



**BOGOLIUBOV**

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**LABORATORY OF  
THEORETICAL PHYSICS**

# THEORY OF FUNDAMENTAL INTERACTIONS 2014-2018

**4 projects**

**Standard Model  
and its extension**

**Leaders**

**D.I. Kazakov, E.A. Kuraev**

**QCD parton  
distributions for  
modern colliders**

**A.V. Efremov, O.V. Teryaev, D.V. Shirkov**

**Physics of Heavy and  
Exotic Hadrons**

**A.E. Dorokhov, M.A. Ivanov**

**Hadron matter under  
extreme conditions**

**E.-M. Ilgenfritz, S.N. Nedelko    D. Blaschke**

**6 sectors, 79 employees (17 part-time), including 23 students**

## SCIENTIFIC ACTIVITY

### ► Publications

	2014	2015	2016	2017	2018
Journal publications	103	109	111	102	55
Conference proceedings	24	26	22	27	10
Total	127	134	133	129	65

- Participation in and support of experiments (ATLAS, CMS, ALICE, COMPASS, BES, BELLE, JEDI, NICA...)
- Conferences: about 5 each year
- Grants: RFBR, RSCF, Ministry of science (RU), Plenipotentiaries of Bulgaria, Slovakia, Chekhia, Poland, Hungary, Romania
- **Joint projects:** Heisenberg-Landau (BLTP-Germany), Votruba-Blohkintsev (BLTP-Chekhia), Bogoliubov-Infeld (BLTP-Poland), Smorodinsky-Ter-Antonian (BLTP-Armenia), Ciceika-Markov (Romania) , BLTP-Slovakia, JINR-INFN, JINR-IN2P3

## PARTICLE PHYSICS: MAIN TOPICS

- ▶ LHC related physics/New physics BSM
- ▶ Multiloop/leg calculations and precision physics
- ▶ Neutrino physics
- ▶ Exotic hadrons/Confinement
- ▶ Hadronic matter at extreme conditions/Heavy Ions
- ▶ Cosmology & Astrophysics/Dark Matter

## EDUCATIONAL ACTIVITY

Advanced Level



**Dubna International Advanced  
School of Theoretical Physics**

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Advanced Level



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School of Theoretical Physics

2015

June 29 - July 11, 2015

Helmholtz - DIAS International Summer School  
[Dense Matter](#)

July 20 - 30, 2015

Helmholtz - DIAS International Summer School  
[Theory challenges for LHC physics](#)

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2016

July 18 - 30, 2016

Helmholtz - DIAS International Summer School  
[Quantum Field Theory at the Limits: from  
Strong Fields to Heavy Quarks](#)

August 28 - September 10, 2016

Helmholtz - DIAS International Summer School  
[Cosmology, Strings and New Physics](#)

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August 28 - September 10, 2016

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[Cosmology, Strings and New Physics](#)

2017

January 30 – February 4, 2017

XIII<sup>th</sup> Winter School on Theoretical Physics  
[Heavy Ion Physics: from LHC to NICA](#)

August 20 - September 2, 2017

Helmholtz - DIAS International Summer School  
[Hadron Structure, Hadronic Matter and Lattice  
QCD](#)



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Helmholtz - DIAS International Summer School  
[Theory challenges for LHC physics](#)

2018  
April 16 - 18  
*II International Workshop*  
[Simulations of HIC for NICA energies](#)

July 22 – August 1  
*Helmholtz International Summer School*  
[Modern Colliders - Theory and Experiment 2018](#) and Workshop  
[Calculations for Modern and Future Colliders](#)

August 20 - 31  
*Helmholtz International Summer School*  
[Matter under Extreme Conditions in Heavy-Ion Collisions and Astrophysics](#)

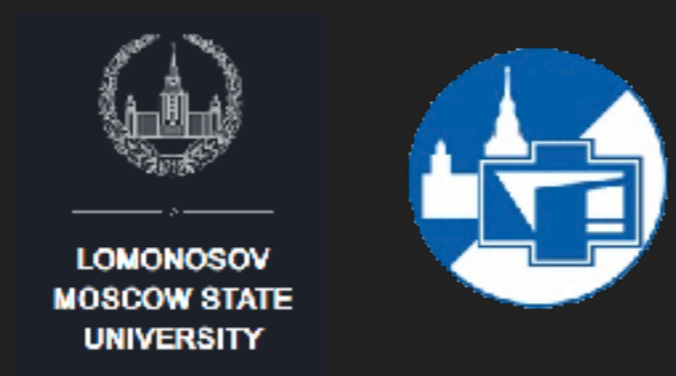
NEWS

2017  
Theoretical Physics  
[NICA](#)

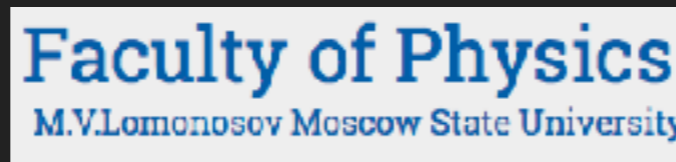
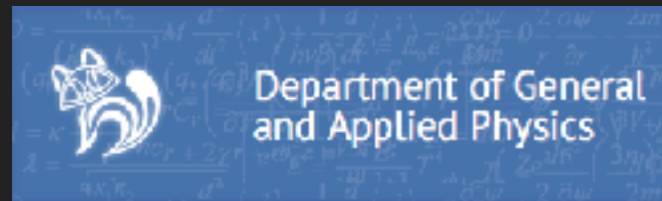
Summer School  
Lattice and Lattice

## EDUCATIONAL ACTIVITY

### Basic Level



State University  
DUBNA



Department of Natural  
and Engineering  
sciences

Chair of  
Fundamental and applied  
problems of microworld physics  
Head. Prof. D.Kazakov

Chair of  
Elementary particle physics  
Head. Prof. V.Matveev

Chair of  
Fundamental problems of  
microworld physics  
Head. Prof. D.Fursaev

## EDUCATIONAL ACTIVITY

### Basic Level



Al-Farabi Kazakh National  
University, Almaty, Kazakhstan



Univerzita Komenského,  
Bratislava, Slovakia



University of Pavol Jozef Safarik,  
Kosice, Slovakia

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SUPPORT OF HOT TOPIC GROUPS

## SUPPORT OF HOT TOPIC GROUPS

- ▶ New GROUP within Particle Physics Division on neutrino physics in collaboration with DLNP and participation of people from ITEP on contemporary basis

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- ▶ New GROUP within Particle Physics Division on neutrino physics in collaboration with DLNP and participation of people from ITEP on contemporary basis
- ▶ New PROJECT within Particle Physics Division with participation of Nuclear Physics Division and wide attraction of people from outside on hadronic matter at extreme conditions and theoretical aspects of confinement to provide theoretical support of NICA project

## FUNDAMENTAL INTERACTIONS OF FIELDS AND PARTICLES 2019-2023

**5 projects**

**Leaders**

**QFT and BSM Physics**

***D.I.Kazakov, A.V.Gladyshev, A.V.Bednyakov***

**Theory of EW interactions and Neutrino physics**

***A.B.Arbusov, V.A.Naumov, F.Simkovic***

**QCD and 3D/spin hadron structure**

***I.V.Anikin, O.V.Teryaev***

**Phenomenology of strong ints and precision physics**

***M.A.Ivanov, V.I. Korobov, A.E. Dorokhov***

**Theory of Hadron matter at extreme conditions**

***D. Blaschke, V.V. Braguta, E.E. Kolomeitsev, S.N. Nedelko***

## SCIENTIFIC PROJECTS

### QUANTUM FIELD THEORY AND PHYSICS BEYOND THE STANDARD MODEL

Project leaders: D.I.Kazakov, A.V.Gladyshev, A.V.Bednyakov

Project participants:

Kotikov A.V., Onishchenko A.I., Pikelner A.F., Baushev A.N., Hnatič M., Remecký R., Mižišin L., Vladimirov A.A., Kozlov G.A., Das Ch.R., Tolkachev D.M., Borlakov A.T., Yakhibbaev R.M. + 5 students

Scientific programme:

- Construction of field-theoretical models and their application to the elementary particle physics and modern statistical physics.
- Development of QFT formalism in gauge and supersymmetric theories.
- Construction and study of the models of particle physics beyond the Standard Model. Theoretical support of experiments at the LHC on the search of new physics.
- Calculation of multiloop radiative corrections within the Standard Model and its extensions as well as in the theory of critical behaviour.

Collaboration with JINR laboratories:

LIT (Gerdt V.P., Tarasov O.V.);

DLNP (Bednyakov V.A., Kalinovskaya L.V., Budagov J.A., Khramov E.V., Tkachev L.G., Yakushev E.V.)



# SCIENTIFIC PROJECTS

## THEORY OF ELECTROWEAK INTERACTIONS AND NEUTRINO PHYSICS

■ **Research subjects:** phenomenology of electroweak interactions at high and low energies; applications to astroparticle physics; high-precision tests of the Standard Model; radiative corrections; description of neutrino interactions with electrons, nucleons and nuclei, field-theoretical approach to neutrino oscillations; nuclear  $\beta$ ,  $2\nu\beta\beta$  and  $0\nu\beta\beta$  decays, electron capture.

**Theoretical support of existing and future experiments:** LHC, ILC, FCC, BES-III, Super Charm-Tau Factory; NoVa, ... etc.

**Project leaders:** Arbuzov A.B., Naumov V.A., Simkovic F.

**BLTP researchers involved:** Babich A., Bednyakov A.V., Bystritskyj Yu.M., Bytev V.V., Dorokhov A.E., Krivoruchenko M.I., Kuzmin K.S., Pikelner A.F., Sokalski I.A., Shkirmanov D.S

**Collaboration with:** groups from DLNP and LHEP; many international experimental and theoretical groups

## SCIENTIFIC PROJECTS

### Project: QCD and Spin/3D Structure of Hadrons

**Leaders:** *I.V. Anikin and O.V. Teryaev*

- **3D mapping of hadron structure:** Factorization Theorem for exclusive processes, Generalized Parton Distributions, Generalized Amplitude Distributions, Transverse-momentum Dependent Parton Distributions (new hot topic)
- **Spin Physics:** Factorization Theorem for (Semi)-Inclusive processes, High-Twist Spin-dependent Parton Distributions, Fragmentation Functions, Spin Sum Rules, Gravitation Form Factors, Light-Cone Sum Rules.

# SCIENTIFIC PROJECTS

## PHENOMENOLOGY OF STRONG INTERACTIONS AND PRECISION PHYSICS

**Project leaders: M.A. Ivanov; V.I. Korobov; A.E. Dorokhov**

### Topics:

**Effective quantum field theories. Low energy QCD. Fundamental constants. Precision physics and search for new physics.**

- Exclusive processes with hadrons, which contain heavy charm- and bottom quarks.
- Estimates of the Wilson coefficients for four-quark operators, which are not presented in the Standard Model.
- Meson creation in  $e^+e^-$  annihilation and tau-lepton decay in an extended Nambu–Jona-Lasinio model.
- Hadronic contribution to the hyperfine splitting of the levels in muonic hydrogen atoms and to the anomalous magnetic moment of muon.
- Precise spectrum of ro-vibrational states in molecular ions of hydrogen isotopes within the nonrelativistic QED to improve values of the Rydberg constant, masses of electron, proton and deuteron and the proton charge radius.

## SCIENTIFIC PROJECTS

**Activity: Theory of Hadronic Matter under Extreme Conditions**

**Leaders:** D. Blaschke, V.V. Braguta, E.E. Kolomeitsev, S.N. Nedelko

**Participants:**

BLTP

D.E. Alvarez-Castillo, M. Deka, S. Dorkin, A.E. Dorokhov,  
A.V. Friesen, A.A. Golubtsova, M. Hnatic, M. Hasegawa,  
M. Ilgenfritz, M. Ivanov, L. Kaptari, A.S. Khvorostukhin,  
N. Korchagin, A. Kotov, K. Maslov, V. Melezhik, A. Nikolsky,  
S. Pandiat, A. Parvan, A.M. Snigirev, O.V. Teryaev, V.D. Toneev,  
V.E. Voronin, D. Voskresensky, G.M. Zinoviev + 5 students

LIT

A.S. Ayriyan, H. Grigorian, Yu.L. Kalinovsky, E. Nikonov

VBLHEP

O.V. Rogachevsky, V. Voronyuk

**Collaborating organizations (>20 from 14 countries)**

**Models of QCD vacuum.** The analytical QFT models, development of the self-consistent mean field approach to QCD vacuum and hadronization, analytical studies of the properties of effective meson action with simultaneous incorporation of static and dynamical quark confinement and mechanisms of breakdown of chiral symmetry. Studying the mechanisms of deconfinement and chiral symmetry restoration under extreme conditions in explicit analytical approach.

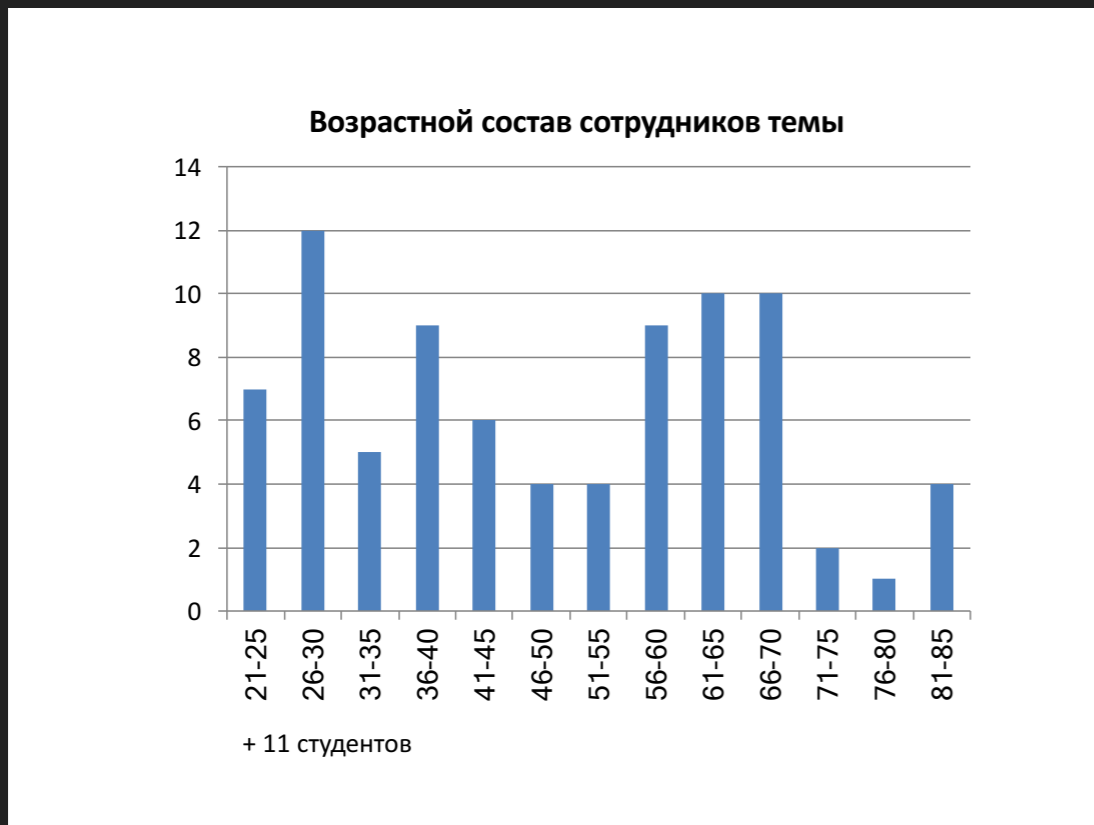
**Models for HIC.** Hydrodynamic, kinetic and hybrid approaches to the task of modelling different stages of heavy ion collisions. Parton-Hadron-String-Dynamics (PHSD) transport model as a powerful method in application to highly complicated problems of RHI.

**Statistical models.** Statistical approaches capable to treat strongly interacting systems with finite size and short life time. Description of systems of colliding relativistic heavy ions emphasizing its character as a rapidly evolving finite statistical system, which goes far beyond the exploration of equilibrium QCD.

**New phenomena related to strong EM fields.** Detailed understanding of the important role of strong electromagnetic (EM) fields, generically generated in heavy ion collisions, achieved via hydrodynamical and transport approaches to heavy ion collisions, in LQCD computations, and FRG and analytical models of QCD vacuum.

# MANPOWER

main stuff



main stuff+part time



► Total = 68+ 15(1/2)+11(st)

## BUDGET

Time frame of the theme 2019 – 2023

Total estimated cost of the theme k\$

№№	Activities	Total cost	Costs per years (thousand USD)				
			1st year	2nd year	3rd year	4th year	5th year
1.	Salary	10401,9	1772,2	1949,4	2105,4	2231,6	2343,3
2.	Unified social tax	3141,3	535,2	588,7	635,8	673,9	707,7
3.	Social Fund	676,2	115,2	126,7	136,9	145,1	152,3
4.	The international cooperation	750,0	150,0	150,0	150,0	150,0	150,0
5.	Materials	250,0	50,0	50,0	50,0	50,0	50,0
6.	Equipment	400,0	80,0	80,0	80,0	80,0	80,0
	<b>Total</b>	15619,4	2702,6	2944,8	3158,1	3330,6	3483,3
7.	Infrastructure BLTP	4288,8	776,2	815,9	855,7	898,5	943,4
	<b>Total</b>	19908,2	3478,8	3759,8	4013,8	4229,1	4426,7
8.	Infrastructure JINR	6761,1	1151,9	1267,1	1368,5	1450,5	1523,1
	<b>Total</b>	<b>26179,3</b>	4630,7	5026,9	5382,3	5679,6	5949,8

## CONCLUSION

Theme “Theory of Fundamental interactions” successfully completed

New theme “Fundamental interactions of fields and particles” follows the current trends and supports JINR flagship project NICA