventions, rationalization.
The paper paid attention competencies that can be formed in a pedagogical university students through the introduction of specific training related engineering principles and pedagogical culture — engineering and pedagogical thinking, the ability to teach and perform work to date equipment and technology achievements, effectively apply theoretical knowledge to solve practical problems.

Keywords: integrated developmental approach principle, students, training, factors engineering and teacher education.

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Основна мета інженерно-педагогічної освіти в процесі професійної підготовки — підготувати майбутніх фахівців — творчих особистостей,здатних до саморозвитку, самоосвіти, інноваційної діяльності, ефективної організації своєї роботи у процесі навчання у вищому закладі освіти. Передусім, слід зазначити поєднання і взаємозв'язок навчання, загальнонаукової й професійної підготовки із професійно-виробничою працею студентів. У зв'язку з цим інженерно-педагогічну освіту слід розглядати як систему, що включає взаємопов'язані підходи до педагогіки і виробництва з метою формування майбутніх фахівців.

Інженери-педагоги мають володіти високим рівнем педагогічної й технологічної культури, теорії і практики використання: найраціональніших технологічних режимів і параметрів, сучасних контрольно-вимірювальних засобів; передових професійних прийомів і способів, що забезпечують високу якість і продуктивність праці при виконанні завдань; оптимальних педагогічних технологій [1]. У сучасній інженерно- педагогічній діяльності частіше стали вирішуватися нетрадиційні завдання, що вимагають нового мислення. Отже, формування такого мислення є актуальною задачею на сьогоднішній день.

Аналіз останніх досліджень і публікацій засвідчив, що модернізація змісту вищої освіти залежить від створення необхідних умов для реалізації варіативної частини навчальної програми (відбір інноваційних технологій, оновлення змісту освіти тощо), забезпечення змістовної та методичної наступності на всіх етапах професійної підготовки та розвитку студентів; наявності мотивації у студентів під час їхньої професійної підготовки.

Проблема сучасної підготовки інженерів — педагогів неодноразово була предметом дослідження багатьох науковців. Сучасна система вищої освіти сформувалась під впливом положень і педагогічних ідей з: філософії освіти (В. Андрущенко, Б. Гершунський, І. Зязюн, В. Кремень та ін.); теорії педагогічних систем (Л. Берталанфі, В. Беспалько, В. Загвязинський, Н. Кузьміна, В. Сластьонін та ін.); теорії особистості, психології професійної освіти на засадах особистісно розвивального і діяльнісного підходів (Л. Виготський, В. Давидов, І. Зімняя, Г. Костюк та ін.); компетентнісного підходу в зарубіжній професійній освіті (Ж. Делор, Дж. Равен, Г. Халаж, В. Хутмахер та ін.); методологічних підходів до формування інтелектуального і винахідницького мислення (В. Абушенко, Г. Альтшуллер, В. Моляко, Ю. Саламатов, Н. Слюсаренко, В. Речинський та ін.); формування особистісних і професійних якостей (І. Бех, Н. Кузьміна, О. Леонтьєв, І. Якиманська та ін.); педагогічної творчості (І. Зязюн, С. Сисоєва та ін.).

Аналіз педагогічної практики засвідчує, що наявна професійна підготовка майбутніх інженерів-педагогів не спроможна задовольнити потреби ринку праці компетентними кадрами. Незважаючи на посилення уваги дослідників до професійної підготовки інженерів-педагогів, проблема її удосконалення не має ґрунтовного відображення у науково-педагогічній та методичній літературі.

Істотні зміни, що відбуваються в системі вищої освіти в останні роки, вимагають перегляду існуючої теорії і практики професійної підготовки майбутніх фахівців. Поточний етап розвитку професійної освіти висуває підвищені вимоги до випускників вищих навчальних закладів інженерно-

педагогічного спрямування, які повинні бути креативними фахівцями, володіти новітніми педагогічними й виробничими методами і технологіями.

Питання підвищення нестандартного мислення, мотивації у студентів вищих навчальних закладів (ВНЗ) набувають особливої актуальності в контексті її реформування. Досягнути реального поліпшення у підготовці інженерно-педагогічних кадрів можливо за умови впровадження новітніх технологій і методів навчання.

Висвітлюючи особливості інженерно-педагогічного рівня освіти, варто зазначити про кваліфікаційні вимоги реєстру «Міжнародний інженер-педагог», що включає: *технічні знання й уміння викладача технічних дисциплін* (з необхідністю мати вищу технічну освіту і досвід практичної роботи); *інженерно-педагогічні знання*; *інженерно-педагогічну практику* [2–4].

Зважаючи на це, особливість підготовки фахівців інженерно-педагогічного напряму зазначає формування в них педагогічних та виробничих умінь, зокрема пов'язаних із роботою в колективі, з обслуговуванням складних обладнанн та виконань технологічних процесів, що вимагають нестандартних рішень, чіткого виконання встановлених правил, інструкцій, технічних і технологічних вимог. Досягається це оволодінням правил і норм комунікації, охорони праці, санітарії та гігієни, екологічних вимог і створенням безпечних умов навчально-виробничої праці студентів, а також шляхом навчання нестандартним та безпечним прийомам і способам праці, систематичним контролем за виконанням правил безпеки, санітарії та гігієни в процесі виробничого навчання та виробничої практики.

Перехід країни до ринкової економіки вимагає підвищення ефективності економічного виховання та економічної підготовки майбутніх інженерів-педагогів: заохочення них до вибору найбільш доцільних в економічному відношенні технологій виконання навчально-виробничих робіт; виконання доступних економічних розрахунків, застосування найбільш вигідних в економічному відношенні інженерних прийомів і способів виконання навчально-виробничих робіт, обгрунтування норм часу і виробітку та інших питань економіки праці. Важливо, щоб студенти не тільки засвоїли економічні питання, а й активно шукали рішення завдань щодо підвищення якості, продуктивності, економічної ефективності своєї праці.

Вершиною професійної підготовки майбутніх інженерів-педагогів є творче ставлення до праці, активізація пізнавального інтересу.

Отже, на підставі викладеного, особливість професійної підготовки майбутніх інженерів-педагогів залежить від наступних чинників:

1) пріоритетними стають завдання формування гармонійно розвиненої особистості, розвитку пізнавальної активності і творчості студентів, формування у них високих професійних і особистісних якостей;
2) зміст професійної підготовки має бути доповненим оптимальним підбором матеріально-технічного забезпечення, інтерактивних форм і методів навчання;
3) формування інженерно-педагогічної культури праці та загальної культури особистості (грамотне використання навчальної та технічної документації, технологічна дисципліна, виробнича естетика, дбайливе ставлення до обладнання, устаткування, матеріалів,

енергії, раціональна організація праці, висока самодисципліна, старанність, акуратність та багато ін. якостей);

4) підвищення ефективності економічного виховання та економічної підготовки інженерів-педагогів (заохочення студентів до вибору найдоцільніших в економічному відношенні технологій виконання навчально-виробничих робіт).

Методологічні підходи до формування інтелектуального й винахідницького мислення досліджували: В. Абушенко, Г. Альтшуллер, В. Моляко, Ю. Саламатов, Н. Слюсаренко, В. Речинський та ін. Теорія винахідництва, інтегрована з низкою дотичних методик, нині отримала міжнародне визнання. Вона надає інструменти для вирішення завдань різних рівнів. Але у вітчизняних ВНЗ ця теорія не впроваджена впродовж усього навчально-виховного процесу. Якщо в деяких ВНЗ і викладаються курси « Основи інженерно-педагогічної творчості», «Методи технічної творчості» та ін.. з використанням теорії винахідництва та технічної творчості, то лише як окремі курси. Як показала практика, епізодичне ознайомлення студентів на курсах не дає сталого позитивного результату в розвитку їхнього творчого (технічного та винахідницького) мислення.

У результаті анкетування, бесід та спостережень в студентів діагностовано недостатньо високу мотивацію до навчання, відсутність знань і умінь з розв'язання нестандартних проблем, міждисциплінарних зв'язків та сформованості професійних якостей майбутніх фахівців (інтелектуальний розвиток, старанність, нестандартне мислення, самостійність тощо). У зв'язку з цим автором пропонується інтегровано розвивальний підхід, що успішно опробовано у ВНЗ інженерно-педагогічного спрямування.

Інтегровано розвивальним підходом ми вважаємо засіб професійної підготовки майбутніх інженерів-педагогів, що передбачає формування у них професійних якостей та інших складових професійної компетентності за допомогою міжпредметної методики інтегровано розвивального навчання.

Інтегрованим розвивальним навчанням ми визначаємо як комплекс дидактичних і розвивальних ресурсів, спрямованих на результативну професійну підготовку інженерів-педагогів у вищих навчальних закладах.

Міжпредметна методика інтегровано розвивального навчання є комплексом взаємопов'язаних розвивальних методик і методів викладання загальнопрофесійних та професійно орієнтованих навчальних дисциплін, професійного навчання та виробничої практики, спрямованих на сучасну професійну підготовку інженерів-педагогів з метою формування їхньої професійної компетентності). Міжпредметна методика передбачає єдність загальнопрофесійних і професійно орієнтованих знань та застосування комплексу методик, зокрема: винахідництва у виробничому процесі, «тонкого торкання» контрольно-вимірювальних систем, інтеграції інженерних, педагогічних і природничо-математичних знань, моделювання у вивченні технічних об'єктів, ігрових методик розвитку технічних здатностей, фінансово-математичних розрахунків на виробництві, проблемно-дослідницьких методів вивчення технічних об'єктів, у яких розкрито закономірності систематизації, моделювання та дослідження складових техніки [1; 5].

Як показала практика, систематичне впровадження інтегровано розвивального підходу дає можливість всебічно розвинути студентів; містить

засади теорії винахідництва, природничо-математичних наук; розвивальні методики педагогічного й технічного спрямування, що використовуються у вигляді окремих фрагментів на лекціях, практичних заняттях або тренінгів. Серед інших, методи інтегровано розвивального навчання виявилися найбільш продуктивними і результативними внаслідок інтегрування знань, умінь з різних галузей науки, техніки, творчості.

Під час впровадження методів і прийомів зарекомендували себе принципи загальнодидактичні (системності, інтегративності) і професійно-розвивальні (міжпредметних зв'язків, ергономічності, випереджувальності, творчо-винахідницький і професійно-мобільний) [5; 6].

Серед сучасних принципів (інтегративності, науковості, наочності тощо) слід відзначити принципи, що ефективно зарекомендували себе під час викладання у ВНЗ [5,6]: *випереджувальності, технологічності та творчо-винахідницький.*

Завдяки принципу випереджувальності зміст навчання у професійній підготовці студентів забезпечується сучасними та перспективними виробничими технологіями.

Принцип технологічності сприяє поєднанню професійних навичок і вмінь, засобів, методів, відповідних знань, необхідних для досягнення очікуваних результатів у професійній діяльності.

Творчо-винахідницький (професійно-розвивальний принцип) сприяє створенню нового, нетрадиційного підходу до вирішення поставлених інженерних і педагогічних цілей, умінню творчо розв'язувати професійні проблеми.

Вищезазначені принципи реалізовані у розробленої нами міжпредметної методики.

Міжпредметна методика інтегрованого розвивального сприяє цілісному розвитку інженерів-педагогів. Вона складається із методик та проблемно-дослідницьких методів навчання, у яких розкриваються закономірності систематизації, моделювання та дослідження навчального матеріалу (винахідництва у виробничому процесі, «тонкого торкання» сучаних контрольно-вимірювальних систем, інтеграції природничо-математичних знань, моделювання у вивченні технічних об'єктів, ігрових методик розвитку технічних здатностей, фінансово-математичних розрахунків на виробництві, оптимізації проблемно-дослідницьких методів навчання).

Так, під час викладання дисципліни «Розслідування, облік і аналіз нещасних випадків, професійних захворювань та аварій» для студентів зі спеціальності «професійна освіта (охорона праці)» слід приділити увагу чинникам здебільшого випадків, що є причиною надзвичайних ситуацій у виробництві. Після надання необхідної інформації та опрацювання відповідної літератури, логічно поставити студентам «проблемне питання: «Що є причиною надзвичайних ситуацій у напівавтоматичному способі виробництва?» Після належного міркування студенти мають визнати, що цією причиною є відхилення позиціювання заготівки та зношеність інструмента. Використання приладів точного контролю, що розглядається в міжпредметній методиці інтегровано розвивального навчання, дає можливість отримати якісні показники механічної обробки, економічний ефект при великий безпечній праці працівника. Так, наприклад, руйнування інструмента

в обробних центрах завжди викликають руйнування шпинделя (біля 90% випадків). При середній вартості обробного центра вартість ремонту шпинделя становить від 50000 гривеньі більше, що відповідає приблизно 10% вартості верстата, не враховуючи простой обробного центра [7, с. 6]. Звісно, є можливість часткового уникнення надзвичайних ситуацій у виробництві, базуючись на відомих характеристиках стійкості різального інструмента і властивостях матеріалу деталі. Проте повне уникнення таких ситуацій без наявності приладів контролю стану інструмента, деталі та обладнання є неможливим. Сформовані трудові навички та уміння дозволяють працівникам виконувати складні трудові операції з необхідною точністю, швидкістю і мінімальними затратами енергії. На виробничій практиці для засвоєння сучасної техніки та систем контролю й вимірювання студенти з охорони праці мають навчитись аналізувати різні навчальні об'єкти, розрізняти їх суттєві та другорядні ознаки (типові й одиничні), різнобічно аналізувати об'єкти технологічного процесу, зокрема відчутник, прилади контролю торкання. На виробничій практиці студентам важливо ознайомитись як працює сучасний комплекс з відповідною системою контролю, як рухається інструмент під час обробки та контрольних вимірювань [8]. Побудову такого комплексу та траєкторія ріжучого інструмента відображено на рис. 1 та рис. 2, де T — визначення торкання інструмента та деталі, PX — координати різального інструмента, які закладені в банку даних CNC, АНБ — активна нульова база, XY — реальні величини зношення матеріала деталі та інструмента, що попадають у банк даних CNC.

Студенти мають бути ознайомленими з тим як: взаємодіють прилади контролю торкання й прилад контролю амплітуди вібрацій з відчутником, діє активна нульова база (АНБ) з CNC [9, с. 239].

Згідно програми, яка надходить з CNC, починається процес обробки. Під час технологічного процесу студенти мають усвідомити, як у випадку аварійної ситуації різко підвищується амплітуда вібрації, що реєструється згідно відповідним рівнів контролю амплітуди. У такому випадку ріжучий інструмент виходить із зони обробки і прямує до АНБ на контрольне вимірювання зношення. Якщо зношення перевищує заплановане, то викликається оператор. У випадку катастрофічної ситуації відчутник значно підвищує надійність роботи системи.

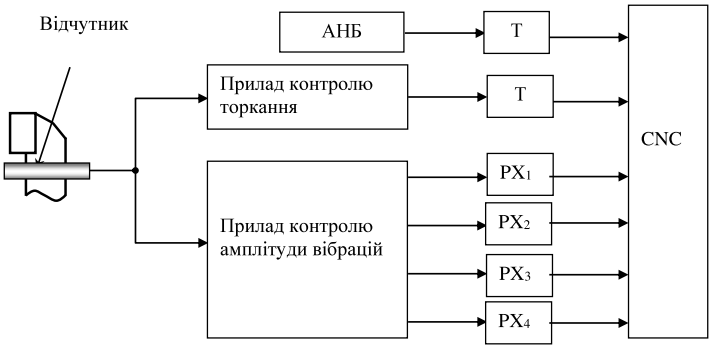

Рис. 1: Узагальнена блок схема комплексу

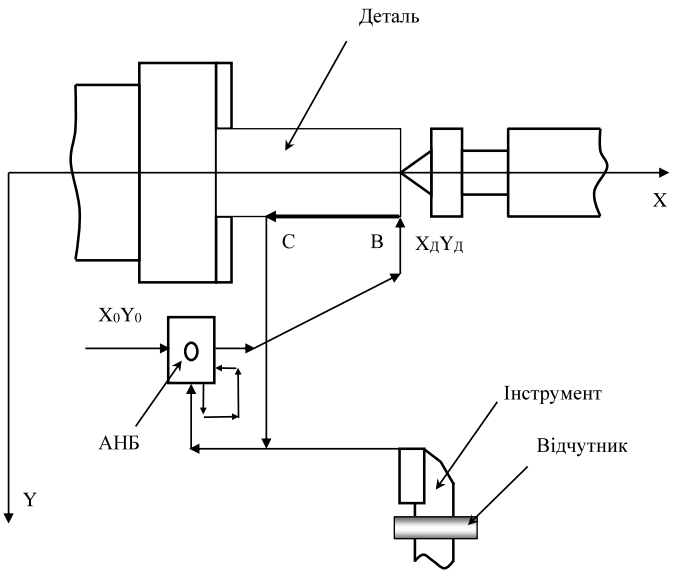

Рис. 2: Траєкторія руху інструмента під час обробки та контрольних вимірювань

Таким чином отримується контроль і передбачення зносу інструмента під час нормальної безаварійної обробки.

Під час обговорення впровадження сучасних систем контролю та вимірювання в технологічний процес обробки деталі, слід звернути увагу студентів на ефективність роботи відчутників, що разом з розглянутою системою в найкоротший шлях контролюють і вимірюють стан інструментів, обладнання, оброблюваної деталі, а також, у випадку аварійного стану обладнання, зупиняють його в автоматичному режимі.

Науково-практичний досвід переконує, що інтегровано розвивальний підхід стимулює розвиток професійної мотивації, оскільки мета навчання передбачає поєднання пошукових, винахідницьких та ін. творчих методів.

Як показав експеримент, серед цих методів найбільш продуктивними і результативними виявилися методи інтегровано розвивального навчання, зокрема винахідницькі, внаслідок інтегрування знань, умінь з різних галузей науки, техніки, творчості.

Досвід педагогічного дослідження зі студентами у ВНЗ показує на результативність використання інтегрованого підходу між технічними дисциплінами, теорією розв'язання винахідницьких задач (ТРВЗ), теорією токого торкання та іншими [9]. Виявлення їх міжпредметних зв'язків надає можливість покращити навички до розв'язання комплексних творчих задач, які зустрічаються в професійній діяльності сучасних фахівців з охорони праці.

Розглянемо, наприклад, метод оцінювання опанування студентами міжпредметних зв'язків.

Так, для комплексного підходу при оцінюванні впливу основ ТРВЗ під час експерименту зарекомендувала модель за такою формулою:

$$W = K + \sqrt{KL},$$

де K — оцінка відповідної компетентності (здатностей, умінь),

L — оцінка здатностей (умінь) з основ ТРВЗ,

$\sqrt{KL}$ — оцінка, яка враховує їх взаємозв'язок,

W — остаточна оцінка, яка визначає набутий показник професійної компетентності (або умінь з дисципліни, враховуючи ТРВЗ та відповідні компоненти професійної компетентності) [9].

Так, при вивченні, наприклад, розділів з фахової дисципліни «Розслідування, облік і аналіз нещасних випадків, професійних захворювань та аварій» для студентів зі спеціальності «професійна освіта (охорона праці)» та ТРВЗ, оцінюємо окремо матеріал з фахової дисципліни ($\boldsymbol{K}$), матеріал з ТРВЗ ($\boldsymbol{L}$) та інтегрований матеріал, який враховує їх взаємодію (міжпредметний зв'язок): $\sqrt{\mathbf{KL}}$. Чим вище цей показник, тим вищою є оцінка за інтегрований розвивальний матеріал. Такий підхід спонукає студентів до більш глибокого вивчення і ТРВЗ, і самої дисципліни та надасть мотивацію до більш якісного засвоєння навчального матеріалу.

Наочним прикладом вченого, математика, інженера і педагога, який використовував інтегровані знання з методик, що описані в статті, можна назвати Леонарда Ейлера, швейцарця за походженням, академіка Петербурзької, Берлінській, Туринської, Лісабонської і Базельської академій наук, іноземного члена Паризької академії наук [10]. Це був видатний вчений математик, фізик, механік і астроном 18 століття, праці якого суттєво справили значний вплив на розвиток науки. У цьому році виповнюється кругла дата — 310 років з дня його народження. Автор понад 800 наукових праць з математики, небесної механіки, математичної фізики, оптики, балістики, кораблебудування, теорії музики та з інших сфер науки. Він глибоко вивчав медицину, хімію, ботаніку, повітроплавання, музику, європейські та стародавні мови.

За відгуками сучасників, Ейлер був талановитим педагогом, все життя залишався скромною, життєрадісною, надзвичайно чуйною людиною, завжди готовою допомогти іншим. Ейлер охоче допомагав своїм учням, колегам і молоді, щедро ділився з ними своїми ідеями. Серед його учнів — відомі талановиті академіки М. Є. Головін, П. Б. Іноходцев, С. К. Котельников, А. І. Лексель, С. Я. Румовський, Н. І. Фусс, старший син І. А. Ейлер.

Серед великої кількості творінь Ейлера — праці з механіки і фізики. Цінність цих праць оцінив К. Трусделл, сказавши що: «механіка, як її сьогодні викладають інженерам і математикам, є значною мірою його творінням ...». Ейлер удосконалив балістику і теорію маятника, вперше в історії науки вказав на три складові частини машини, які в XIX столітті були визначені як двигун, передача та робочий орган.

В теорії гідравлічних машин і вітряних млинів він досліджував тертя частин машин, займався профілюванням зубчастих коліс, обгрунтував і розвинув аналітичну теорію евольвентного зачеплення). У 1765 році він заклав основи теорії тертя гнучких тросів, вивів формулу для визначення натягу троса, яка використовується і зараз при вирішенні низки практичних завдань, наприклад, при розрахунку механізмів з гнучкими ланками. Ейлер вдосконалив теорію пружності. 1757 році в роботі «Про навантаженні колон» він відкрив формулу для визначення критичного навантаження при стисненні пружного стержня, поклавши початок теорії стійкості пружних систем. Практичне застосування дана формула знайшла значно

пізніше — майже сто років по тому, коли в багатьох країнах розгорнулося будівництво залізниць, що зумовило до проведення розрахунків на міцність залізничних мостів — саме в цей час інженери і взяли на озброєння відкриття моделей Ейлера.

Великий вчений багато працював у сфері математики і небесної механіки. Ейлер розробив метод варіації орбітальних елементів і виклав дуже точну теорію руху Місяця. Згодом, в XIX столітті, цей метод був розширений, застосований в моделі руху великих планет, використовується до теперішнього часу. У кораблебудуванні, кораблеводінні і навігації Ейлер застосував аналітичні методи до практичних завдань, присвяченим формі судів, їх стійкості і рівновазі, методам управління рухом корабля.

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Філософія науки

Philosophy of science

Interdisciplinary Studies of Complex Systems
No. 10–11 (2017) 107–117

Небо вечного города

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I. Игорь Сикорский

Начало

В начале XX века газеты с восторгом писали о лучших в мире аэропланах созданных авиаконструктором Игорем Сикорским. Читая эти газеты, не только переносишся в то, уже кажущееся далеким время, но и удивляешся как быстро и уверенно Игорь Сикорский совершенствовал свои модели аэропланов. Газета «Тяжелея воздуха», № 8, 1912 г., в статье «Полет И. И. Сикорского над Петербургом» писала: «И. И. Сикорский совершил полет над Петербургом на аэроплане своей конструкции «Сикорский 6-А», с мотором «Аргус» в 85 л.с. и с новым приспособлением для автоматического подъема на воздух. Полет начался в 7 часов 15 минут и через 3 минуты аэроплан летел на высоте 100 метров со скоростью 115 км/час делая круги над аэродромом. Скоро И. И. Сикорский стрелой вылетел на взморье, поднимаясь все выше и выше. Пролетев Стрелку, он направился к устью Б.-Невы, по ней повернул в город, на высоте 500 метров обогнул Исаакиевский собор, пролетел еще над Невским, над Троицким мостом и через 24 минуты после начала полета, с той же высоты, планируя спирально, опустился на Комендантском аэродроме».

В следующем году газеты писали: «Конкурс военных аэропланов открылся на Корпусном аэродроме в С.-Петербурге. Конкурс пока не отличается блестящим успехом и интересных полетов почти не было. Зато аварии уже были, к счастью без человеческих жертв: пострадали машины летчиков Габер-Влынского и Жануара. Габер-Влынскому что называется не повезло: то он попадает в канаву, то падает на землю, то не может подняться совсем. Последняя же неудача Габер-Влынского совершенно поражает своим безобразием. На вновь присланном ему аппарате «Миллер № 2» при первом же полете вывалился небрежно прикрипленный к аэроплану мотор. Только изумительно-удачный планирующий спуск спас авиатора от смерти. Поврежден аппарат «Гранд» И. И. Сикорского на который упал «Миллер № 2»... Остается одна надежда, что конец конкурса с блеском искупит неудачное начало! — «Русский Витязь» Сикорского вызывает всеобщее изумление своими высокими качествами.» («Всемирное обозрение», № 89, 1913 г.)

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«С большим удовольствием следует остановиться сейчас на крупном успехе молодого конструктора, путем усидчивого труда и долгих опытов выработавшего аэроплан, равного которому сейчас нет во всем мире. Мы говорим об И. И. Сикорском и его грандиозном аэроплане «Русский Витязь». («Природа и люди», № 45, 1913 г.)

А уже через год, авиатор Г. Пиотровский в своем очерке «Шестнадцать человек и собака — на аэроплане», описывал исторический полет на воздушном корабле И. И. Сикорского «Илья Муромец», в котором он принимал участие. «Илья Муромец» установил мировой рекорд полета с шестнадцатью пассажирами, общей нагрузкой в 1300 кг, на высоте 300 метров в продолжении 18 минут и 10 секунд.

Аэропланы, воздушные корабли, — все это манило в небо, манило ощутить отрыв от земли, манило славой и геройством, ибо, действительно, было делом опасным. Газеты, например, писали: «Воздадим должное памяти трех военных летчиков, — поручика Балабушки, Цамая и Поликарпова, убившихся при катастрофах с их аэропланами. Пусть кресты из пропеллеров на их могилах будут чаще напоминать нам о тех жертвах долга, которыми усеян трудный, но все-таки победный путь к окончательному покорению воздушной стихии».

Что же так стремительно влекло Игоря Сикорского в Небо? От матери он услышал о проектах летательных аппаратов великого Леонардо да Винчи. И легенда рассказывает, что однажды ему приснился сон, что летит он на воздушном корабле и это стало мечтой всей его жизни. Его мечтой стал полет в Небо бесконечного Света, который неизбежно поглощает все конечное темное, ибо все конечное преходяще... Об этом Небе он написал в своих религиозно — философских работах, параллельно создавая лучшие в мире вертолеты. Возможно, он никогда бы не написал этих удивительных произведений человеческого духа, если бы не родился в Киеве, где закончил Политехнический институт, не работал бы в Петербурге и не эмигрировал бы в 1919 году в Америку.

«Да придет царствие Твое, да будет воля Твоя, яко на небеси и на земли»

В 2009 году киевлянин Игорь Криштафович выложил на своем сайте свой перевод работы Игоря Сикорского «Послание Молитвы Господней», в которой автор говорит о своем понимании молитвы «Отче наш». Этой молитве посвящены многие глубокие исследования и комментарии на многих языках мира, но впервые, человек выдающегося инженерного ума и необыкновенно развитой интуиции взялся за изложение точки зрения исследователя, не боящегося делать смелые заключения, и в тоже время искренне верующего.

Игорь Сикорский разделил царство земное и царство Небесное и сделал, на первый взгляд, неожиданный вывод: «Молитва Божия указывает нам, что нужно молиться за Царство Божия НА НЕБЕСАХ. Эти слова и определяют значение и цель молитвы».

Царство земное нам хорошо известно, как и две тысячи лет назад мы видим много несправедливости и бываем потрясены невыносимым видом торжествующего зла и можем в отчаянии восклицать «Господи, зачем ты покинул нас?». Сикорский пишет, что земная жизнь нужна для укрепления духа, формирования характера и осознания ценностей царства Небесного. Ибо ценности эти и радости не от мира земного, это не радости от власти над людьми, не радости от владения сокровищами земными, это радости духовного сотрудничества, творчества, познания единства и красоты Мира. И если мы молимся за царство Небесное, значит мы осознаем Его, верим в Него и молитвой нашей притягиваем пришествие Его на землю.

Сикорский пишет о царстве Небесном: «Традиционная христианская доктрина, как правило, не усматривала ничего общего между небом астронома и небом религиозного человека. В этом отношении религиозная доктрина следует заключениям ранних христиан, которые находились под влиянием их веры о том, что Земля является основанием вселенной с солнцем и звездами в качестве придатков к ней. Их вселенная была малой структурой, созданной, как они думали, в течении шести дней где-то около четырех тысяч лет назад. Создание пошло неверным путем почти с самого начала и ожидалось, что будет вскорости разрушено, сожжено пламенем и заменено совершенно новой конструкцией. Для современного просвещенного человека общая картина представляется другой. Вселенная, получившая импульс энергии много миллиардов лет назад, вероятнее всего, останется существовать еще примерно такое же время. Ее размер и величие находятся за пределами нашего разума. Я упоминаю об этом, так как думаю, что слово ВСЕЛЕННАЯ должно пониматься в его высшем значении как очень близкое, если не идентичное, слову НЕБО. ...

Функционирование небесных механизмов дает нам представление о том, что может происходить в явлениях высшего порядка, находящихся вне видимости, где силы гравитации и притяжения заменены доброй волей и любовью в их высшем значении. Мы можем представить множество разумных и могущественных живых существ порядком выше, чем мы с вами, и действующих в этой небесной вселенной совершенно свободно и между тем в абсолютной гармонии, воссоединенные между собой и объединенные Властелином Вселенной непреодолимым чувством доброй воли».

Сикорский делает далее очень интересное сопоставление земного и Небесного царств: «Анализируя главные из основных характеристик материальной вселенной, мы можем придти к интересному заключению. Представим себе свет в качестве аналогии жизни, добра, счастья и противоположную ему тьму, олицетворяющую зло, агонию и разрушение. Очевидно, что размах и интенсивность каждой из них абсолютно различны. Человек может создать свет определенной интенсивности. Свет, излучаемый Солнцем, бесконечно более ярок. Существуют звезды в десятки тысяч раз более яркие, чем Солнце. Во вселенной имеется свет бесконечно более яркий, чем это доступно человеку. Выражение «безмерно или бесконечно яркий свет» имеет вполне практическое значение. По отношению же ко тьме, картина получается совершенно иной. Выражение «безмерная или бесконечная тьма» не имеет значения. Полная темнота это все , чем она могла бы быть. Если человек спускается в шахту всего лишь несколько сотен

футов под землей, он находит абсолютную темноту, как если бы он погрузился в самую глубину «внешней тьмы». То же самое является истинным по отношению к теплоте. . . . Точно так же, как тьма и холод, которые могут быть достигнуты на земле, являются практически предельно возможными, в то время как получаемые нами свет и энергия являются пренебрежимо малыми по сравнению со светом, существующим во вселенной-небесах Господа. Зло, страдания и агония, которые мы наблюдаем на земле, вероятно близки к наивысшему пределу, какой только может существовать во вселенной».

Сикорский рассматривает земную жизнь человека как «великолепный дар и возможность, данную с целью выработки индивидуальности, достойной выживания в высшем порядке бытия». Он пишет о божественном даре, данном человеку, — свободе воли: «Как ни невероятно это звучит, свободное согласие человека имеет, очевидно, значение применительно к будущему пришествию Царства Небесного. Важность и достоинство, принимаемое человеком, когда он обращает свое прямое ходатайство к Царю вселенной касательно результата всего земного процесса, распознается редко. Когда человек произносит эти смелые и значительные слова («Да будет воля Твоя яко на небеси и на земли»), он поднимается над всеми нуждами, амбициями, гневом, всем очевидным триумфом греховности. . . . В молении о будущем Божественном Царстве вечной жизни, правды и славы, человек косвенно выражает свою собственную надежду вступления в него; в противном случае, было бы жестоким разочарованием молиться о триумфе божественной праведности если человек приговорен никогда не увидеть его и если все его личное сознательное существование было бы ограничено устроением настоящей земной жизни тьмы и страдания».

И в заключении Игорь Сикорский пишет: «Молитва Господня была составлена Автором для нашей земной жизни с целью проведения нас через бурный и драматический процесс нашего духовного рождения. Когда же этот период завершиться на Земле и, возможно, на других похожих планетах, цель всей Молитвы будет исполнена. Но является вполне допустимым, что, воздавая хвалу и славя Творца, счастливые обитатели высшего порядка бытия будут все использовать следующие три предложения Божьей Молитвы, которые есть и останутся сверх всех границ времени и пространства.

Отче наш, иже еси на небесах!
Да святится Имя Твое...
Яко Твое есть Царствие и сила, и слава во веки».

Сборник философско-религиозных работ Игоря Сикорского на русском языке, — «Небо и Небеса», был издан в 2010 году и переиздан в 2013.

«Тихо задзвонили у Києві, мов на Небі. . . »
Тарас Шевченко

Игорь Сикорский родился в Киеве в 1889 году. В 1898 году был основан Киевский Политехнический Институт. В 1911 году Игорь Сикорский

окончил Киевский политехнический институт, а в 2016 году Киевскому Политехническому Институту было присвоено имя Игоря Сикорского.

Киев начала XX века. Уже долго Киев — город богомолья, огромное количество церквей, монастырей и соборов. Великих соборов, от построенной Ярославом Мудрым Святой Софии до недавно освященного собора Святого Владимира, расписанного Васнецовым, Нестеровым, Врубелем... Маковки церквей и соборов покрывают город молитвенным куполом, кресты на куполах как антенны в небо и под этим куполом люди, которые хотят подняться вверх, взлететь ... — Ровесник Сикорского, киевлянин, студент Киевского университета Св. Владимира Михаил Булгаков, — его Мастер и Маргарита улетят, глядя вниз на Землю, как сам Булгаков смотрел с высоты Старокиевской горы на Подол; киевлянин, студент Киевского университета Николай Бердяев, чьи философские работы оказали влияние не только на Сикорского, но и на все общество, он разработает понятия мира духа и мира природы, невозможность (трудность) преодоления царства природы и трансцендирование как творческий прорыв, преодоление рабства природно-исторического бытия; ровесник Николая Бердяева, киевлянин Казимир Малевич ученик Киевской рисовальной школы Н. И. Мурашко, в свое время закрасит черным квадратом цветные геометрические фигуры декораций к футуристической опере «Победа над Солнцем» и увидеть в этом черном квадрате радуги надземного мира, и напишет, затем, философские работы о мире вне земных форм; ... Их было много, детей города, кого духовный магнит Киева притянул к себе...

Семья Терещенко была одной из самых известных в городе, — промышленники, меценаты, общественные деятели, — представители этой семьи очень много сделали для Киева, в частности, внесли 150 000 рублей на строительство Киевского политехнического института, который строился по примеру Политехнических институтов в Цюрихе, Мюнхене и Ганновере.

В 1909 г., в Киевском политехническом институте, профессором Н. Б. Делоне (ученик Жуковского) было организовано общество воздухоплавателей (КОВ), среди членов общества были Игорь Сикорский и Федор Федорович Терещенко. Ровесники, они оба работали над своими моделями самолетов. Федор Терещенко мечтал сделать Киев столицей авиастроения, в своем имении Червоно он соорудил летное поле и мастерские для сборки самолетов собственной конструкции, построил помещения для своего конструкторского бюро. Один за другим стали появляться самолеты «Терещенко-1», «Терещенко-2», «Терещенко-3», ... Федор Терещенко был достойным представителем своей знаменитой семьи, — он был промышленником и мечтал о заводах, которые будут массово выпускать самолеты. После революции поместье Червоно у Терещенко отобрали, в прекрасном неоготическом замке поместья разместили беспризорников, в авиамастерских скот. Федор Терещенко уехал во Францию и авиацией уже больше никогда не занимался...

По инициативе общества воздухоплавателей в Киеве при Политехническом институте был построен авиагараж, где студенты и преподаватели КПИ создавали свои первые летательные аппараты, было расчищено Летное поле для первых полетов. Здесь Игорь Сикорский, а так же Петр Нестеров совершали свои первые полеты, — полеты на хрупких летательных машинах с мотором мощностью всего в 25 лошадиных сил...

В большой физической аудитории КПИ Сикорский слушал лекции по физике. Пройдет совсем немного времени и в этой же аудитории будет слушать лекции по физике тот, кто пошлет в космос первого космонавта, — Сергей Королев. Они пересекутся в пространстве аудиторий и лабораторий, а через сто лет, уже в XXI веке на территории института в их честь им будут установлены памятники.

В помещении бывшего авиагаража сейчас находиться музей И. Сикорского. Символическую ленту на входе в который, 14 мая 2008 года, в присутствии студентов и преподавателей КПИ перерезали академик НАНУ М. Згуровский и экс-мэр Нью-Йорка, политик и бизнесмен Рудольф Джулиани.

«Америка, Америка...»

Легенда говорит, что Игорь Сикорский приехал в Америку всего с двадцатью долларами и купил на них билет на концерт Сергея Рахманинова. После концерта Сикорский и Рахманинов встретились, разговорились, Рахманинов поверил в Сикорского и отдал ему свой гонорар за концерт, — 5 000 долларов.

Мы не знаем сколько долларов было у Игоря Сикорского, когда он приехал в Америку, известно только, что первое время он сильно нуждался, зарабатывая уроками математики, которые давал детям эмигрантов. Но встреча с Сергеем Рахманиновым, действительно, состоялась и Рахманинов вложил пять тысяч долларов (большие деньги по тем временам) в проект Игоря Сикорского. Союз этих двух людей не является странным, — они оба служили царству Небесному, каждый по своему.

В 1923 году Сикорский собрал группу из эмигрантов, причастных к авиации и основал авиационную фирму «Sikorsky Aero Engineering Corporation». Он стал президентом этой фирмы, а Рахманинов какое-то время числился вице-президентом. Деньги, вложенные Рахманиновым в фирму, дали возможность ей выжить и уже в 1929 г. Сикорский смог вернуть эти деньги.

Работа шла успешно, — убирающееся шасси, пропеллер с постоянной скоростью вращения, ... Грузовые и гражданские летательные машины, созданные Сикорским в Америке, как и раньше, продолжали устанавливать мировые рекорды по грузоподъемности, скорости и высоте полета. Пришло признание великой страны.

В Америке Сикорским было создано 14 базовых типов самолетов и 18 вертолетов. Лучший вертолет гениального инженера поднялся в воздух в 1954 году, — это был S — 58. Основатель мирового вертолетостроения долго оставался на недосягаемой высоте.

Тихо зазвонили на Небе, ... 26 октября 1972 года Игорь Иванович Сикорский не проснулся, — он покинул земной план.

II. Олег Антонов

Олег Антонов приехал в Киев в 1952 году, здесь он прожил тридцать лет. В Киеве он организовал конструкторское бюро и создал самые большие в мире, для своего времени, самолеты, — «Антей» и «Руслан». Эти самолеты установили десятки мировых рекордов и потрясли воображение современников.

Когда Олега Антонова спросили, что он испытал при первом взлете на «Антее» в качестве пилота, он ответил: «А что может испытать человек, в правой руке которого шестьдесят тысяч лошадиных сил, а в левой — больше двухсот тысяч килограммов веса?» Богатырская линия в авиации, начиная от «Русского Витязя» и «Ильи Муромца» Сикорского нашла свое завершение в «Антее» и «Руслане».

А все начиналось с планеров. Олег Антонов изучал планеры Сикорского, потом строил свои. Планеры он строил и тогда, когда был уже известным авиаконструктором. Ибо планер это — крылья, а если человек хочет взлететь, если его неудержимая мечта летать, — ему нужны крылья...

Планер

В двадцатых годах прошлого столетия, в Коктебеле проходили ежегодные слеты планеристов. Среди участников слетов были будущие знаменитые летчики, авиаконструкторы, конструкторы космических аппаратов. В этих слетах, со своим планером участвовал и Олег Антонов. В 1923 году на Коктебельский слет приехали студенты КПИ, и среди них Сергей Королев. Здесь и познакомились Олег Антонов и Сергей Королев. Их взгляды на техническое развитие авиации не всегда совпадали, Олег Антонов не мог понять стремление Королева поставить на планер реактивный мотор, это казалось ему неэкономичным расходованием энергии. В Королеве Антонова поражала его устремленность и сила воли и он назвал его всадником ветра. Хотя Королев был скорее всадником огня, а истинным всадником ветра был сам Антонов. Обоих объединяло творческое устремление, желание летать и молодость. Позже, в своих мемуарах «На крыльях из дерева и полотна», Олег Антонов опишет атмосферу планерных испытаний в Коктебеле: «Стоя над крутым южным склоном горы Климентьева, наклонившись против упругой громады ветра, мы с волнением следили за схваткой человека с небом. Было видно, как гнутся тонкие длинные крылья. Все дальше, вот уже в десятке километров от нас мерцает под катящимися с моря желто-серыми валами облаков, то появляясь, то исчезая, тонкая родная черточка. Там человек в тесной фанерной гондоле, поддерживаемый только легкими крыльями из дерева и полотна упрямо стремился вперед, навстречу порывам осеннего шторма. Вот черточка качнулась, наклонилась и решительно двинулась через залив. Вот мелькнула еще, вот еще раз, последний раз на пределе зрения молодых глаз. Все... Видны только рвущие пену свинцовые волны моря, сомкнутые валы хмурых облаков да черная, насупившаяся громада Кара-Дага.»

Олег Антонов прекрасно владел словом, писал стихи, но больше увлекался живописью и говорил: «Если бы я не стал авиаконструктором, я бы стал художником». По его мнению конструктор должен был уметь рисо-

вать, ведь только «красивый самолет будет хорошо летать». Его самые большие самолеты в мире были похожи на летающих дельфинов, они были красивы.

В феврале 2017 года в Музее ГП «Антонов» в Киеве, к 111-той годовщине со дня рождения Олега Антонова была открыта выставка его картин. Это были работы разных лет и разных настроений. Были работы, похожие на ученические натюрморты, работы сугубо личных переживаний, пейзажи, но все работы звучали одной нотой, — нотой человека, который парил над землей. Вот работа «Детские игрушки»,- грустный мишка и голая кукла лицом вниз, как упавший самолет, возможно, это были подсознательные переживания о катастрофе в детстве, — рано умерла мать. А вот и работа «Катастрофа», — части разбившегося самолета и изящная женская туфелька на шпильке, — такую туфельку могла носить только молодая и красивая женщина... И, конечно, самолеты, красивые самолеты как птицы и много-много неба.

Приемные дети города

Что такое город? Город это прежде всего люди, люди, которые жили в нем, которые живут сейчас. Которые его строят или разрушают, наполняют радостью или печалью. Среди них есть те, кто создает метафизическую основу города, те, кто служит приходу царства Небесного и имеют Его покровительство.

Революция, коммунистические репрессии и гражданская война многое разрушили, многое не позволили совершить... Сикорский, Терещенко, Булгаков, Бердяев, Малевич,.... дети Киева покинули свой родной город и нашли последний приют в других городах, странах и континентах. Репрессии тридцатых годов и война причинили большие разрушения городу, были попытки разрушить самый центр молитвенного купола города. — храм Св. Софии Киевской. Но храм уцелел, Оранта оставалась гарантом света царства Небесного, который не покидал город. И с конца сороковых годов этот свет стал притягивать в город новых людей. И задачи уже стояли совсем новые. В конце 1949 года в Киеве под руководством Сергея Лебедева был создан первый в СССР и континентальной Европе компьютер (МЭСМ). В Киев приехал один из пионеров мировой кибернетики Виктор Глушков, математик Анатолий Скороход начал фундаментальные работы в области теории вероятности, из Казани в Киев приехал физик Петров и начал строить один из первых в мире детекторов по улавливанию гравитационных волн, в Киев приехал знаменитый кардиохирург, кибернетик и писатель Николай Амосов, и другие. В Киев приехал и Олег Антонов. Здесь, в Киеве совершался прорыв в информационных технологиях. И когда позже собирался триумфальный грузовой самолет «Руслан», то отдельные его блоки уже рассчитывались на компьютере и часть деталей самолета изготовляли роботы.

Николай Амосов хорошо знал Олега Антонова, он так же хорошо знал и находился под влиянием творчества Виктора Глушкова и проводил исследования мозговой деятельности человека, хорошо знал он и Бориса Патона и в некотором смысле был объединяющим центром научной элиты Киева.

Поэтому идеи, высказанные им в его произведении «Мое мировозрение» во многом выражают мировоззрение его круга и времени. Амосов писал:

«Мир материален и познаваем... Эволюция мира объясняется самоорганизацией структур. Ее первый этап — неорганическая природа. Второй — биологические системы — от клетки до стаи, с целевыми функциями (ЦФ). ЦФ выражаются в потребностях и мотивах и реализуются через разум. Разум — это аппарат управления использующий модели и сигналы. Высшим его проявлением является творчество — создание новых моделей... Техническая эволюция на базе искусственного интеллекта способна изменить не только мир природы, но и человека».

В этом мировоззрении кибернетика выступала уже как предтеча синергетики, но творчество еще не рассматривалось как самоорганизация духа. И что есть дух? И если мир материален и познаваем, то что есть материя духа и можем ли мы ее познать? Эти вопросы оставались в сфере философии, но не конкретной науки.

Это было время веры в человеческий разум, время оптимизма и надежды, что компьютеры, роботы, эволюция на базе искусственного интеллекта принесет человечеству счастье. Сегодня, летом 2017 года, СМИ пишут, что потери мировой экономики от кибератак в 2016 году составили примерно 450 миллиардов долларов (насколько примерно?), а Илон Маск с тревогой обращается к правительствам мира о том, что искусственный интеллект может начать распространять фейковую информацию и манипулировать ею, что в военной сфере может привести к войне. Он так же предупреждает, что хакеры могут взламывать автономное оружие и использовать боевых роботов в недопустимых целях ...

Появление первых моделей квантовых компьютеров заставляют задаться вопросами: могут ли квантовые компьютеры взломать все охранные системы и вскрыть всю секретную информацию? Может ли искусственный интеллект подчинить себе людей?... Процесс познания остановить нельзя, но что является гарантией дальнейшей эволюции человека как творческой единицы в гармонии с Космосом? Что может предупредить возможное возникновение вирусных ветвей искусственного интеллекта, которые выйдут из-под контроля ? Здесь можно обратиться к одной из важнейших теорем кибернетики, — теореме Маккалока — Литса: промоделировать некую самоорганизующуюся систему может только система на порядок более сложная. Достоевский сформулировал эту теорему как «красота спасет мир».

Ведь красота это гармония вибраций, пропорций, масштабов... Это гармонические иерархии, где высшее ведет низшее, что, к сожалению, нарушено в нашем царстве земном. Орган, который оценивает вибрации получаемых человеком энергий и информаций есть сердечный центр (нервный узел и связанная с ним вилочковая железа). Положительный гармонический обмен вибрациями — симпатия, сочувствие, бескорыстие... В природе все колеблется, вибрирует. Гармонические частоты вибраций приводят к притяжению. В этом плане сердечный центр можно рассматривать как магнит. Магнит, притягивающий и синтезирующий гармонические вибрации. Красота жизни в ведущем принципе творческого магнита. Человеческое общество сегодня имеет дефицит красоты, или, что есть си-

ноним, — гармонии. Гармонии человека с человеком, человека с природой, обществом, человека с космосом... иначе нам бы не приходилось говорить об опасностях искусственного интеллекта.

Самолет это синтез гармонических вибраций, пропорций и масштабов. Можно ли создать самолет для мирных целей, послушный и надежный не обладая чувством красоты?

Олег Антонов служил красоте осознанно, в своем стихотворении «Красота» он писал:

Зачем я сражался упорно, жестоко,
Какой поклонялся безумной мечте?
Какая стезя завела так далеко?
Мечта о прекрасном —
любовь к красоте.
Усталость и муки с терпеньем Сизифа
Лишь ради тебя я, не дрогнув сносил,
Лишь ради далекого, светлого мифа
Я горы ворочал и камни дробил.
И где бы я ни был,
и чтоб ни случилось,
Всегда поклоняться я буду тебе,
И в час неизбежный
позволь мне, как милость,
Сгореть в твоем чистом и светлом огне.

До последних своих дней, Олег Антонов переживал о несправедливости по отношению к Игорю Сикорскому со стороны государства. Имя Сикорского и его достижения не упоминались, его отъезд заграницу подвергался осуждению. В книге из серии «ЖЗЛ» «Олег Антонов» Василия Захарова можно прочитать подробности о причинах по которым Игорь Сикорский уехал заграницу: «Сикорский , оставшись в 1917 году не у дел, обратился к руководству ВСНХ Ларину с вопросом о судьбе и будущем отечественной авиации. По свидетельству присутствующего при разговоре будущего создателя красной авиации Акашева, Ларин (тесть Николая Бухарина) ответил однозначно: «Пролетарскому государству авиационная промышленность не нужна, как не нужны фабрики косметики, духов и других ненужных предметов». Тут же Ларин отдал распоряжение перевести мастерские, изготовлявшие и ремонтировавшие самолеты на выпуск мебели...

В начале 80-тых годов прошлого века, когда появились первые реабилитации известных людей, Олег Антонов организовал и подписал письмо с просьбой реабилитировать имя Игоря Сикорского и получил ответ: «Вертолеты Сикорского бомбили Вьетнам, — о реабилитации имени конструктора не может быть и речи»...

Опять начало

Что такое вечный город? Почему люди называют некоторые города вечными, как, например, Рим? Наверное, вечный город, это город, в кото-

ром на протяжении столетий и тысячелетий из поколения в поколение передается эстафета творчества, наслаивается энергия духа. Это город в котором заложен магнит, который несмотря на попытки разрушить его продолжает притягивать к себе родственных духов. Вечный город это город за который из века в век идет битва царства земного против людей царства Небесного.

Связь поколений существует даже если мы этого не осознаем, ибо эта связь обусловлена законом причины-следствия. Ничего нет случайного, в двадцатом веке было математически показано, что случайность это большая сложность. Сложность, которую мы не можем осознать. И ничего нет бесследного,- «Тот, кто когда-то думал и действовал, и поныне мысль и действие. Ничто истинно сущее не умирает». (Джон Ди)

Приемные дети Киева познали все тягости, которые сопровождают тех, кто идет впереди, — предательство коллег, анонимные доносы завистников, непонимание чиновников,... тем не менее они жили в относительно спокойное и благополучное время. О таком времени Игорь Сикорский писал в «Послании Молитвы Господней»: «Во времена относительного затишья и мира, когда цивилизованная учтивость и традиционное лицемерие заслоняют от нас дьявольскую сущность (царства земного), мы становимся готовыми к тому, чтобы отрицать его реальность, думая о том, что вся бесчеловечность осталась в далеком прошлом. В такие времена легче иметь веру в триумф прогресса и идеализм. Но когда наступает кризис, божественное пламя в сердце может стать светом, который приведет на крест и Голгофу, которые могут стать реальными, даже если только причиняют душевные страдания. Те, кто являются духовно возвышенными и сильными, могут вынести свой крест, хотя это и бросает вызов их вере и мужеству».

В 90-тые годы прошлого столетия относительное затишье в Киеве окончилось, начался очередной кризис. Несостоявшийся социализм уступил место варварскому капитализму, деньги стали главной ценностью и коррупция расползлась по всем направлениям. А люди хотели строить красивое и справедливое общество, — начались революции...

Сегодня город продолжает переживать трудное время, много молодых одаренных людей уезжает из него, но кто знает, может быть именно сейчас в Киеве работает инженер, который изучает материю духа, — новые энергии с удивительными свойствами, которые могут дать людям неограниченные возможности жизни и творчества; может быть тот, кто родился в Киеве, но уже работает в другой стране приближает время квантовых компьютеров, которые, будем надеяться, фантастически изменять нашу жизнь к лучшему; а кто-то в математических структурах и моделях прозрел закономерности синтеза, того синтеза, который сегодня является магистральным направлением эволюции ... Ибо стоит на берегу Днепра вечный город и влюбляются в нем люди друг в друга, и сочиняют новую интересную музыку, и пишут художники картины, а кто-то придумывает новый сценарий сказки, вечной сказки о том, что добро побеждает зло...

И молятся в городе люди о царстве Небесном, и знают, что приход царства Небесного можно замедлить, цену Его прихода можно увеличить, но отменить нельзя.

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Discussion Club

Artificial intelligence (AI) — danger or a new possibility for humanity?

Artificial Intelligence is part of our life.

Computers and robots help us cure diseases, build and explore the world around us.

They help us communicate with each other, and the world becomes more interesting.

Nevertheless everything has its shadow:

> Leaders in the fields of AI and robotics (the founders of 116 AI and robotics companies from 26 countries), including Elon Musk and Google DeepMind's Mustafa Suleyman, have signed a letter calling on the United Nations to ban lethal autonomous weapons, otherwise known as "killer robots".

In their petition, the group states that the development of such technology would usher in a "third revolution in warfare", that could equal the invention of gunpowder and nuclear weapons.

The founders wrote: "Once developed, (autonomous weapons) will permit armed conflict to be fought at a scale greater than ever, and at timescales faster than humans can comprehend. These can be weapons of terror, weapons that despots and terrorists use against innocent populations, and weapons hacked to behave in undesirable ways...".

Francois Chollet, the creator of the deep neural net platform Keras, replied that while AI "makes a few existing threats worse" it was unclear if it created any new ones. "Arguably the greatest threat is mass population control via message targeting and propaganda bot armies. (machine learning is) not a requirement thougt", said Chollet.

David Yang, the founder of ABBYY, marked that AI could get out of control, like a virus spreading to millions of computers.

Some well-known politician said that future wars might end when all the drones on one side destroyed all the drones on the other side.

.....

The process of Machine learning and research is unstoppable.

Can Human Consciousness (HC) control AI?

Do they correlate with each other as Sherlock (HC) and Watson (AI) do?

HC is not only intellectual abilities, it is also a person's capacity to feel and discern feelings:

> pain or no pain, remorse or no shame, beauty or disharmony, ...

Why does Sherlock Holmes play the violin?

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Announcement

The new book by ROGER PENROSE:

FASHION, FAITH and FANTASY
in the New Physics of the Universe

Roger Penrose, one the world's foremost theoretical physicists, has won numerous prizes. He is the bestselling author:

"*The Nature of Space and Time*" (with Stephen Hawking),

"*The Emperor's New Mind: Concerning Computers, Minds, and Laws of Physics*",

"*Shadows of the Mind: A Search for the Missing Science of Consciousness*",

"*The Road to Reality: A Complete Guide to the Laws of the Universe*",

"*Cycles of Time: An Extraordinary New View of the Universe*".

Roger Penrose is the Rouse Ball Professor of Mathematics Emeritus at the University of Oxford.

What can fashionable ideas, blind faith, or pure fantasy possibly have to do with the scientific quest to understand the universe? Surely, theoretical physicists are immune to mere trends, dogmatic beliefs, or flights of fancy? In fact, acclaimed physicist and bestselling author Roger Penrose argues that researchers working at the extreme frontiers of physics are just as susceptible to these forces as anyone else. In this provocative book, he argues that fashion, faith, and fantasy, while sometimes productive and even essential in physics, may be leading today's researchers astray in three of the field's most important areas — string theory, quantum mechanics, and cosmology. ...

Finally, Penrose describes how fashion, faith, and fantasy have ironically also shaped his own work, from twistor theory, a possible alternative to string theory that is beginning to acquire a fashionable status, to "conformal cyclic cosmology", an idea so fantastic that it could be called "conformal crazy cosmology."

The result is an important critique of some of the most significant developments in physics today from one of its most eminent figures.

Princeton University Press

By all means, scientific hypotheses and fantasy should be verified by precise calculations and experiments, however they should not depend on fashion and dogma in science. In this case the Science does evolve.

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Зміст

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Contents

Тематика та мета журналу

«Міждисципрлінарні дослідження складних систем» — це рецензований журнал із вільним доступом, що публікує дослідницькі статті, огляди, повідомлення, дискусійні листи, історичні та філософські студії в усіх областях теорії складних систем для впровадження взаємодії між науковцями з різних галузей математики, фізики, біології, хімії, інформатики, соціології, економіки та ін. Ми бажаємо запропонувати істотне джерело актуальної інформації про світ складних систем. Журнал має стати частиною наукового форуму, відкритого та цікавого як для експертів з різних областей, так і для широкої аудиторії читачів: від студентів до досвідчених дослідників. Журнал надає можливість для науковців з різних галузей презентувати нові ідеї, гіпотези, піонерські дослідження. Особливо запрошуються до публікації автори наукових статей та (але не тільки) наукових оглядів, проте статті з історії та філософії науки, інформації про наукові події, дискусійні повідомлення також вітаються.

Інформація для авторів

Журнал друкує оригінальні статті, огляди, повідомлення українською, російською, англійською та німецькою мовами. Статті українською та російською мовами мають містити переклад англійською назви статті, анотації та прізвищ авторів.

Статті приймаються виключно в електронному вигляді, файли мають бути підготовлені в LaTeX чи в текстовому процесорі (Microsoft Word, Open Office Writer і т. д.). Інші формати файлів мають бути попередньо узгоджені з редакцією. Ілюстрації мають бути високої якості, графіки та діаграми, що підготовлені в інших програмах, мають подаватися окремо, у вихідному форматі. Журнал друкується чорно-білим, проте у електронній версії матеріали будуть відображені у кольорі.

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Aims and Scope

"Interdisciplinary Studies of Complex Systems" is a peer-reviewed open-access journal, which publishes research articles, reviews, letters, discussions, historical and philosophical studies in all areas of the complex systems theory in order to provide the interaction between scientists working in different areas of Mathematics, Physics, Biology, Chemistry, Computer Science, Sociology, Economics etc. We would like to promote the significant source of up-to-date information on complex systems worldwide. The journal shall be a part of the scientific forum, open and interesting for experts from several areas and for a broad audience from students to senior researchers. The journal shall give a possibility for scientists from different disciplines to present new ideas, conjectures and pioneering developments. The research papers and (but not only) reviews are especially encouraged. At the same time, papers in the history and philosophy of science, information about scientific events, discussion papers will welcome.

To authors

The journal publishes original articles, reviews, information on English, Ukrainian, Russian, and German. Russian and Ukrainian articles should contain English translations of a title, an abstract and authors' names.

The submitted articles should be in an electronic form only. Files should be prepared in LaTeX or in a text-processor program like Microsoft Word, Open Office Writer etc.). Other formats of files might be accepted by the previous agreements with editors only. Pictures should have the high quality, graphs and diagrams which are prepared in external programs must be submitted separately in the original format. The journal is published 'black-and-white' however the electronic version will represent the full color of all materials.

Articles, questions, and advices should be sent to the editorial office by e-mail: **iscsjournal@gmail.com**.

Наукове видання

Міждисциплінарні дослідження складних систем

Номер 10–11

Головний редактор — **В. П. Андрущенко**
Виконавчий редактор — **Ю. Г. Кондратьєв**
Секретар — Л. В. Савенкова
Редагування, коректура — Л. Л. Макаренко
Підготовка оригінал-макету — О. Л. Шаповалова

Підписано до друку 27 жовтня 2017 р. Формат $70 \times 108/16$. Папір офсетний. Гарнітура ComputerModern. Друк офсетний. Умовн. друк. аркушів 11.025. Облік. видав. арк. 9,35.

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Свідоцтво про реєстрацію № 1101 від 29. 10. 2002
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