Manuscript

PRONSKIKH VITALY STANISLAVOVICH

EPISTEMOLOGICAL AND SOCIAL-ONTOLOGICAL PROBLEMS OF THE CONTEMPORARY PHYSICS EXPERIMENT

Specialty 09.00.08 – Philosophy of Science and Technology

Synopsis

of Candidate of Science (PhD) thesis

Moscow – 2016

The study was carried out at Moscow Institute of Physics and Technology (State University), Department of Philosophy.

Scientific advisor	**Lipkin Arkadiy Isaakovich,** PhD, DSc in Philosophy, Assistant Professor.
Official opponents:	**Storozhuk Anna Yurievna**, PhD, DSc in Philosophy, Novosibirsk National Research State University, Assistant Professor at Department of Logic and Methodology of Science, Institute of Philosophy and Law.
	Belinskiy Aleksandr Vitalievich, PhD, DSc in Physics and Mathematics, Lomonosov Moscow State University, Lead Scientist, Department of Mathematical Modeling and Informatics, Faculty of Physics.
Leading organization:	Institute of Philosophy, Russian Academy of Sciences

The final examination will take place on May 17 2017 at 15:00 at the meeting of the Dissertation Council D 501.001.37 of Lomonosov Moscow State University at the address: 119991, Moscow, Lomonosovskij prospect, 27, bldg. 4 («Shuvalovskij»), Faculty of Philosophy, room A-518.

The thesis is available at:

- M.V. Lomonosov Scientific Library, Dissertation Department at the Fundamental Library building at the address: Moscow, Lomonosovskij prospekt, 27, sector A, 8-th floor, room 812.
- The official web-site of Dissertation Councils: http://istina.msu.ru/dissertation_councils/councils/595807/.

The summary was distributed on «____» ______________ 2016

Scientific Secretary of the Dissertation Council	Bryzgalina Elena Vladimirovna

Relevance of the research topic

Despite the fact that physics and other natural sciences have been deemed experimental sciences, since they emerged as sciences in the Renaissance sense, the notion of the contemporary experiment had not been paid sufficient attention until the end of 20th century. The distinction between the Galilean Renaissance physics experiment, and observation and experimentation of antiquity and Middle Ages scholiasts, has been discussed in Russian-language philosophy literature from all perspectives. However, contemporary big science experiments and megascience[1] have essentially been different in nature from the classic experiment. Examples include those carried out at CERN (France/Switzerland), Fermi National Accelerator Laboratory (USA), or the Joint Institute for Nuclear Research (Dubna). They usually involve thousands of participants, cost hundreds of thousands of dollars, and last tens of years. By their social organization, such experiments can be compared to industry and, therefore, require the special attention of society. Those experiments are characteristic of the postnonclassical stage in the development of science[2]. In spite of this, a consistent historical, philosophical, and sociological analysis of such experiments is relatively rare in the research literature, and is almost entirely absent in the Russian-language one.

In view of that, the following questions formed the research focus of this work. Firstly, the question of the role of theory in experiment comes to the forefront. Funding of big experimental projects requires certainty and predictability of the results in view of high investment risks, and thus exacerbates the problem of theory-ladenness. Aside from that, the exceptional technical and organizational complexity of such experiments, and analysis of results, makes it necessary to employ experimental methods with high uncertainty (statistics, data selection), and to take into consideration social and psychological factors.

Secondly, the effects that can mimic the phenomenon under study, but that have a different nature (so-called background), become especially important because they are capable of introducing an additional theory-ladenness. The special role of the background is related to the indistinguishability of quantum particles.

Thirdly, the division of labor, which arose in contemporary experiments, has led to the stratification of the scientific community into theorists, experimentalists, and manufacturers of devices (instrumentalists), as reflected in the epistemic dependence of some groups on others. For an optimal organization of the cognitive process in such experiments, and taking into account the requirements of epistemic equality of all members of the scientific community, a detailed analysis of the epistemological processes taking place in the scientific community is required. The

[1] Hoddeson, L., Kolb, A. W., and Westfall, C., "Fermilab, Physics, the Frontier, and Megascience". Chicago and London: The University of Chicago Press, 2008, p. 497.

[2] Stepin, V. S., "Theoretical knowledge". Moscow, 1999. (in Russian) http://philosophy.ru/library/stepin/index.html

development of guidelines and regulations is important. For this reason, studies of collaborations — distributed worldwide scientific and technical groups united by common research goals — are becoming more common. This is due to the fact that, on the one hand, globalization of research projects is taking place, and on the other, new communications technologies make it possible to coordinate spatially distributed scientific groups. All of these factors also require a philosophical analysis.

Research topic development

Scientific experiment became the focus of attention of philosophers during the scientific revolution of the 17th century. Discussions on the nature and role of experimentation were mainly related to the physics experiment. One of the first and most detailed works became Galileo's treatise[3] (Day Three). Here, he described possible experiments with falling bodies and the inclined plane using a detailed methodology, discussed the use of devices (e.g., a water clock), and also explained the ways in which he arrived at the theoretical conclusions. The ways in which natural philosophers can make a choice between competing hypotheses were discussed from empiricism positions by Francis Bacon in his "New Organon"[4]. This work was published in 1620. In it, he put forward the concept of *experimentum crucis*, i.e. the crucial experiment, which may help exercise the choices facing philosophers. This issue is still a hot topic in the philosophy of science. The inductivist view of the role of experiment is reflected in the work of Newton[5]. A review of early opinions on the role of the experiment in knowledge, and debate between experimentalism and empiricism about the place of experimental manipulations, followed by a popular account of physics experiments, is presented in the book by Shapin and Schaffer[6].

In place of the debate between empiricists and rationalists, the 20th century brought debates related to the emergence and development of logical positivism. The logical positivists were guided by the primacy of experience over theory. However, because they constrained themselves by analysis of language, they focused on the concept of observational claims, since they based all possible knowledge on the "protocol statements", which, in turn, relied on the facts of observation. Therefore, the experiment was understood by them as a simple supplier of observational sentences. In 1966 Hempel[7] suggested the "bottom-up" positivistic scheme of development of physical knowledge: from the experiments, producing observational statements up to the "high-level" theories of phenomena. Carnap[8] performed a similar

---

[3] Galilei, Galileo, “Two New Sciences, Including Centers of Gravity and Force of Percussion.” Translated by Stillman Drake, Toronto: Wall and Emerson, 2000.
[4] Bacon, Francis, “The New Organon.” Eds. Lisa Jardine and Michael Silverthorne, Cambridge, UK: Cambridge.
[5] Newton, Isaac, “Newton’s Philosophy of Nature: Selections from His Writings.” Whitefish, MT: Kessinger, 2003.
[6] Shapin, Steven and Schaffer, Simon, “Leviathan and the AirPump: Hobbes, Boyle, and the Experimental Life.” Princeton, NJ: Princeton University Press, 1985.
[7] Hempel, Carl Gustav, “Philosophy of Natural Science.” Englewood Cliffs, NJ: Prentice Hall, 1966.
[8] Carnap, Rudolf, “Protocol Statements and the Formal Mode of Speech.” In *Essential Readings in Logical*

analysis that led him to believe that the theoretical statements of physics are based solely on the observational protocol statements. Other followers of logical empiricists[9] debated the question of testability and falsifiability of hypotheses by experiment, and accompanied it with discussions on a number of important experiments (such as the Michelson-Morley experiment).

Questions about the conditions for obtaining data in the experiment, and the multidimensionality of relations between experiment and theory, have been raised already by Popper, and thereafter in the late 1970s, with the emergence of the "New Experimentalism". Hacking[10] can be considered as the founder of this movement. He put forward two claims. The first of these was that experiments have “a life of their own". By this we mean that experimental observations (which can more properly be called measurements) remain unchanged and stable (robust), despite the fact that experimental installations depend on various theories. The second claim of Hacking boiled down to the fact that if an object can be manipulated (e.g. electrons sprayed), then it is real, thus declaring the position of so-called manipulative realism. A review of "New Experimentalism" positions can be found in the work of Hacking, "Philosophers of Experiment"[11]. In subsequent work, Gooding, Pinch and Shaffer[12], provided a broader and more complex view of the potential role of experiment, other than it serving merely as a confirmation of theory. They carried out a historical, sociological, and philosophical, analysis of 14 different experiments from different epochs: Galileo's experiments on mechanics, Victorian electricity, and climatology and nuclear physics. The authors concluded that experiments always involve a choice, as well as tactics and strategies to persuade the public that nature reveals itself in the way experimenters demonstrate.

Since the 1980s, one of the central themes of philosophical discussions about experiment becomes a problem of theory-ladenness of experiment. The first statement on theory-ladenness of observation, and under determination of theories by data, was made by Duhem[13] in 1906. In contrast to the position of logical positivism, Kuhn[14] and Feyerabend[15] argued that what is fundamental are physics theories, not experimental data. Their position was that the observational and experimental results are part of the theory and cannot independently confirm it, whereas observational

---

Positivism. Ed. Oswald Hanfling, 150–160, Oxford: Blackwell, 1981.

[9] Laymon, Ronald, “Independent Testability: The Michelson-Morley and Kennedy-Thorndike Experiments.” Philosophy of Science 47.1, (1980): 1–37.

[10] Hacking, Ian, “Representing and Intervening: Introductory Topics in the Philosophy of Natural Science.” Cambridge, UK: Cambridge University Press, 1983.

[11] Hacking, Ian, “Philosophers of Experiment.” PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association 2, (1988): 147–156.

[12] Gooding, David, Trevor Pinch, and Schaffer, Simon eds., “The Uses of Experiment: Studies in the Natural Sciences.” Cambridge, UK: Cambridge University Press, 1989.

[13] Duhem, Pierre Maurice Marrie, “The Aim and Structure of Physical Theory.” Princeton, NJ: Princeton University Press, 1991.

[14] Kuhn, Thomas, “The Structure of Scientific Revolutions.” 50th Anniversary Edition. 4th ed. Chicago: University of Chicago Press, 2012.

[15] Feyerabend, Paul, “Against Method.” 4th ed. London and New York: Verso, 2010.

language independent of theory is impossible. Even readings of a mercury thermometer depend on the theoretical concept of temperature[16]. Bogen and Woodward[17] objected to that, and proposed to distinguish between phenomena and experimental data. They suggested that experiments obtain data independent of the high-level theories (and dependent only on the instrumental theories), which can serve for further independent confirmation or refutation of these theories. A similar proposal was made by Ackerman[18], who noted that theory and data (events) are divided by the domain of instrumentation, and are mediated by it. Therefore, the instruments and tools eliminate the dependence of data on theories.

Social constructivists[19] (the most famous example being the study of experiments on the detection of neutral currents at CERN by Pickering) have shown the important role of social factors, and the influence of the interests of the scientific community (their theoretical and meta-theoretical considerations) on the results of experiments. Collins[20] has shown, by using the example of experiments with gravitational waves, that the experimental results are based on theories that are based on other calibration experiments; those, in turn, are based on other theories, thus forming a vicious circle, or a bad infinity he called "experimenters' regress". That claim provoked objections from Franklin[21], who used case studies to present arguments that reflected the empiricist position.

In the late 1990s – early 2000s, a number of works were published in which the role of experiment in the formation of the theory was studied. In particular, the authors, who examined the classical experiment, criticized the thesis of Kuhn and Feyerabend of incommensurable theories. They have focused on theory change through experiment[22,23]. They noted the impact of the experimentalist's activities in the laboratory, on the development of scientific concepts in the course of scientific discovery (based on the Faraday experiments with electromagnetism[24]). Using examples from quantum mechanics, Perovic[25] has argued that understanding the

---

16 Franklin, Allan and Perovic, Slobodan, "Experiment in Physics.", *The Stanford Encyclopedia of Philosophy* (Summer 2015 Edition), Edward N. Zalta (ed.), http://plato.stanford.edu/archives/sum2015/entries/physics-experiment/

17 Bogen, Jim and Woodward, James, "Saving the Phenomena." Philosophical Review 97.3 (1988): 303–352.

18 Ackermann, Robert John, "Data, Instrument, and Theory: A Dialectical Approach to Understanding Science." Princeton, NJ: Princeton University Press, 1985.

19 Pickering, Andy, "Against Putting the Phenomena First: The Discovery of the Weak Neutral Current." Studies in History and Philosophy of Science Part A 15.2 (1984): 85–117.

20 Collins, Harry M., "A Strong Confirmation of the Experimenters' Regress." Studies in History and Philosophy of Science Part A 25.3 (1994): 493–503.

21 Franklin, Allan, "How to Avoid the Experimenters' Regress." Studies in History and Philosophy of Science Part A 25.3 (1994): 463–491.

22 Andersson, Gunnar, "The Tower Experiment and the Copernican Revolution." International Studies in the Philosophy of Science 5.2 (1991): 143–152.

23 van Dyck, Maarten, "The Paradox of Conceptual Novelty and Galileo's Use of Experiments." Special Issue: Proceedings of the 2004 Biennial Meeting of the Philosophy of Science Association, Part I: Contributed Papers, Ed. Miriam Solomon, Philosophy of Science 72.5 (2005): 864–875.

24 Gooding, David, "Experiment and the Making of Meaning: Human Agency in Scientific Observation and Experiment." Dordrecht, The Netherlands: Kluwer, 1990.

25 Perovic, Slobodan, "Schrödinger's Interpretation of Quantum Mechanics and the Relevance of Bohr's

details of the experiment, and having knowledge of experimental context, can have the greater influence on the development of theories than conceptual arguments. Chang[26], suggested that in some cases a phenomenological theory plays a greater role in experiment than a high-level theory; this was based on case studies in quantum physics such as spectrography and the photoelectric effect. Other authors emphasize the high importance of heuristics in experiments[27].

One of the key observations of the New Experimentalism was that the experimental devices, and measurements performed using them, are not epistemically neutral suppliers of data and protocol observation statements. The role of instruments was conceptualized in the works of Hentschel[28] and Beller[29]. Harre[30] refers to such a philosophically meaningful category, as causality in relation to instruments. Schaffer[31] argues that, from Newton's position, the selection of the observed phenomena by devices was not so important, and observations can be separated from the distortions introduced by devices. However, in contrast, Buchwald[32] cautioned against attempts to consider experimental devices of the classical era in terms of modern physics.

A distinct line of research in the philosophy of experimentation is devoted to discussions of statistical methods and conclusions based on such methods. It is represented in the works of Mill[33], Mayo[34], Franklin and Howson[35], and Achinstein[36]. The problem of the theoretical determination of experiment is discussed by Radder[37],

---

Experimental Critique." Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 37.2 (2006): 275–297.

[26] Chang, Hasok, "The Quantum Counter Revolution: Internal Conflicts in Scientific Change." Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 26.2 (1995): 121–136.

[27] Hudson, Robert G., "Novelty and the 1919 Eclipse Experiments." Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 34.1 (2003): 107–129.

[28] Hentschel, Klaus, "The Interplay of Instrumentation, Experiment, and Theory: Patterns Emerging from Case Studies on Solar Redshift, 1890–1960." Philosophy of Science 64 (December 1997): S53–S64.

[29] Beller, Mara, "Experimental Accuracy, Operationalism, and Limits of Knowledge: 1925 to 1935." Science in Context 2.1 (March 1988): 147–162.

[30] Harré, Rom, "The Materiality of Instruments in a Metaphysics of Experiments." In The Philosophy of Scientific Experimentation, Ed. Hans Radder, 19–39. Pittsburgh, PA: University of Pittsburgh Press, 2003.

[31] Schaffer, Simon, "Glass Works: Newton's Prisms and the Uses of Experiments." In The Uses of Experiment: Studies in the Natural Sciences, Eds. David Gooding, Trevor Pinch, and Simon Schaffer, 67–105, Cambridge, UK: Cambridge University Press, 1989.

[32] Buchwald, Jed Z., "Why Hertz Was Right about Cathode Rays." In Scientific Practice: Theories and Stories of Doing Physics, Ed. Jed Z. Buchwald, 151–170, Chicago: University of Chicago Press, 1995.

[33] Mill, John Stuart, Collected Works of John Stuart Mill, Vol. 7, System of Logic: Ratiocinative and Inductive, Ed. John M. Robson, London: Routledge, 1996.

[34] Mayo, Deborah, "Error and the Growth of Experimental Knowledge." Chicago: University of Chicago Press, 1996.

[35] Franklin, Allan and Howson, Colin, "It Probably Is a Valid Experimental Result: A Bayesian Approach to the Epistemology of Experiment." Studies in History and Philosophy of Science Part A 19.4 (1988): 419–427.

[36] Achinstein, Peter, "The Book of Evidence." Oxford: Oxford University Press, 2001.

[37] Radder, Hans, "Approaches to a More Developed Philosophy of Scientific Experimentation." transl. from Engl. by A. Yu. Storozhuk, Filosofiya Nauki, 22.3 (2004): 62–86.

the separation between the device and the phenomenon by Bohr[38,39], Schreibe[40], Radder[41], Lipkin[42,43], and Janich[44].

Woodward[45] draws on case studies of experiments in biology, and behavioral and social sciences. He introduces the concept of experimental intervention, and argues that the experimenter's intervention over the course of the experiment can prove causal relationships. His approach is a development of the Hume's causality, which reduces the causality relationship to a permanent connection between the two occurring events. However, this is a vicious circle, since the definition of intervention requires, in turn, an appeal to causality. Such a logical fallacy, according to Woodward, can be avoided if one distinguishes between intentional realization and causal origin of experimental systems[46]. This third approach to causality treats causation as something which can be controlled.

Another problem, analyzed in the methodological literature, is the connection of experiments with models and simulations (using models in cognition), and the role and content of computer modeling. Weisberg[47,48], Galison[49], Parker[50], Gelfert[51], Barberousse[52], Winsberg[53], Humphreys[54], Parke[55], and Sokuler[56], are contributors to this debate.

---

[38] Bohr, Niels, "Atomic physics and Human Knowledge." N.Y., Wiley, 1958.
[39] Bohr, Niels, Essays 1958-1962 on atomic physics and human knowledge, N.Y., Wiley, 1963.
[40] Schreibe, E., "The Logical Analysis of Quantum Mechanics." Oxford: Pergamon Press, 1973, p. 25.
[41] Radder, Hans, "Philosophy and History of Science: Beyond the Kuhnian Paradigm." Studies in History and Philosophy of Science 28 (1997): 427–428.
[42] Philosophy of Science: the textbook for graduate schools. Ed. A.I. Lipkin. 2nd ed., Rev. and ext., Urait Publ., 2015 (with A.I. Lipkin) (in Russian), 2015, c.199.
[43]Lipkin, A. I., "Foundations of Physics. Outlook from Theoretical Physics." Moscow: URSS, 2014.
[44] Janich, P., "Was macht experimentelle Resultate empiriehaltig?: Die methodish-kulturalistische Theorie des Experiments" Experimental Essays – Versuche zum Experiment, pp 102–107.
[45] Woodward, J., "Experimentation, Causal Inference, and Instrumental Realism." In *The philosophy of scientific experimentation*, Ed. Hans Radder, The University of Pittsburg Press 2003, p. 87.
[46] Von Wright, G.H., "Explanation and Understanding." eds. L. Routledge and Kegan Paul, 1971.
[47] Weisberg, Michael, "Simulation and Similarity. Using Models to Understand the World." New York: Oxford University Press, 2013.
[48] Pronskikh, "How to Model the World." Metascience, 23 (2014): 597–601.
[49] Galison, Peter, "Computer Simulations and the Trading Zone." In *The Disunity of Science: Boundaries, Contexts, and Power*. Eds. Peter Galison and David J. Stump, 118–157. Stanford, CA: Stanford University Press, 1996.
[50] Parker, Wendy S., "Franklin, Holmes, and the Epistemology of Computer Simulation." International Studies in the Philosophy of Science 22.2 (2008): 165–183.
[51] Gelfert, Axel, "Scientific Models, Simulation, and the Experimenter's Regress." In *Models, Simulations, and Representations* Eds. Paul Humphreys and Cyrille Imbert, 145–168. New York: Routledge, 2011.
[52] Barberousse, Anouk, Franceschelli, Sara and Imbert, Cyrille, "Computer Simulations as Experiments." Synthese 169.3 (2009): 557–574.
[53] Winsberg, Eric, "Science in the Age of Computer Simulation." Chicago: University of Chicago Press, 2010.
[54] Humphreys, P., "Extending Ourselves: Computational Science, Empiricism, and Scientific Method." New York: Oxford University Press.
[55] Parke, E., "Experiments, Simulations, and Epistemic Privilege." Philosophy of Science, 81.4 (2004): 516–36.
[56] Sokuler, Z. A., "Computational Experiment as a Problem for Epistemology", Moscow University Bulletin, Series Philosophy 4 (2014): 62–77. (in Russian)

Among the particularly actively developed areas of philosophy of scientific experimentation, in the last decade, are studies of the philosophical and sociological aspects of experimentation in high-energy physics and elementary particle physics. Their emergence and development has coincided with the period of New Experimentalism. Complex and large-scale accelerator and detector installations and techniques, as well as the necessity for joint efforts of numerous and highly organized groups, gave rise to questions not raised in the era of the classical experiment. Features of such experiments, in which the epistemic aspects are closely intertwined with the social and political, have much in common with traits of the "postnonclassical science" [57] introduced by Stepin. Here, a division of specialists according to the fields of knowledge takes place, and social and political goals begin to determine research priorities.

A defense of the empiricist position regarding the complex modern experiment, in conjunction with the consideration of a number of important case studies, is presented in the works of Franklin[58,59]. In his now-classic book "How experiments end"[60], Galison revealed the role of theoretical concepts and the priorities of scientists in their findings. He singled out three subgroups within the structure of the scientific community: the theorists (high-level), the experimenters, and the instrumentalists. He also described the mechanisms of their interaction concerning the production of results. Pickering suggested a social constructivist approach to experiments in high-energy physics, in an attempt to explain the discoveries in this area from the standpoint of the interests of the scientific community[61,62]. Galison[63] developed his analysis, pointing to the communities creating complex experimental setups in the project, and showed how the long-term need in the construction of the instrument separates scientist from the final result and its analysis. This gives rise to a variety of technical traditions, and serves to herald the coming separation of the once epistemically united scientific community. At the same time, he observed the emergence in experiment of so-called "trading zones", i.e. spaces where an exchange occurs between the representatives of the various communities, with the products of their labor, by analogy with trade between culturally different tribes. This work has drawn attention to the problem of organization and division of epistemic labor in heterogeneous groups of scientists. It

[57] Stepin, V. S., "Theoretical Knowledge.", Moscow, 1999. (In Russian) http://philosophy.ru/library/stepin/index.html

[58] Franklin, Allan, "The Neglect of Experiment." Cambridge, UK: Cambridge University Press, 1986.

[59] Franklin, Allan. "Experiment, Right or Wrong." Cambridge, UK: Cambridge University Press, 1990.

[60] Galison, Peter Louis, "How Experiments End." Chicago and London: The University of Chicago Press, 1987.

[61] Pickering, Andrew, "The Mangle of Practice: Time, Agency, and Science." Chicago: University of Chicago Press, 1995.

[62] Pickering, A., "Constructing quarks. A sociological history of particle physics." The University of Chicago Press, 1984.

[63] Galison, P., "Image and Logic: a Material Culture of Microphysics." Chicago: The University of Chicago Press, 1997, p. 955.

also drew attention to the emergence of political interests at the micro-level in groups of scientists.

Staley[64] has studied in detail the experiments of The Collider Detector at Fermilab (CDF) and D0 collaborations at Fermilab, which measured the mass of the top quark at the Tevatron collider. He pointed to the emergence of problems of ownership of collective cognitive results in collaborations, which did not arise in a classic experiment, and, in a broader sense, to the problem of authorship in large research teams. Schrum[65] and colleagues examined the meso-level of cooperation in research projects, namely the co-operation between different organizations in a distributed scientific project. This book challenged epistemological status of the jointly produced scientific knowledge, and raised the question of relevance of studies of epistemic dependence of collaborators on each other.

In 2008, Hoddeson, Kolb, and Westfall[66] published a monograph which investigated the history of collaborations in high-energy physics at Fermilab. The authors examined big science, which usually means fundamental science of large collaborations, facilities, duration, and cost, organized similarly to industry. They found that it is gradually turning into a special degenerate kind of science called megascience. They emphasized the importance of considering the interests of groups of scientists in the experiment, for understanding the logic of the development of research projects in modern high-energy physics. They also highlighted the need for further study of the social structure arising in scientific collaborations in this field, as well as its epistemological implications.

In modern philosophical literature on experiment, the strategies that experimentalists apply to ensure there are no errors are widely discussed, as well as questions about whether or not a phenomenon is discovered experimentally or created in a laboratory. Do experiments give any reason to believe in theoretical ontic? What is the scientific and philosophical significance of the instrument? What is the role of experimental background in experiment? What is the difference between experiments in various sciences? Is the reproducibility of experimental results a requirement of inductive logic? What are the similarities and differences between computer simulations and experiments[67]?

On the basis of the previously-mentioned study of Russian literature (primarily the review by A. Yu. Storozhuk[68]), and the international philosophical literature, on

[64] *Staley,* Kent W., "The Evidence for the Top Quark*:* Objectivity and Bias in Collaborative Experimentation."

[65] *Schrum,* Wesley, Genuth, Joel, and *Chompalov,* Ivan, "Structures of Scientific Collaboration."

[66] Hoddeson L., Kolb A. W., and Westfall, C., "Fermilab, Physics, the Frontier, and Megascience." Chicago and London: The University of Chicago Press, 2008, p. 497.

[67] Pronskikh, V. S., "Topical issues of the philosophy of experimentation." (Review of a conference), Epistemology & Philosophy of Science 42.4 (2014): 192–196. (in Russian)

[68] Storozhuk, A. Yu., "Philosophy of Scientific Experimentation: Reaction to the Rationalism Crisis.",

experiment, it can be asserted that, despite the critical importance of a philosophical analysis of the contemporary experiment in high energy physics, these problems are not sufficiently studied in the Russian-language philosophical literature. This research is, therefore, still in its initial stages. The choice of the dissertation topic, "Epistemological and socio-ontological problems of the contemporary physics experiment", was essentially predetermined by this circumstance.

The object of study in this thesis examines the contemporary physics experiment, in high-energy physics, as a complex social and cultural phenomenon.

The subject of study is the language for describing the relationship between theories of phenomena and instrumental theories in the context of the contemporary physics experiment. We contemplate on the experimental background as a factor of theory-ladenness of experiment with theories of phenomena, and the epistemic dependence and disunity of the scientific community in the contemporary megascience experiment as a socio-cultural phenomenon.

The main aims and objectives of the study

The purpose of this dissertation research is explication of the role of the instrumental theories, on the one hand, and those tested in the experiment, on the other, as well as socio-cultural factors in the structure of modern physics experiments. Achieving this goal involves the following research tasks: review of a number of important experiments of the last third of the 20th century with emphasis on the influence of the theory being tested at different stages, and a study of the history of experiments to establish the probable mechanisms of such influence; the development of a universal language for description of experiment, distinguishing stages of experiment such as preparation, measurement, and data analysis, and allowing for inclusion of the theoretical components at these stages; the use of advanced language for the schematic representation of the considered experiments and subsequent analysis of the schemes; development of a typology of physics experiments based on the inclusion of the theoretical components at the stages of preparation and measurement; identification of trends in the role of theoretical components in the transition to complex experiments with accelerated particle beams; the use of the operational language in the description of the experiment to analyze the socio-ontological structure of the scientific community of big science and megascience.

Scientific novelty of research consists in a systematic study of the influence of physics theories of phenomena and meta-theoretical factors, on the modern physics experiment at its various stages. In the course of the study, a language for the description of experiment was developed that is applicable to both the operational side of the experiment, and to its socio-ontological structure. It is shown that the experimental background introduces not only instrumental theories, but also theories

---

Filosofiya Nauki 3(22) (2004): 87–120.

of phenomena, in the structure of experiment. It was illuminated in an example that a special situation with regard to the role of the neutrino background in accelerator experiments is related to their insufficient instrumental localizability. Boundary objects have been identified in the structure of modern accelerator megascience experiments, such as beams of accelerated particles, setups, and data. The role of boundary objects in the emergence of epistemic division and stratification of the scientific community has been elucidated. Based on the provisions proposed by the theoretical feminist epistemology, a regulative approach to overcoming epistemic division has been proposed. This consists of suggested regulations for collaborative project work, and prescriptions for training of representatives of various strata, which is justified by a requirement for epistemic democracy.

The theoretical significance of the research results

The thesis is devoted to solving a topical problem of the philosophy of experimentation: the influence of various theoretical and meta-theoretical components on the results of experiment in big science and megascience. The author traces the occurrence of theoretical components at various stages of the experiment, and develops a scheme of the Fock-Lipkin type, by including instrumental theories and adapting the scheme to the description of social ontic arising in connection with megascience experiments. Analysis of the philosophical aspects of the modern physics experiment in megascience gives reason to identify the role of these types of experiments in epistemology, as well as social and ethical issues raised by the scientific community in the course of implementation of such experiments.

The practical significance of the work

The practical significance of the results consists in the possibility for their use in the history and philosophy of science, as well as in natural science and humanities courses, and science outreach. There is also the potential to develop specialized courses on the philosophy of scientific experimentation, which is particularly relevant in the modernization of Russian education, taking into account global trends.

Provisions of the thesis

1. Drawing on the operational approach of V. A. Fock and A. I. Lipkin, a language for the description of experiment has been developed that explicitly includes components of phenomenal theories ("high-level theories") and instrumental theories, in the process of obtaining of experimental results at the stages of preparation and measurement of phenomena, as well as during data analysis.
2. Using the descriptive language developed in the thesis, a theoretical-operational scheme of a contemporary complex accelerator experiment in particle physics has been proposed. This is based on a case study of the CERN experiments on the detection of neutral currents.

3. It has been found that the presence of an experimental background, and the need for its quantification in a complex accelerator experiment, can introduce in the data analysis the theory of the phenomenon under scrutiny. I argue that this observation is especially relevant to experiments with neutrinos because of their deficient instrumental localizability.
4. A socio-ontological scheme of experiment in big science and megascience has been suggested. This complements the operational diagram of a complex experiment by an explication of the stratification of the scientific community in high-energy physics into separate communities of theorists, experimenters, and instrumentalists, and by establishing in it boundary objects (accelerated beams, detectors, and data) separating these communities.
5. I suggest that the presence of boundary objects in the socio-ontological structure of megascience experiment can cause epistemic dependence and fragmentation of the scientific community. This entails the transformation of a significant part of the community to non-epistemic, in the sense of the theory of phenomenon.
6. In the framework of the concept of epistemic institutional justice and democracy, a requirement to overcome epistemic disunity is substantiated. Regulatory approaches to solving this problem are proposed. They consist of the creation of conditions for collaborative learning and joint project activities of the members of the different communities, at all stages of the experiment, to ensure epistemic equality.

The approbation of the thesis

Key provisions of the thesis were presented at Russian and international conferences and meetings: scientific conferences MIPT-50 (2007), MIPT-53 (2010), MIPT-55 (2012); International Conferences "The Image of Russia in Cross-cultural Perspective" (Dubna, 2012, 2013), "Russia in Global Scenarios of the XXI Century" (Dubna, 2014), “Models and Simulations 6” (Notre Dame, USA, 2014), "Social Philosophy of Science. Russian Prospects "(Institute of Philosophy of the Russian Academy of Sciences, 18 - 19 November 2014) ; MIPT seminars on the philosophy of science (2013, 2014); Seminar "Constructing Reality in Science" at the University Center of the Joint Institute for Nuclear Research (2007); seminars of the Fermi Philosophy Society (Batavia, USA, 2014, 2015); public lecture "Understandable Science" (Dubna, 2014); Meeting of the ELBNF proto-collaboration (Batavia, USA, 2015).

Structure of the thesis

The thesis consists of an introduction, three chapters divided into paragraphs, a conclusion, and a bibliography.

SUMMARY OF THE THESIS

In the introduction, the relevance and scientific novelty of the dissertation topic is substantiated, and the degree of its elaboration in Russian and international philosophical literature is discussed. The subject, aims, and objectives of the study, as well as the theoretical and practical significance of the results, are described.

In the introduction to Chapter 1, the three streams of interest to philosophy of experimentation are analyzed. The necessity to develop a descriptive language for experiment, that would allow an explicit expression and analysis of the theory-ladenness of the contemporary physics experiment, is formulated.

Section 1.1, "The Specifics of the Renaissance Experiment", discusses theoretical-operational object structure of the Renaissance experiment, and that proposed by V. A. Fock for quantum mechanics, which was generalized by A. I. Lipkin to the classical Galilean experiment. The structure is a three-part scheme, at the center of which the phenomenon (or a theoretical model) is placed. The operational parts, such as preparation and measurement of the phenomenon, are located to the sides; the operational parts are artificial, i.e. technical. The central, theoretical, part of the scheme belongs to the "first nature", i.e. natural processes. The operational, technical, part belongs to the "second nature." This heterogeneous structure, which combines the theoretical and operational parts, is one of the most important features of the scientific revolution of the 17th century, during which the transformation of natural philosophy to the natural science of the Renaissance occurred. We discuss the possibility of describing contemporary physics experiments, as discussed in the works of Hacking and Galison, with this scheme. This section identified the need to develop the operational scheme to describe the contemporary physics experiment, by clarifying the concept of the instrument and elaborating on instrumental components.

In Section 1.2, "The Structure of a Complex Experiment: Theory, Experiment and Instruments", the focus of the author's attention is Galison's distinction between theoretical, experimental, and instrumental, components, as well as his observation of the independent development of theoretical and experimental work in the 20th century. Among the findings is the fact that the specific work of the experimenter in a modern experiment mainly boils down to the choice of instruments, setting their operating modes corresponding to the implementation of a specific measurement, and data analysis. This last item (data analysis) did not attract philosophers' attention until the middle of the last century, since it could practically be degraded to reading of instruments, but in today's experiment it becomes central. Extraneous events that could distort readings (so-called experimental background) were considered negligible, since experimentalists of the past usually managed to establish experimental conditions such that their influence on the result could be eliminated.

In contemporary experiments, the choice and development of instruments became so complicated, and began to demand such a large amount of research and theoretical work, that the part of the community of experimenters (that is involved in the creation of detectors in particle physics for example), stands out as a separate community, called instrumentalists by Galison. This activity is characterized by its periods of normal development (improvement of the known types of detectors) and revolution (the creation of new types of detectors). Qualitatively, the task of theorists has undergone the least change, in comparison, since the beginning of the last century, and is usually reduced to creation of the theory and definition of observables of that theory (in general terms). The contemporary experiment is considered in the framework of that division.

In Section 1.3, "The Setting of the Modern Physics Experiment", a complex interweaving of theory, experiment, and instruments, arising in the modern physics experiment, is explored. The experiment Gargamelle analyzed in this Chapter is one of a series of experiments to test a Quantum Field Theory (QFT) of the electroweak interaction. In our classification, this a theory of "first level" (i.e. a new branch of physics (in this case, a new QFT), which created new primary concepts and objects of a division of physics. The basis of this experiment is also a theoretical model which includes "neutral currents", a product of a "second level" theory (a theory which is a consequence of a first level theory). In the experiment at CERN using the Gargamelle setup, which is described in detail in the works of Galison and Pickering, the accelerated proton beam hit the target and formed in it pions and kaons. These moved through dirt, and disintegrated with the formation of muon neutrinos and antineutrinos. The neutrinos reached the bubble chamber and caused interactions in its medium, while the other particles were retained in the dirt. Some of the neutrinos entered the materials surrounding the chamber, such as magnets and the radiation shield, and formed background neutrons there. Those background neutrons also penetrated the chamber, and were able to cause in it processes similar to those caused by the original particles. Discussion of this experiment, on the one hand, clearly illustrates the feature of Galison's periodization consisting in the non-simultaneity of fundamental paradigmatic shifts in the theoretical (non-cumulative transition to more general theories), experimental (maintaining the same measurement program), and instrumental (continued use of existing facilities) layers. On the other hand, it shows that one can speak of an instrument-centric set of Gargamelle experiments, consisting of individual theory-centric experiments, one of which — an experiment on search of "neutral currents" — is analyzed in this Chapter.

In Section 1.4, "Description of the Gargamelle experiment ", a description of the experiment is elaborated within the framework of the A. I. Lipkin's objective approach, and the scheme of experiment developed in this thesis. The description includes the operations of preparation and measurement of the phenomenon under study, and instruments, (dp ((Tp) a; b) and dm ((Tm) c; d), where the indices «p» and «m» indicate the attribution of the instrument to preparation or measurement operations, respectively. Tp (Tm) is the underlying theory of the third level (theoretical component of the instrument), a (c) is the source material, and b (d) is the end product of the operation. Then the classical scheme of the experiment, taking into consideration theory-ladenness of the instrument, can be expressed as follows:

$$\langle P(d_p((T_p)\ a;b)|ph(T)|M|d_m\ ((T_m)\ c;d)\rangle$$

For the contemporary experiment described in the preceding section, the above scheme was developed by presenting the preparation of phenomenon as a combination of many processes: preparation of protons in the target (based on the physics and technology of accelerators); preparation of pions and kaons in the target under the action of a proton (based on the theory of nuclear reactions); preparation of muons and muon neutrinos or antineutrinos (based on the theory of weak decays); the preparation of electrons, protons, or neutrons, in a bubble chamber under the influence of the neutrino (based on the exchange of $W^{\pm}$ and Z^0 - bosons); and the preparation of background electrons, protons, or neutrons, in a bubble chamber (caused by interactions of background neutrons produced in the surrounding chamber materials — a process that is discussed in detail in Chapter 2). On the other hand, the measurement part of the scheme is presented as a combination of the indication operations in the bubble chamber, resulting in pictures of the phenomena occurring within the chamber. It is based on the theories of the measuring instrument as well as on the data analysis that in the classical experiment was constrained to a comparison with the standard (the procedure analyzed in detail in Chapter 2).

In Section 1.5, "The Problem of Closedness of Experiment," the debate between Pickering and Franklin, on whether contemporary physics experiment can be considered a closed system, is analyzed; can all theoretical components of experiment discussed in the previous paragraph be accounted for? Franklin sums up the so-called epistemic strategies of the experiment, i.e., the approaches and methods which experimenters use in their work in order to prove correctness of the results. These aim of these strategies is to ensure the closedness of an experimental system, or indeed to determine the absence of such. From our point of view, these strategies correspond to the two levels of closedness of an experiment: internal (e.g. calibration and stability of results) and external (independent confirmation in another experiment). The object scheme, with an explicit form of theory-ladenness proposed in this Chapter, calls into question the possibility of an experiment's independence on the theory of phenomenon as suggested by Franklin.

In Chapter 2, "The Theory-Ladenness of Data Analysis," the author considers data analysis as a special source in the theory-ladenness of contemporary experiments. Data analysis is the process of translating raw experimental data, presented in terms of indications of groups of sensors placed in the setup, into the language of the theory of phenomenon. The theory-ladenness of data analysis can emerge through several major channels. First, through the ways of determination of statistical deviations of the results from the background; secondly, through the selection and exclusion of data; thirdly, through experimenters' bias; fourth, through triggers, i.e. setting the electronic logical schemes filtering the data for analysis; fifth, through the introduction in the result of not only the instrumental but also phenomenal theories, via the background.

Section 2.1, "Data Analysis", scrutinizes the focus of modern experiments: data analysis. Inclusion of the theoretical component, Ti, in the operation of "pattern recognition" that makes up the core of data analysis, entails that the crucial role in the result formation is played not only by technological (development of experimental techniques and data analysis methods), but also by the theoretical component of the analysis. Consequently, various approaches to data analysis (i.e. use of different basic and supplementary theories), as is illuminated in this section, can lead to significant differences in the results.

In Section 2.2, "Selection and Exclusion of Data," the role of selection and exclusion of data in the experiment is clarified. I discuss Franklin's definition of good data: the data produced by correctly functioning apparatus, which is also free from the background effects, i.e. events that may reveal themselves in the installation or its parts, which are similar to the phenomena under scrutiny but have a different physical nature. We suggest in this section that statements of correct operation of equipment are based on expert evaluations. The problems of the background are discussed in Section 2.4.

Section 2.3, "Triggers and Theory-Ladenness", investigates the role of triggers. These are electronic systems in the experiment, based on logic circuits, used to select for storage and further processing only part of the data produced by the installation. In this section, we discuss such traits of contemporary experiments as the application of the trigger construction to high-level theoretical models directly. This creates a case of theory-ladenness of the experimental results by phenomenal theories.

In Section 2.4, "Background and Theory-Ladenness," we introduce the concept of the background (indistinguishable from the phenomenon under study and due to effects of a different nature), the preparation of which is almost inseparable from the preparation of the phenomenon under investigation. As is indicated by the critical analysis of Galison's and Pickering's historical descriptions, as well as the works of other contemporary authors carried out in the course of this work, the presence of background has many implications. 1) It may constitute an essential content of the experimenter's activity. 2) It introduces into a physical experiment, and its result, a large number of theoretical components of instrumental theories (additional theory-ladenness). 3) It may require development of theories in order to determine whether an effect is a background one or a phenomenon being studied. 4) It may introduce into meaningful results a theory of the phenomenon. 5) It may challenge closedness of the experimental system as a whole.

Section 2.5, "Experimenters' Bias", discusses the concept of bias, that is, an (unconscious) tendency to use experimental data analysis methods that are more likely to entail an observation of the desired effect. This section shows that the problem of bias can lead to uncontrollable results. However, use of Franklin's epistemic strategies (in particular the different types of independent reproducibility) can substantially mitigate its severity.

Section 2.6, "Standard Deviation as a Conventional Criterion for the Ending of Experiment", explores such aspect of theory-ladenness as the criterion of "standard deviation" or "sigma criterion." Probability theory suggests that the more standard deviations away from a conditional "zero" the measured result is, the greater the likelihood that the measured result is the desired effect rather than the background (i.e. a false alarm caused by other natural phenomena). This section discusses how application of this criterion is based on certain assumptions, and so the result is influenced by the theories underlying such assumptions.

Section 2.7, "The Problem of the Reliability of the Sigma Criterion " analyzes how reliable the use of the sigma criterion in the modern physics experiment is. It is deminstrated that determination of the number of sigma for an experimental result is not an unambiguous and unequivocal procedure, and depends on a variety of instrumental theories, and the methods of their application. Thus, the conclusion is made that the number of sigma by itself, without a detailed knowledge of the entire set of instrumental theories included in the scheme developed in Chapter 1, cannot serve as a reliable criterion for the ending of an experiment.

In Chapter 3, a socio-ontological scheme of the experiment is developed, and the problem of epistemic disunity of the scientific community involved in the experiment is analyzed. Issues around changes in the modes of presentation and authorship of the experimental results are scrutinized, and the boundary objects encountered in the experiment are identified. The emergence of chains of megascience experiments, as well as the epistemic and ethical implications of the social structure of experiment, are discussed. Normative approaches to the creation of the model for experimenters' communities to overcome epistemic disunity are proposed.

In Section 3.1, "Division of Labor in the Contemporary Experiment," the author analyzes specifics of the epistemic labor of the three main communities in the contemporary physics experiment according to Galison's classification, namely, theorists, experimentalists, and instrumentalists. The particularities of the experimenters' labor mainly boil down to the choice of instruments, assignment of modes of operation corresponding to the implementation of a specific measurement, and data analysis. The part of the community of experimentalists, engaged in the creation of accelerators or detectors in particle physics, stands out as a separate community, called instrumentalists. The community tasked with creation of a theory, as well as definition (in general terms) of the phenomena proposed by this theory, is called theorists according to this classification.

Section 3.2, "Epistemic Disunity in Big Science", analyzes the connection between big science and the concept of epistemic disunity. Big science emerged in the US in the early 1940s, and is often defined as the science of large teams and installations, as well as studies of long duration requiring large amounts of funding. Epistemic disunity is understood in this paper as the division of labor between the communities, characterized by their epistemic and communicative isolation. The basis for the analysis is Galison's anthropological model, in which the interaction of various specialized communities is considered as taking place in the trading zones. This is similar to interactions between different tribes belonging to different cultural and linguistic backgrounds, for which they develop simplified languages: jargons, pidgins, and creoles.

Section 3.3, "Novelties in Authorship of Publications of Contemporary Science", researches one of the social features of big science associated with changed attitudes to the authorship of scientific publications. According to Franklin, in today's research teams, although the number of authors of a publication amounts to thousands, only a small number of them has access and the opportunity to develop skills of presentation and data analysis, which, leads to an epistemic outcome. I argue that this stratification makes part of the experimentalists' community epistemically more privileged, and serves as the basis for yet another level of stratification, now internal to the experimentalists' community itself.

Section 3.4, "Changes in Presentation of Experiment", analyzes one of the important novelties in the presentation of the results in big science — changes in the mode of representation of the experimental setup and results. Up to one page is often allocated in publications for a description of the entire system, whereas the analysis procedure is described very selectively and generally. All details and characterizations of the experiment, although preserved, remain available only to a limited number of participants. We suggest that this reduces the circle of those who are able to reproduce the experiment (making use of Franklin's strategies).

In Section 3.5, "Interactional Expertise and Boundary Objects in Experiment", the changing model of communication in the community of big science is discussed. We maintain that in high-energy physics interaction in the trading zones is carried out by means of boundary objects. The boundary object is an object that has a different meaning and value in different cultures, and representatives of those cultures interact with each other indirectly, thereby placing a different meaning on the interaction process. In this section we demonstrate that, in particular, the proton beam can play the role of a boundary object for interaction between accelerator physicists and experimenters. We point out that for the accelerator physicists (instrumentalists), the proton beam is the ultimate goal of their research, while experimenters consider it as the raw material for their own research.

In Section 3.6, "Big Science and Premises of Megascience", the author explores a feature of the present stage of big science, that is, its transformation into its degenerate kind, called megascience. Megascience is the type of big science in which experiments are chained into thematically related sequences of experiments (the so-called "experimental string"); they no longer end in the classical sense. The experimenters can no longer articulate what kind of effect (or lack thereof), and under what conditions, it is necessary to observe, in order for the research to be considered complete, and for the chain to be ended. This section discusses the main features of megascience.

In Section 3.7, "Charmed" Quarks and the Emergence of Megascience", a case study is analyzed in which a megascience apparatus was first used for the study of the "charmed" quark. Based on historical material, this section illuminates how at a social level, megascience is characterized by intense micro-level politics and competition for resources such as apparatus and proton beams. Megascience experiments are defined, in this section, as science experiments which make repeated use of resources, and complement previous work. Due to competition for resources with limited funding, they are connected in chains of thematically related research (long-term traditions), joined by a common task or installation, and the ultimate aim of which cannot be formulated. I argue this case can be consistently described by the model of boundary objects, discussed in Section 3.5.

In Section 3.8, "Epistemic and Ethical Implications of Disunity of Experimentation", the author, by analogy with the object scheme of Chapter 1, develops a heterogeneous socio-ontological structure of the megascience experiment. We suggest that the occurrence of boundary objects in the structure of megascience, transforms the process of production of knowledge into an analog of a factory assembly line, and turns part of the community into a non-epistemic one. This allows one to raise the question of the relevancy of such epistemic division of a community, into more, and less, epistemically privileged strata.

The Conclusion summarizes the main results and findings of the thesis, and makes regulatory suggestions to promote epistemic democracy in the contemporary physics experiment.

The main provisions of the dissertation research are reflected in the following publications by the author:

Publications on the topic of the dissertation in journals recommended by the Higher Attestation Commission, as well as those indexed by Scopus and Web of Science.

1. A. I. Lipkin and V. S. Pronskikh, Theoretical components in particle accelerator-based experiments, Bulletin of Peoples' Friendship University of Russia, Series: Philosophy, 2010, № 3, pp 56–62. (in Russian)
2. V. S. Pronskikh, Epistemic disunity of experimentation in megascience and approaches to its surmounting, Epistemology & Philosophy of Science, 2015, Vol. 43, №1, pp 207–222. (in Russian)
3. V. S. Pronskikh, Novelties in standards of experimentation in elementary particle physics of XX century, Filosofiya Nauki, 2015, Vol. 66, №3, pp. 147–167. (in Russian)
4. V. S. Pronskikh, Epistemic role of experimental background in the philosophy of experimentation, Filosofiya Nauki, 2015, Vol. 65, №2, pp. 41–57. (in Russian)
5. V. S. Pronskikh, Topical issues of the philosophy of experimentation (review of a conference), Epistemology & Philosophy of Science, 2014, Vol. 42, №4, pp 192–196. (in Russian)
6. V. S. Pronskikh, How to Model the World ?, Metascience, 2014, Vol. 23, pp 597–601.
7. V. S. Pronskikh, "A. Franklin. Shifting Standards: Experiments in Particle Physics in the Twentieth Century", Philosophy of Science, 2015, Vol. 82, №4, pp 727–730.

Other publications.

1. V. S. Pronskikh, The philosophy of experimentation in natural sciences, Philosophy of science: the textbook for graduate schools. Ed. A. I. Lipkin. 2nd ed., Rev. and ext., Urait Publ., 2015 (with A. I. Lipkin) (in Russian).
2. V. S. Pronskikh, Cross-cultural communication in modern science (on the example of high-energy physics), The Image of Russia in Cross-cultural Perspective: Proceedings of the International Scientific Conf. (Dubna, 13 April 2012) / Dubna, 2012, 127 p. (In Russian).
3. V. S. Pronskikh, Scientific experiment as a space of interaction between cultures, The Image of Russia in Cross-cultural Perspective: Proceedings of the International Scientific Conf. (Dubna, 19 April 2013). Dubna, 2013, 154 p. (In Russian).
4. V. S. Pronskikh, Approaches to justification of megascience as a way of organizing research in the Russian science, Russia in Global Scenarios of the XXI Century: Proceedings of the International Scientific Conf. (Dubna, 11 April 2014). Dubna, 2014, 171 p. (In Russian).