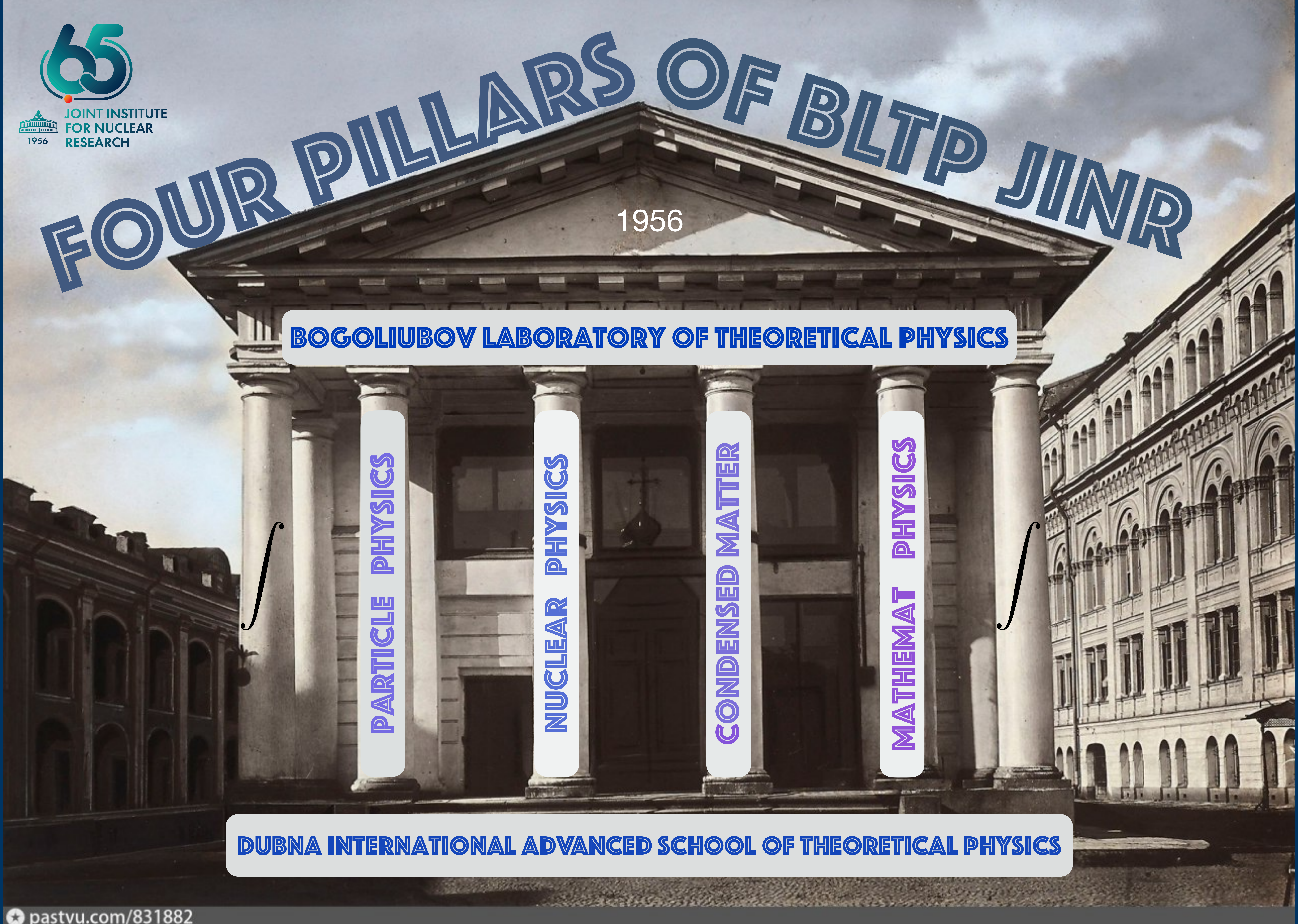

65
JOINT INSTITUTE FOR NUCLEAR RESEARCH
1956
FOUR PILLARS OF BLTP JINR
1956
BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS
PARTICLE PHYSICS
NUCLEAR PHYSICS
CONDENSED MATTER
MATHEMAT PHYSICS
DUBNA INTERNATIONAL ADVANCED SCHOOL OF THEORETICAL PHYSICS
pastvu.com/831882

JOINT INSTITUTE FOR NUCLEAR RESEARCH
1956

SCIENTIFIC DIVISIONS OF BLTP

PARTICLE PHYSICS

43 perm
+50 temp

NUCLEAR PHYSICS

38 perm
+28 temp

CONDENSED MATTER

24 perm
+12 temp

MATHEMATICAL PHYSICS

16 perm
+16 temp

BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

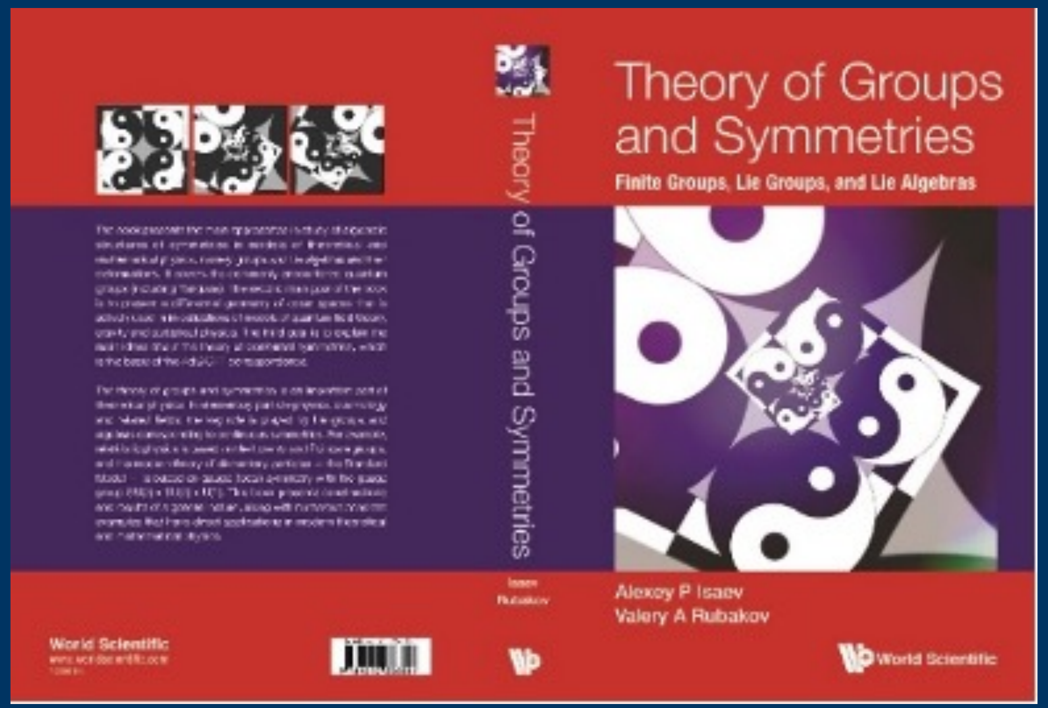
JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956

Scientific Stuff: 239

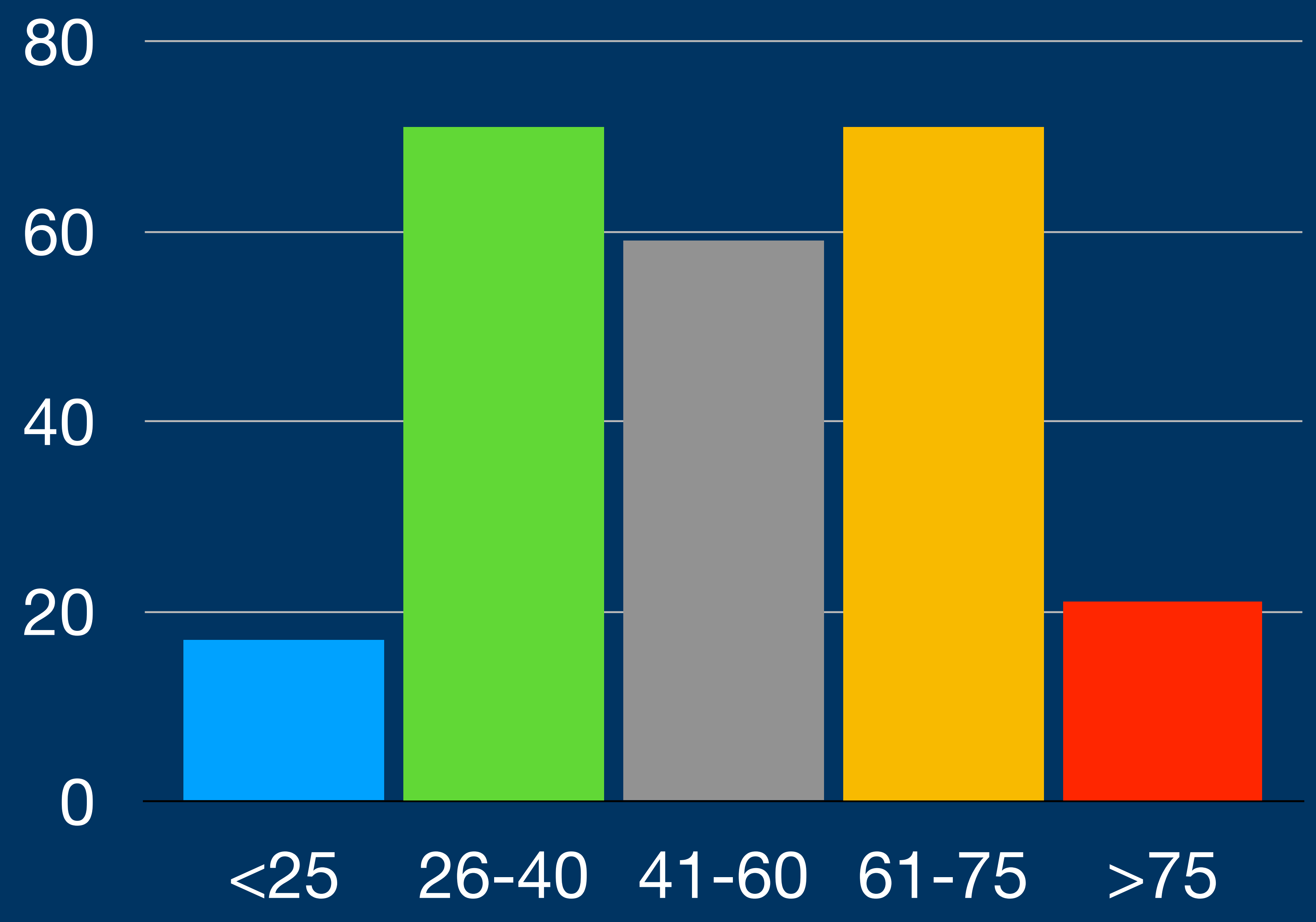
- Doctor of science — 94
- Candidate of science — 97
- Graduate and Post-graduate students — 25

Papers published per year

- journals ~ 330
- proceedings ~ 220
- Monograph (A.P.Isaev and V.A.Rubakov)



Age distribution



Conferences organized per year ~10-15

Schools organized per year — 4

BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

Scientific Stuff: 239

- Russian Federation - 171
- Kazakhstan - 12
- Belarus - 6
- Armenia - 5
- India - 5 ❋
- Romania - 5
- Slovakia - 5
- Bulgaria - 4
- Ukraine - 4
- Vietnam - 3
- Germany - 3 ❋
- Poland - 3
- Iran - 2 ❋
- Moldova - 2
- Tadzhikistan - 2 ❋
- Uzbekistan - 2
- Japan - 2 ❋
- Azherbadjan - 1
- Mexico - 1 ❋
- Mongolia - 1

❋ - Non-member state

JOINT INSTITUTE FOR NUCLEAR RESEARCH
1956

CONFERENCES

2019

1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | *2019* | 2020 | 2021 |

January 28 - February 1
XV Winter School on Theoretical Physics
Complex Systems and Advanced Materials

March 20 - 22
International Workshop
Infinite and finite nuclear matter

June 2 - 8
XIV International Workshop
Particle Correlations and Femtoscopy (WPCF2019)

July 14 - 20
BLTP/JINR - APCTP/Korea Joint Workshop
Modern problems in nuclear and elementary particle physics

July 8 - 12, Prague, Czech Republic
The XXVIth International Conference on
Integrable Systems and Quantum Symmetries

July 22 - August 2
Helmholtz International Summer School
Quantum Field Theory at the Limits: from Strong Fields to Heavy Quarks

July 28 - August 2
International School
Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems

August 4 - 17
Helmholtz International Summer School
Cosmology, Strings, New Physics

August 26 - 31, Yerevan, Armenia
International Workshop
Supersymmetries and Quantum Symmetries (SQS19)

September 1 - 10, Sinaia, Romania
VIIIth International Pontecorvo
Neutrino Physics School

September 2 - 7
XVIIIth International Workshop on
High Energy Spin Physics (DSPIN-19)

September 9 - 13
International Bogolyubov Conference
Problems of Theoretical and Mathematical Physics
(dedicated to the 110th anniversary of the birth of N.N. Bogolyubov (1909-1992))

September 16 - 19
II International workshop
Theory of Hadronic Matter under Extreme Conditions

September 22 – 28, Varna, Bulgaria
XXIII International School on
Nuclear Physics, Neutron Physics and Applications

October 27 - November 1, Guangzhou, China
BLTP/JINR - KLTP/CAS Joint Workshop
Physics of Strong Interacting Systems

2020

1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | *2020* | 2021 |

Pandemia Covid-19

May 18 - 22, Almaty, Kazakhstan
International Conference
Astroparticle and Nuclear Physics

June 7 - 13, Pereslavl-Zalessky, Russia
The 21st International Seminar on High Energy Physics **Quarks-2020**

June 29 - July 3
International Conference
Low Dimensional Materials: Theory, Modelling and Experiment

July 6 - 10, Prague, Czech Republic (postponed to 2021)
The XXVIIth International Conference on
Integrable Systems and Quantum Symmetries

July 13 - 18, Yeosu, Republic of Korea
14th International Workshop
Modern problems in nuclear and elementary particle physics

July 20 - 24, Yerevan, Armenia (postponed to 2021)
XVIIIth International Conference
Symmetry Methods in Physics (SYMPHYS)

July 26 - 31, Gyumri, Armenia
BLTP/JINR - KLTP/CAS Joint Workshop
Physics of Strong Interacting Systems

July 26 - 31
International School
Advanced Methods of Modern Theoretical Physics: Integrable and Stochatic Systems

August 16 - 26 (postponed to 2021)
Helmholtz International Summer School
Matter under Extreme Conditions in Heavy-Ion Collisions and Astrophysics

August 27 - September 5 (postponed to 2021)
Helmholtz International Summer School
Hadron Structure, Hadron Matter and Lattice QCD

August 31 - September 4, Saint Petersburg, Russia
The 7th International Conference
Models in Quantum Field Theory
dedicated to the 80-th anniversary of professor A.N.Vasiliev

August 31 - September 3
III International Workshop
Lattice and Functional Techniques for QCD

September 14 - 19 (postponed to 2021)
XXVth International Baldin Seminar
Relativistic Nuclear Physics and Quantum Chromodynamics

September 21 - 25
II International Workshop
Infinite and Finite Nuclear Matter (INFINUM-2020)

September 21 - 25, Khabarovsk, Russiai (postponed to 2021)
IVth International Workshop on
Few-Body Systems

October 22
Workshop (in Russian)
Dark Matter: theoretical proposals and experimental searches

JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956

CONFERENCES

2019

1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |2018 | *2019* |2020
|2021 |

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2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
2020 | *2021*

February 1 - 7
XVI DIAS-TH BLTP Winter School on Theoretical Physics
Actual Cosmology

July 12 - 17
International Conference
Low Dimensional Materials: Theory, Modelling and Experiment (LDM2021)

August 1 - 6 **(postponed to 2022)**
International School
Advanced Methods of Modern Theoretical Physics:
Integrable and Stochatic Systems

August 22 - 27
International Workshop
Geometry, Integrability and Supersymmetry (GIS21)

September 6-11 **(postponed to 2022)**
International Workshop
Supersymmetries and Quantum Symmetries - SQS'21

October 11 - 14
International Conference
Advances in Quantum Field Theory

October 11 - 15, Prague, Czech Republic **(postponed to 2022)**
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Integrable Systems and Quantum Symmetries

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demia Covid-19

JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956

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October 22
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demia Covid-19

SELECTED SCIENTIFIC RESULTS' 2020

QUANTUM FIELD THEORY

D. Kazakov, A.Borlakov, D.Tolkachev, et al

Phys.Lett, JHEP, Phys.RevD, 2016-2020

- A new approach to non-renormalizable interactions in developed.
- For the first time the Generalized Renormalization Group equations for the scattering amplitudes are obtained

- Maximally supersymmetric gauge theory in D=6,8,10 dimensions SYM
- Scalar field theory in D=4,6,8,10 dimensions
- Gauge theory in D=4,6,8 dimensions YM
- Supersymmetric Wess-Zumino model with quartic superpotential in D=4

$$\Gamma_4(s,t,u) = \lambda(1+\Gamma_s(s,t,u)+\Gamma_t(s,t,u)+\Gamma_u(s,t,u))$$

ϕ^4_D

$D = 4,6,8,10$

$$\frac{d\Gamma_s(s,t,u)}{d\log\mu^2} = -\frac{1}{2}\frac{s^{D/2-2}}{\Gamma(D/2-1)}\int_0^1 dx[x(1-x)]^{D/2-2}\sum_{p=0}^{(D/2-2)k}\sum_{l=0}^{p}\frac{1}{p!(p+D/2-2)!}\times$$
$$\times\left(\frac{d^p\Gamma_4(s,t',u')}{dt'^l du'^{p-l}}\Big|_{\substack{t'=-xs,\\ u'=-(1-x)s}}\right)^2 s^p[x(1-x)]^p t^l u^{p-l}$$

$$\Gamma_4(s,t,u) = \mathcal{P}\frac{\lambda}{1+\frac{1}{2}\frac{\Gamma(D/2-1)}{\Gamma(D-2)}\lambda(s^{D/2-2}+t^{D/2-2}+u^{D/2-2})\log(\mu^2/E^2)}$$

- This opens a possibility to work with non-renormalizable interactions and gives the instrument to study their high-energy behaviour

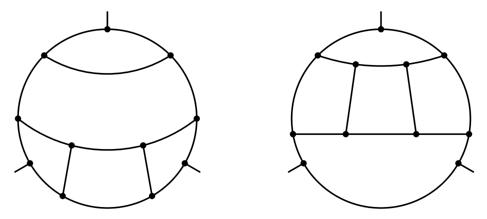
Breakthrough in general model RG calculations

$\lambda\varphi^4$	$\lambda(\vec{\varphi}\vec{\varphi})^2$	$\lambda_{abcd}\varphi_a\varphi_b\varphi_c\varphi_d$
$O(1)$	$O(n)$	G-arbitrary

$d = 4 - 2\varepsilon$

- 6-loop beta functions
- group G arbitrary, e.g. $O(l)\times O(m)\times O(n)$

Bednyakov,Pikelner'JHEP2021

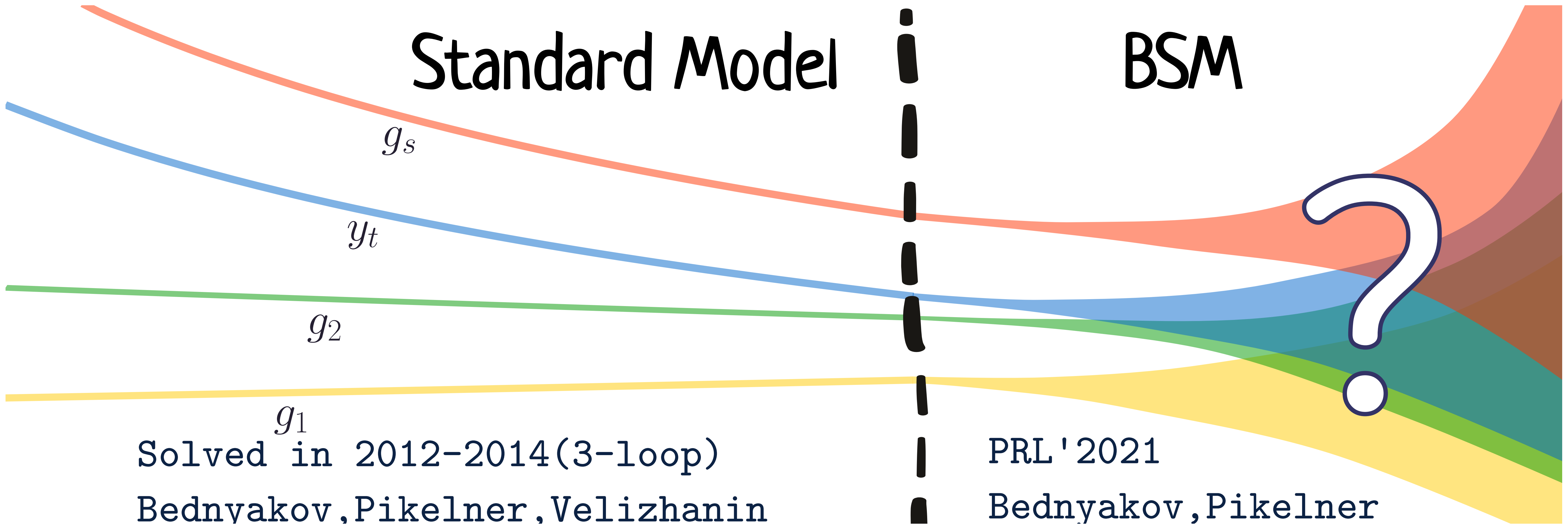


$d = 6 - 2\varepsilon$

- All RG in $g\varphi^3$ at 5 loops
- cf. conformal bootstrap/MC
- Playground for resummation

Kompaniets,Pikelner'PLB2021

4-loop gauge and 3-loop Yukawa couplings evolution in arbitrary BSM model



Gravitational anomaly and vector particle polarization

MPD (NICA)

Chirality and vorticity for vector particles

- There is a calculation of **polarization** from the **axial vortical effect** (AVE) and the chiral **anomaly** for particles with **spin ½**:

[Rogachevsky O., Sorin A., Teryaev O. Phys.Rev.2010.-Vol.C82.-P.054910], [Sadofyev A., Shevchenko V., Zakharov V., Phys.Rev.-2011.-Vol.D83.-P.105025.]

Questions

- Is this true for vector particles (gluons, vector mesons)?
- Is the CVE related to the chiral anomaly in the case of spin 1?

Gravitational anomaly for spin 1

$$< \nabla_\mu K^\mu > = \frac{1}{96\pi^2} R_{\mu\nu\rho\sigma} \tilde{R}^{\mu\nu\rho\sigma}$$

[A. Dolgov, I. Khriplovich, A. Vainshtein, V. Zakharov, Nucl.Phys. B315 (1989) 138]

T^2 dependent term in AVE can be related to the gravitational anomaly (a sort of duality of gravity and statistics):

Shown for spin 1/2 by considering of the Hawking radiation of an analogue of a rotating black hole:

- **Generalized** to spin 1in:

[G. Prokhorov, O. Teryaev and V. Zakharov, Phys.Rev. D102, Rapid Communication, no.12, 121702 (2020)]

- **Problem detected!**

Factor of 2 difference in predictions of statistics and gravitational anomaly:

$$\mathbf{K}_{Kubo} = \frac{\mathbf{1}}{\mathbf{6\pi^2}} T^2 \mathbf{\Omega} \quad \mathbf{K}_{black\, hole} = \frac{\mathbf{1}}{\mathbf{3\pi^2}} T^2 \mathbf{\Omega}$$

- **Solution!**

By using infinitesimal mass for infrared regularization in calculating both anomaly and CVE:

[G. Prokhorov, O. Teryaev, V. Zakharov, Phys. Rev. D 103, no.8, 085003 (2021)]

$$\mathbf{K}_{Kubo} = \frac{\mathbf{1}}{\mathbf{3\pi^2}} T^2 \mathbf{\Omega}$$

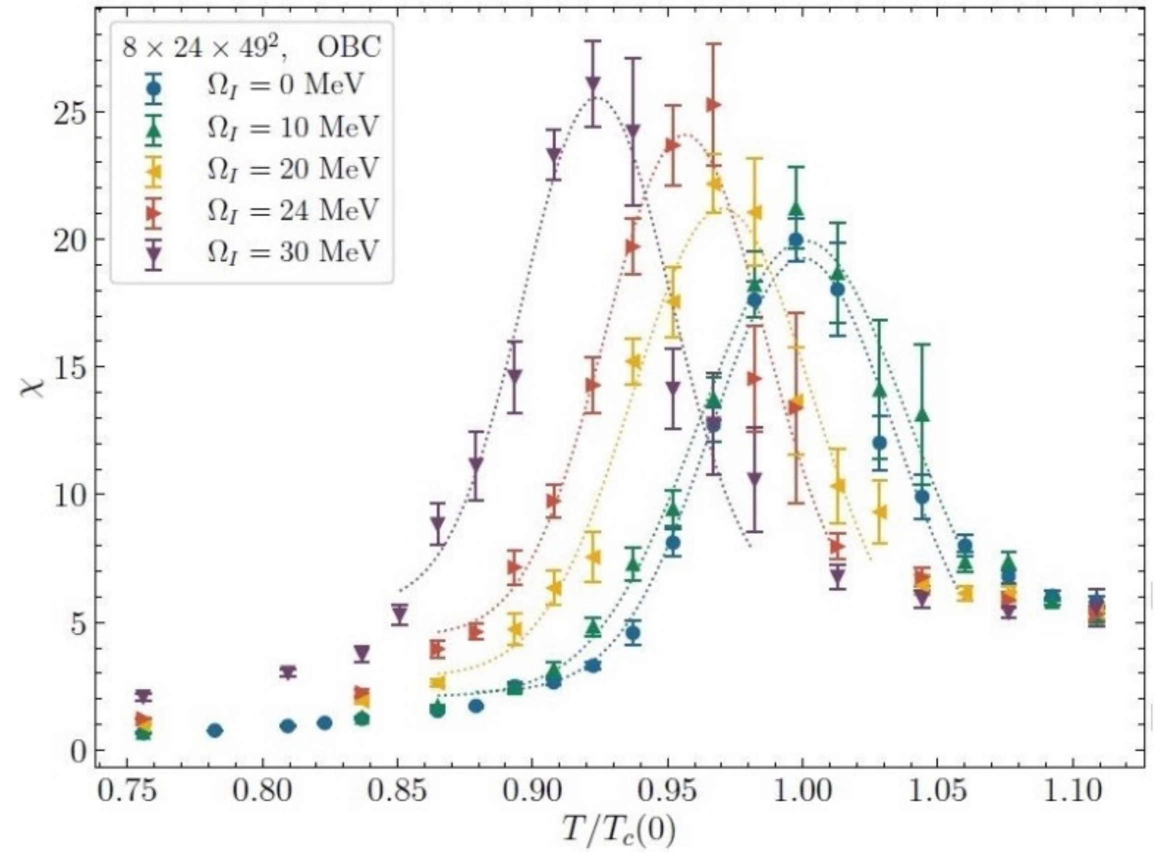
Phenomenological consequences of the chirality of vector particles:

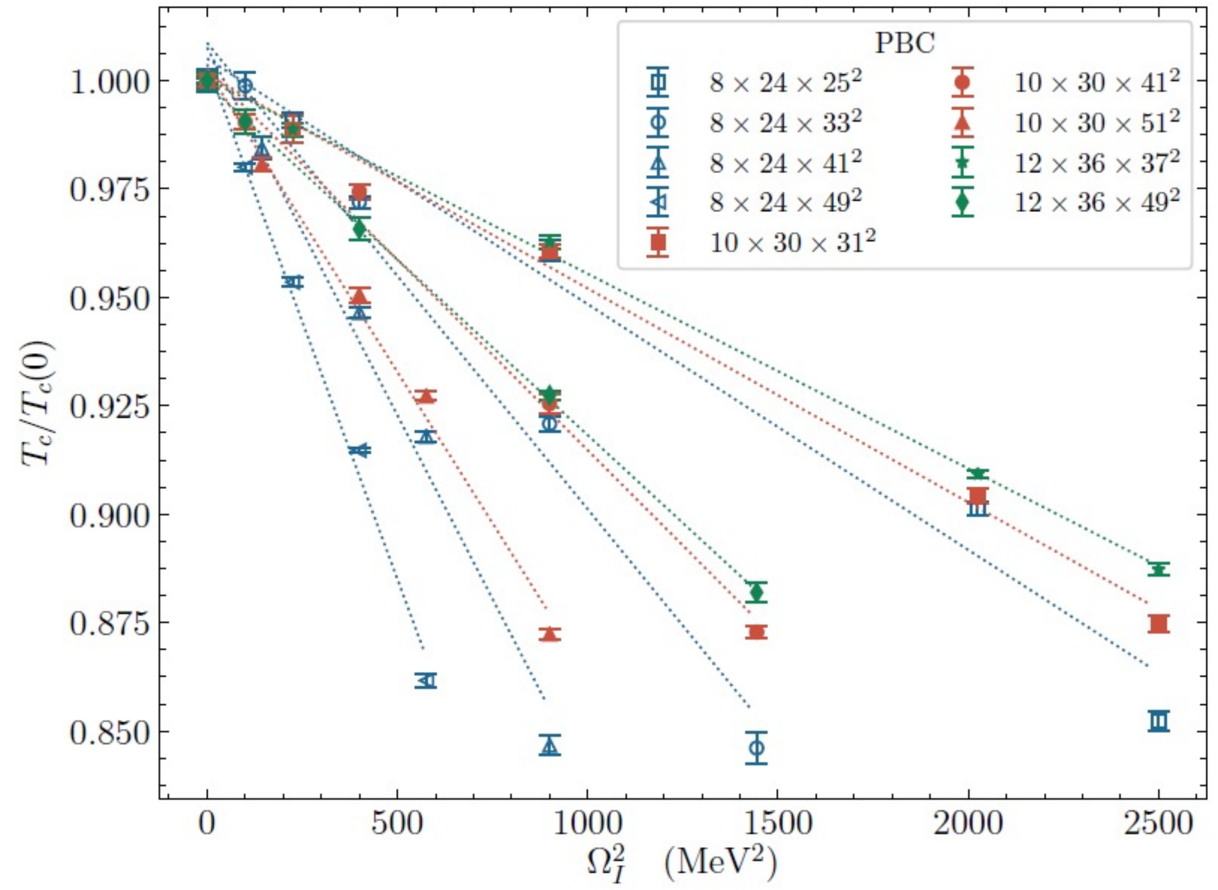
1) Essential in calculating the polarization of Λ and $\bar{\Lambda}$ - part of the axial charge is carried away by vector K^* mesons.
2) Vector (related to chirality) and tensor components of polarizations are mixed in the positivity constraints and invariants of density matrix.

MPD (NICA)

Rotating gluonic matter within lattice simulations

- Relativistic rotation of quark-gluon matter modifies its properties and gives rise to new physical phenomena
- Baryon polarization due to rotation can be observed at NICA experiment (O. V. Teryaev , V. I. Zakharov, 2017)
- Influence of rotation to properties of quark-gluon matter can be studied within lattice simulation based on the first principles
- *Rotation is increasing critical temperature of confinement /deconfinement transition in gluodynamics* (V. Braguta et al, Pisma Zh.Eksp.Teor.Fiz. 112 (2020) 1, V. Braguta et al, Phys.Rev.D 103 (2021) 9, 094515)





Form-factor-independent test of lepton universality

Generic differential $(q^2, \cos\theta)$ distribution for the semileptonic decays $\bar{B}^0 \to D^{(*)+}\ell^-\bar{\nu}_\ell$, $B_c^- \to J/\psi(\eta_c)\ell^-\bar{\nu}_\ell$, $\Lambda_b \to \Lambda_c\ell^-\bar{\nu}_\ell$ is written as

$$\frac{d^2\Gamma(q^2,\ell)}{dq^2\, d\cos\theta} \propto v^2\Big(A_0(q^2,\ell) + A_1 \cos\theta(q^2,\ell) + v\, A_2(q^2)\cos^2\theta\Big)$$

The velocity type factor $v = 1 - m_\ell^2/q^2$ factors out in the quadratic $\cos^2\theta$ coefficient. Therefore one can define an optimized partial rates: $d\Gamma^{\rm opt}(q^2)/dq^2 \propto A_2(q^2)$ which are the same in the SM for all three (e, μ, τ) modes:

$$d\Gamma^{\rm opt}(q^2)|_e = d\Gamma^{\rm opt}(q^2)|_\mu = d\Gamma^{\rm opt}(q^2)|_\tau$$

In this way one can test μ/e, τ/μ and τ/e lepton universality regardless of form-factor effects. New Physics (NP) contributions designed to strengthen the τ rate will clearly lead to a violation of these equalities.

S. Groote, M.A. Ivanov, J.G. Ko¨rner, V.E. Lyubovitskij, P. Santorelli, C.T. Tran, Phys. Rev. D103, 093001 (2021)

Analyzing New Physics in the decays $B \to D^{(*)}\tau\nu_\tau$

SM+NP effective Hamiltonian for the quark-level transition $b \to c\tau^-\bar{\nu}_\tau$:

$$\mathcal{H}_{eff} \propto G_F\, V_{cb}\,[(1 + V_L)\mathcal{O}_{V_L} + V_R\mathcal{O}_{V_R} + S_L\mathcal{O}_{S_L} + S_R\mathcal{O}_{S_R} + T_L\mathcal{O}_{T_L}]$$

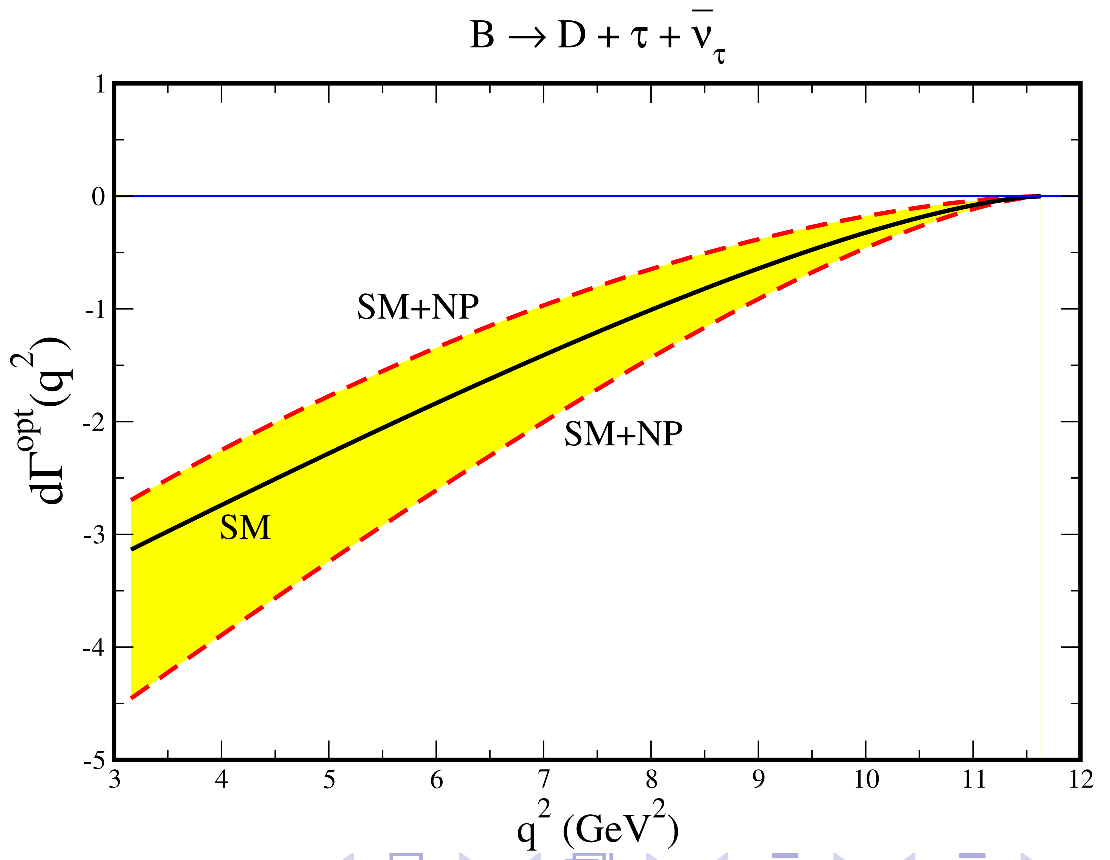
where the four-fermion operators are written as

$$\mathcal{O}_{V_L} = (\bar{c}\gamma^\mu P_L b)(\bar{\tau}\gamma_\mu P_L\nu_\tau) \qquad \mathcal{O}_{V_R} = (\bar{c}\gamma^\mu P_R b)(\bar{\tau}\gamma_\mu P_L\nu_\tau)$$
$$\mathcal{O}_{S_L} = (\bar{c}P_L b)(\bar{\tau}P_L\nu_\tau) \qquad \mathcal{O}_{S_R} = (\bar{c}P_R b)(\bar{\tau}P_L\nu_\tau)$$
$$\mathcal{O}_{T_L} = (\bar{c}\sigma^{\mu\nu}P_L b)(\bar{\tau}\sigma_{\mu\nu}P_L\nu_\tau)$$

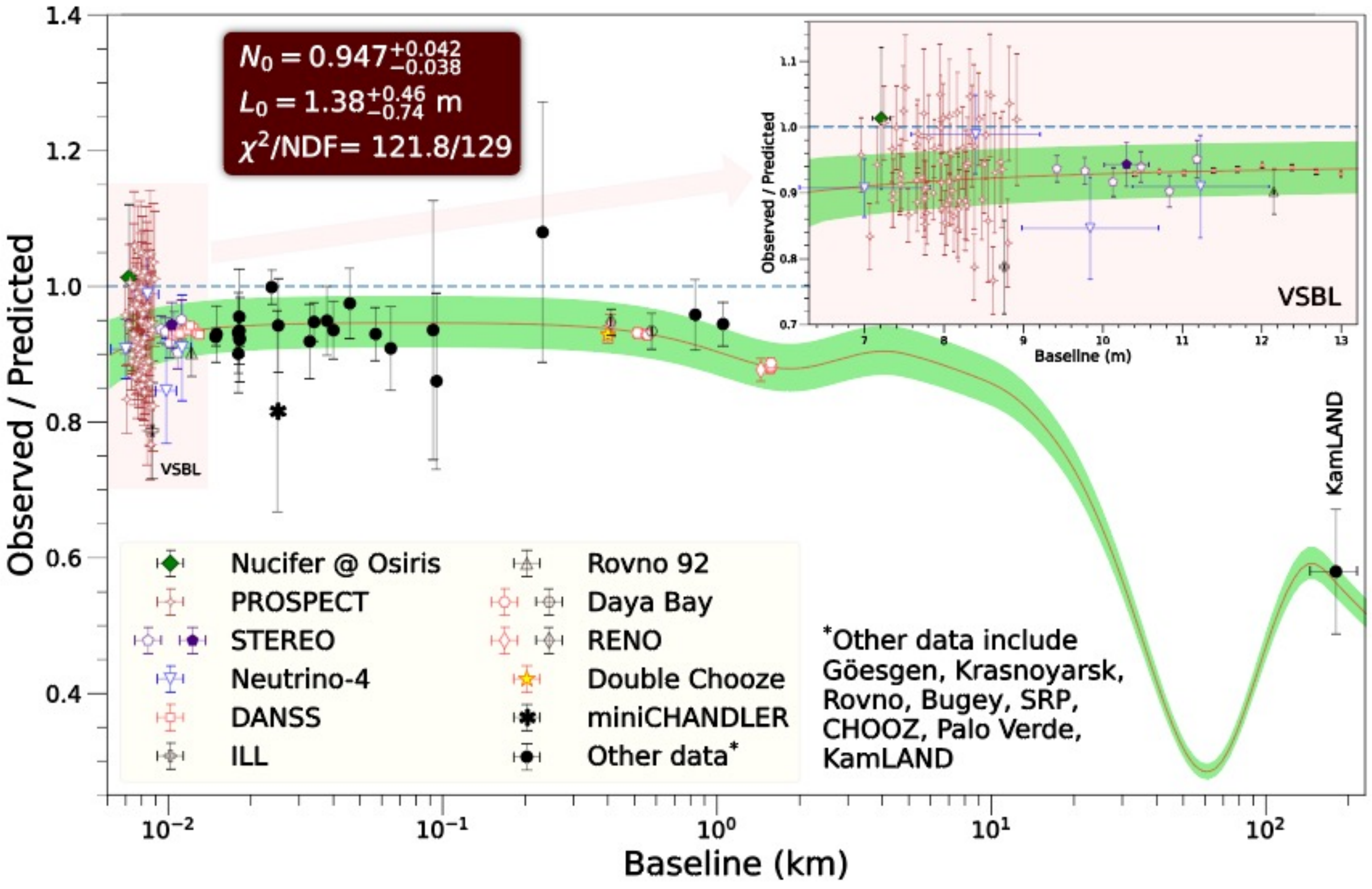
Here, $\sigma_{\mu\nu} = i\,[\gamma_\mu, \gamma_\nu]/2$, $P_{L,R} = (1 \mp \gamma_5)/2$.
$V_{L,R}$, $S_{L,R}$, and T_L are complex Wilson coefficients governing NP.

In the SM: $V_{L,R} = S_{L,R} = T_L = 0$.
NP only affects leptons of the third generation.
The best value for each NP coupling to fit the data for the ratios $R(D)$ and $R(D^*)$:

$$V_L = -1.33 + i\,1.11, \qquad V_R = 0.03 - i\,0.60,$$
$$S_L = -1.79 - i\,0.22, \qquad T_L = 0.38 - i\,0.06.$$



Inverse-Square Law Violation from reactor antineutrino data



A QFT approach to neutrino oscillations predicts that the classical inverse-square law (ISLV) can be violated at short, but possibly macroscopic distances from the neutrino source. The extensive analysis of the current reactor data shows that the averaged over the reactor antineutrino spectrum value of the ISLV spatial scale (L_0) ranges from 0.6 to 1.9 m (at 68% C.L.) that approximately corresponds to 0.7–1.2 eV for the spectrum and reactor/detector averaged effective parameter σ_{eff} representing the cumulative effect of the momentum spreads of the external in and out states (wave packets of nuclei and particles) in reactor and detector, which produce and absorb the antineutrinos .

V. A. Naumov, D. S. Shkirmanov, "Reactor Antineutrino Anomaly Reanalysis in Context of Inverse-Square Law Violation", Universe **7** (2021) 246

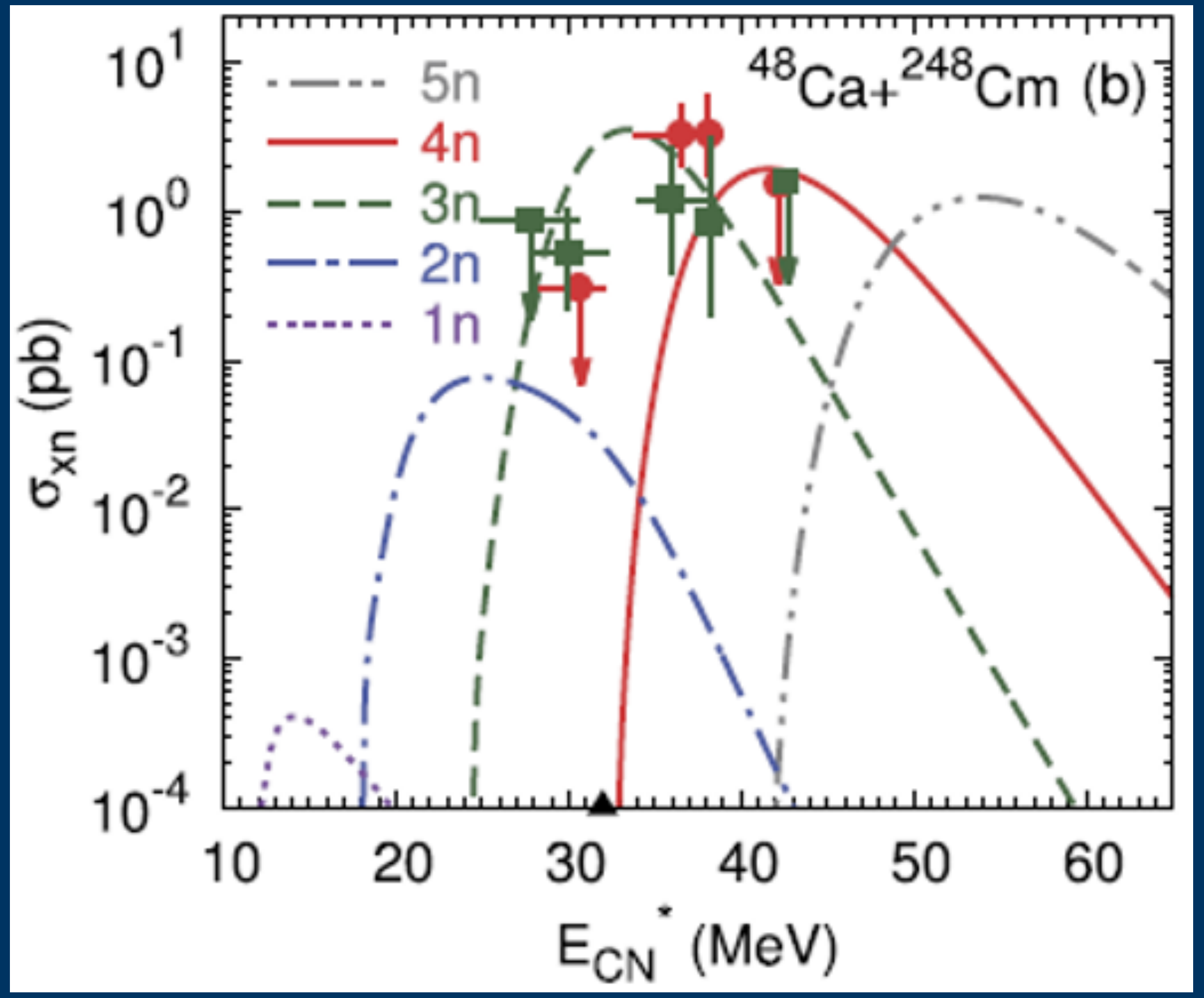
Nuclear Reactions for Superheavy Nuclei

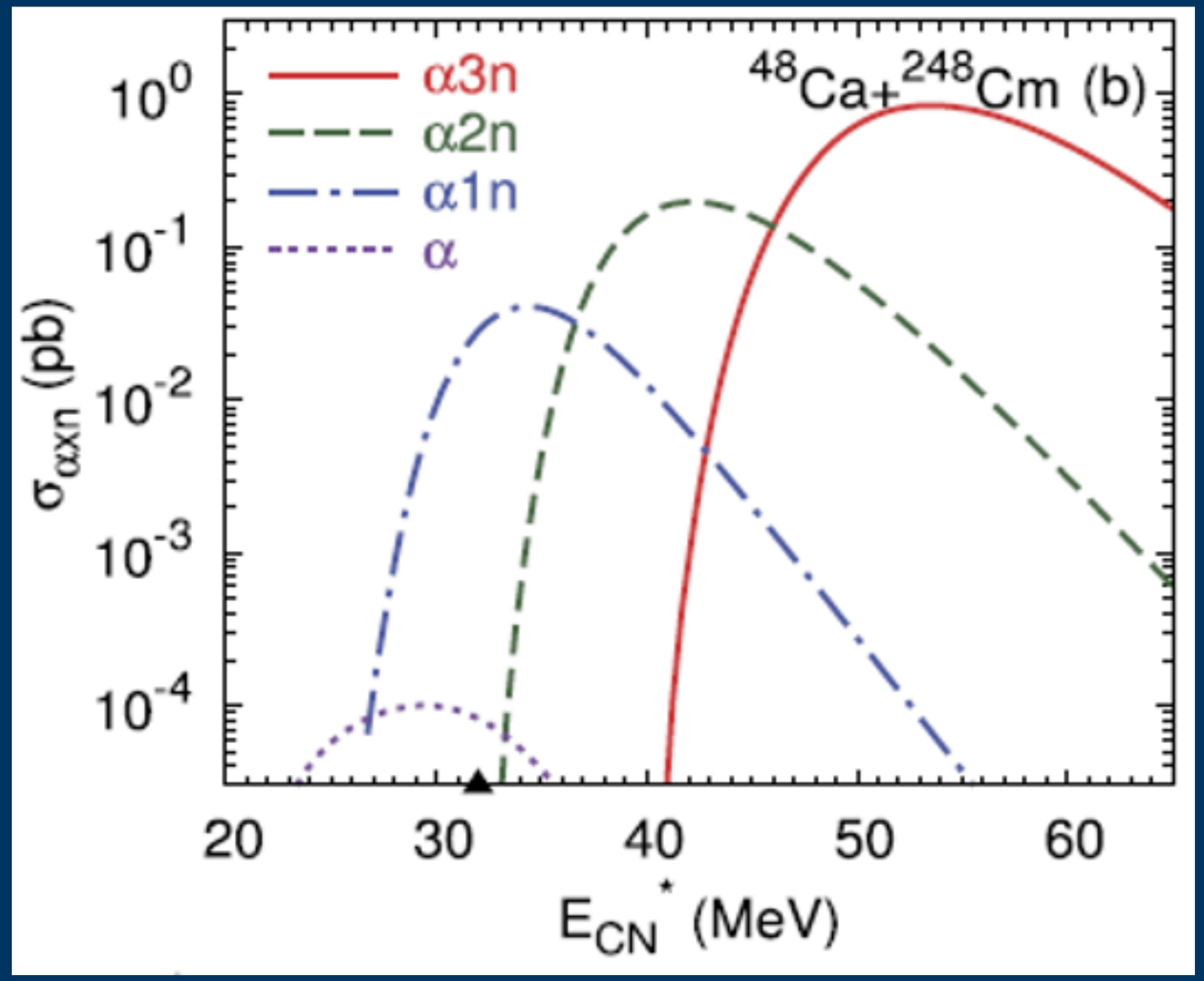
Possibilities of direct production of superheavy nuclei with *Z*=112–118 in different evaporation channels

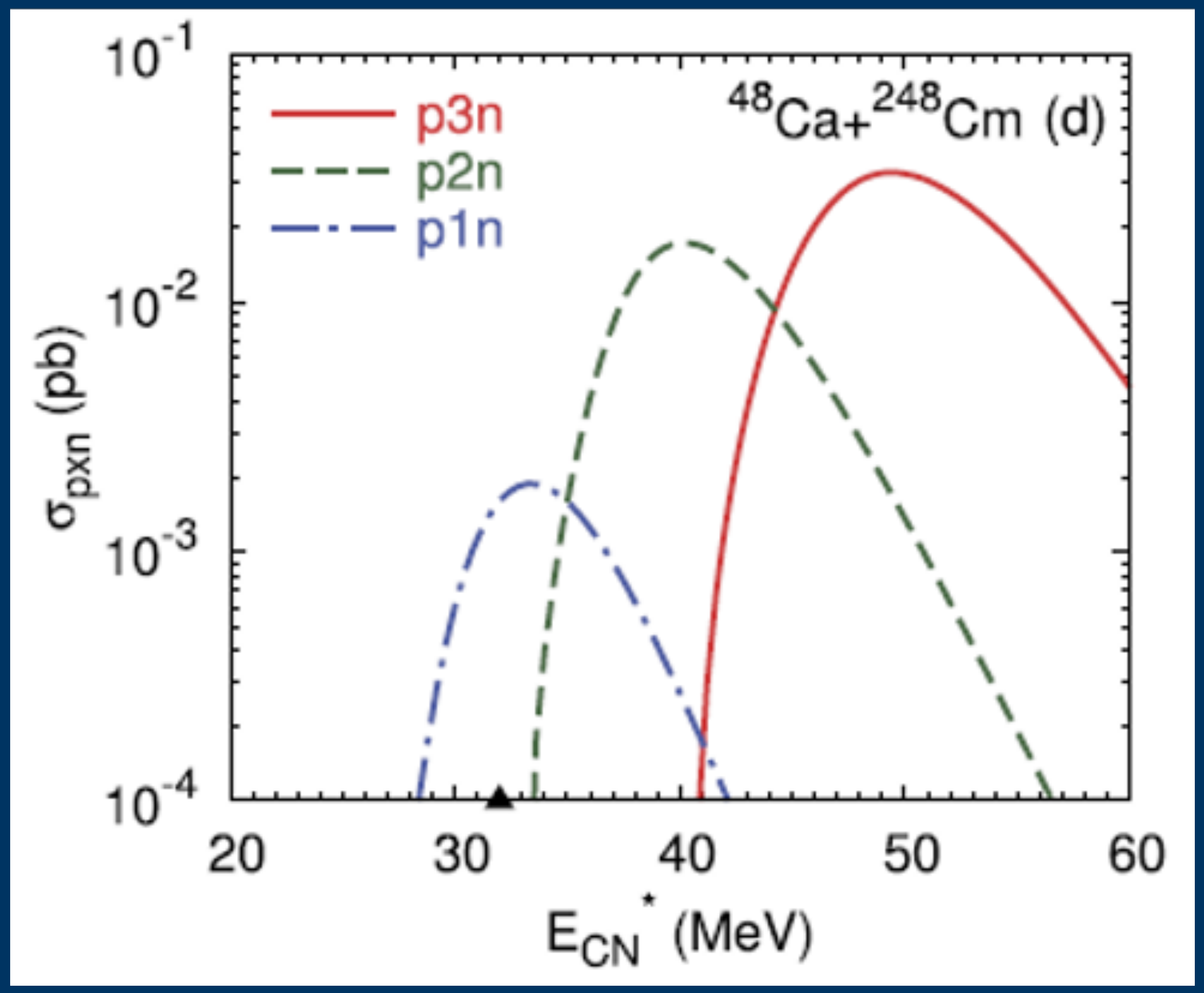
Juhee Hong, G.G. Adamian, N.V. Antonenko, P.Jachimowicz, M.Kowal

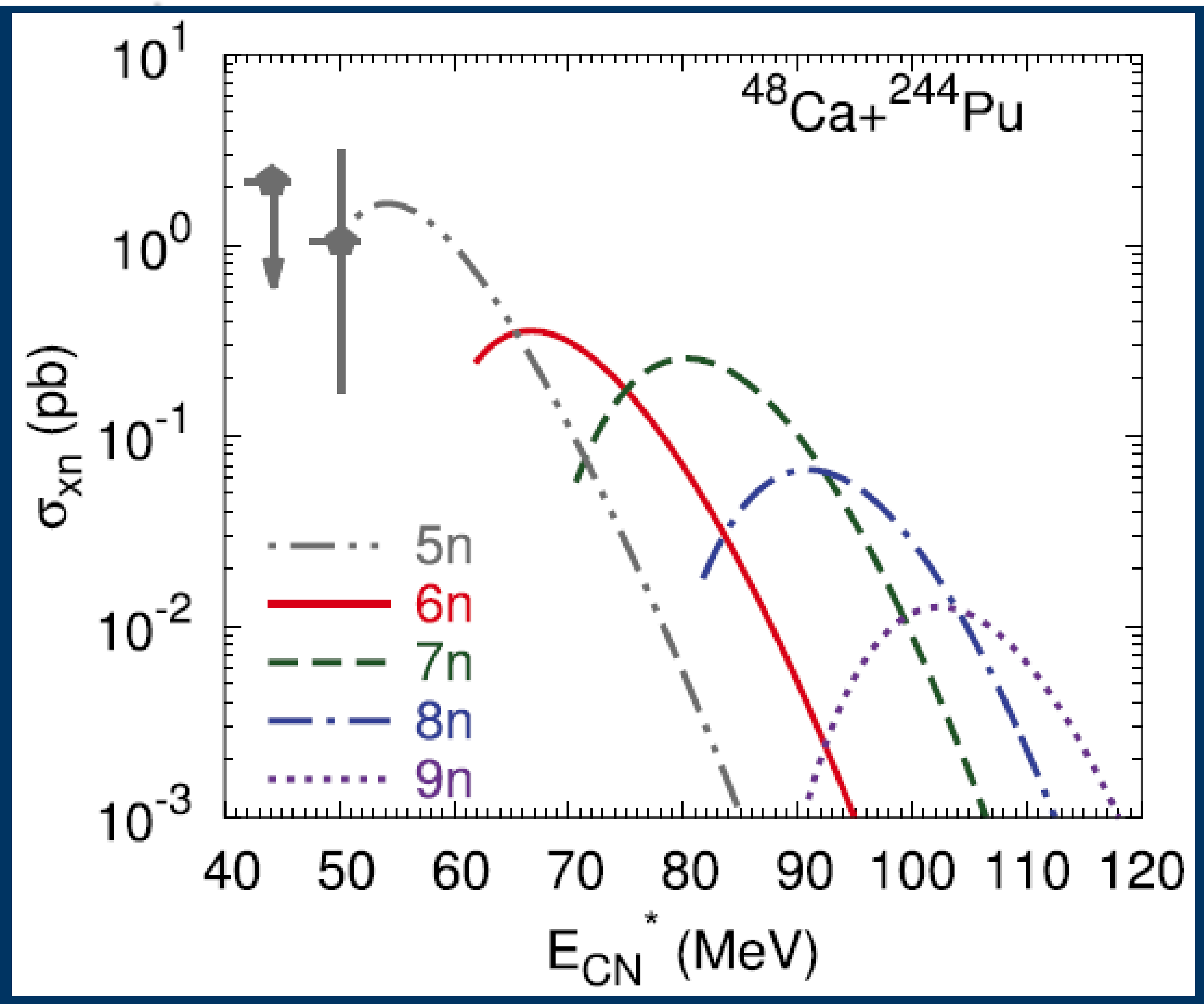
Phys. Lett. B **809**, 135760 (2020); PRC 103, L041601

The production cross sections of heaviest isotopes of SHN with charge numbers 112–118 were predicted in the *xn*–, *pxn*–, and α*xn*–evaporation channels of the ^{48}Ca-induced complete fusion reactions for future experiments. The estimates of synthesis capabilities are based on a uniform and consistent set of input nuclear data. **The synthesis of new superheavy isotopes unattainable in reactions with emission of neutrons is proposed in the promising channels with emission of protons (σ_{pxn} ≈10 −200 fb) and alphas ($\sigma_{\alpha xn}$ ≈50 −500 fb)**.
The decline of the cross section with increasing excitation energy unexpectedly turned out to be relatively weak in the *xn*-evaporation channel.









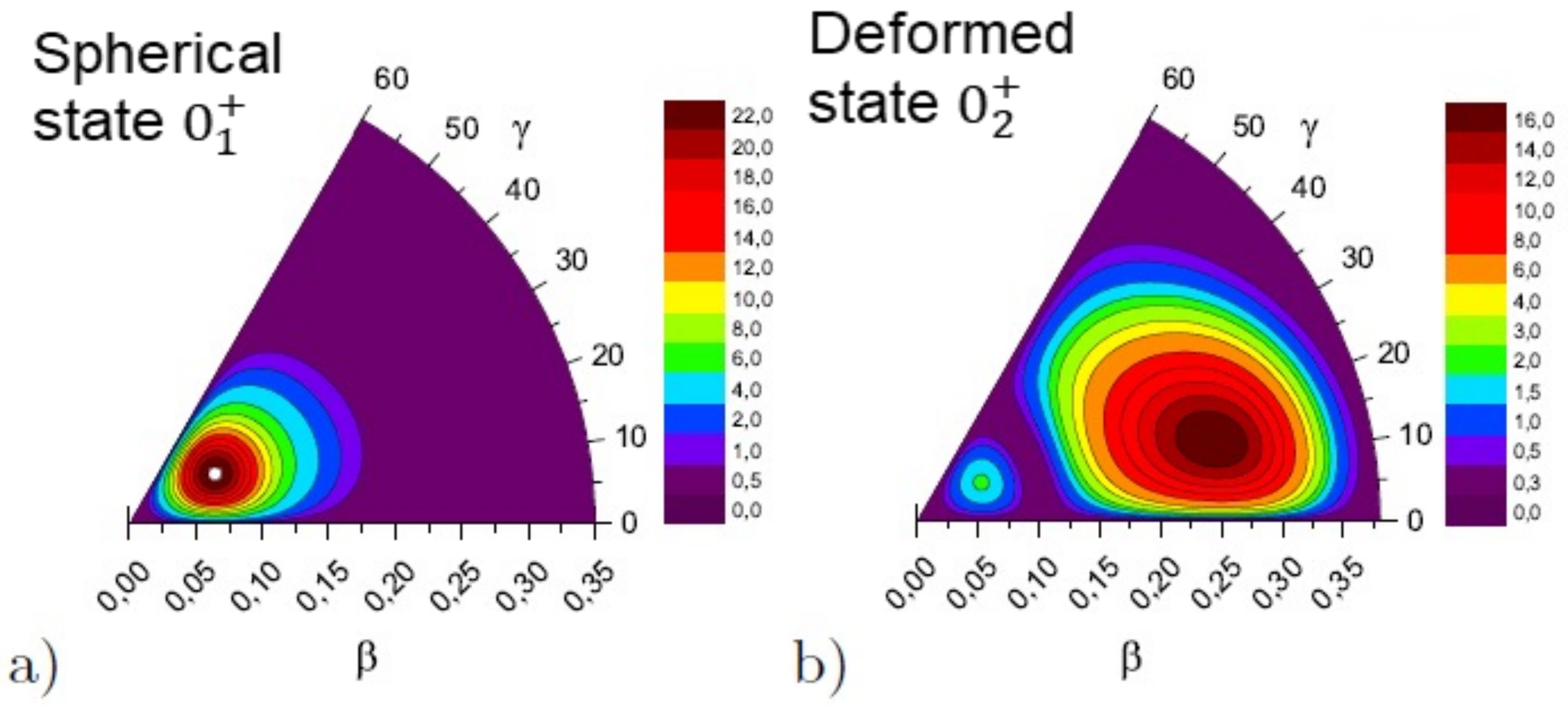
Nuclear Structure

Description of the low-lying collective states of ^{96}Zr based on the collective Bohr Hamiltonian including triaxiality degree of freedom

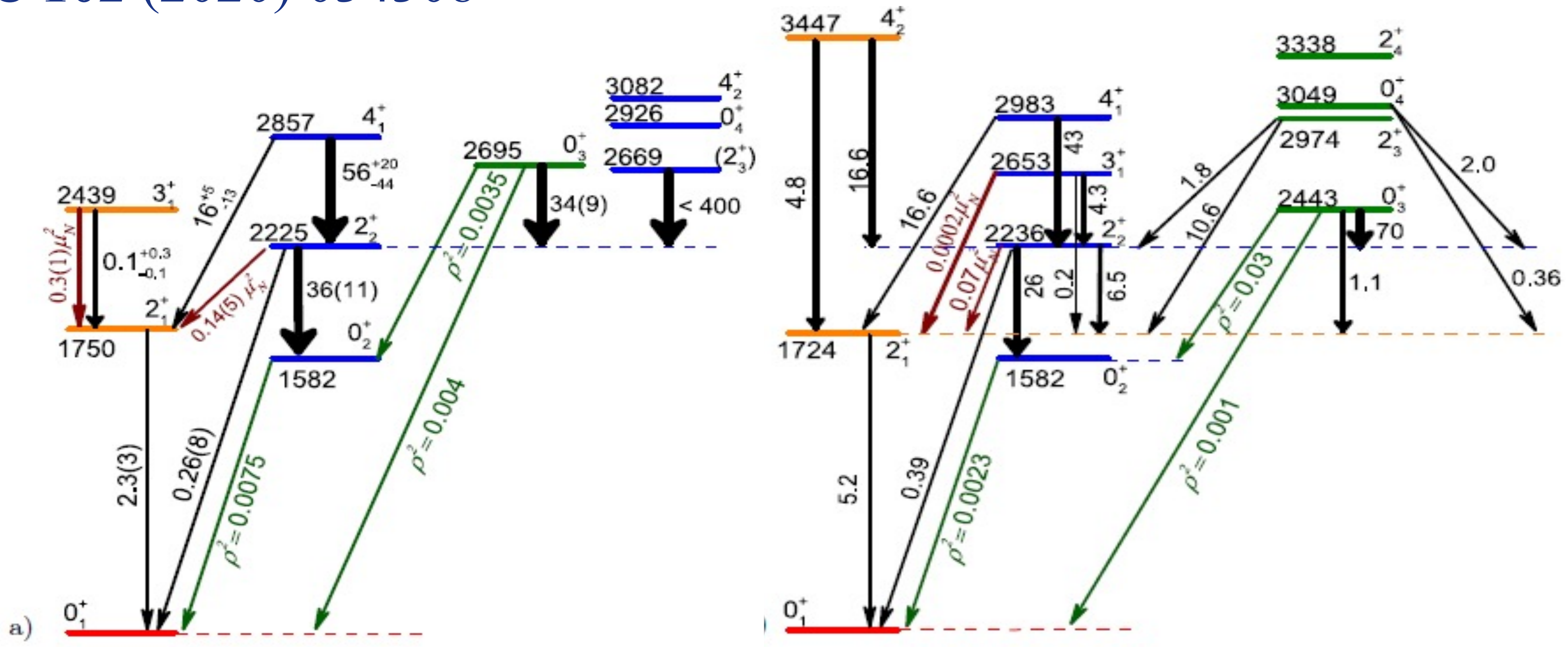
E.V. Mardyban, E.A. Kolganova, T.M. Shneidman, R.V. Jolos, and N. Pietralla

Phys. Rev. C **102** (2020) 034308

- Several collective low-lying states are observed in ^{96}Zr whose properties indicate that some of them belong to the spherical and the other to deformed states. Thus, shape coexistence phenomenon is realized in this nucleus.



The squares of the wave function of the 0_1^+ and 0_2^+ states, multiplied by the volume element



Experimental (a) and calculated (b) low-energy level scheme of positive-parity states of ^{96}Zr. Excitation energies are given in keV, B(E2) - in W.u.

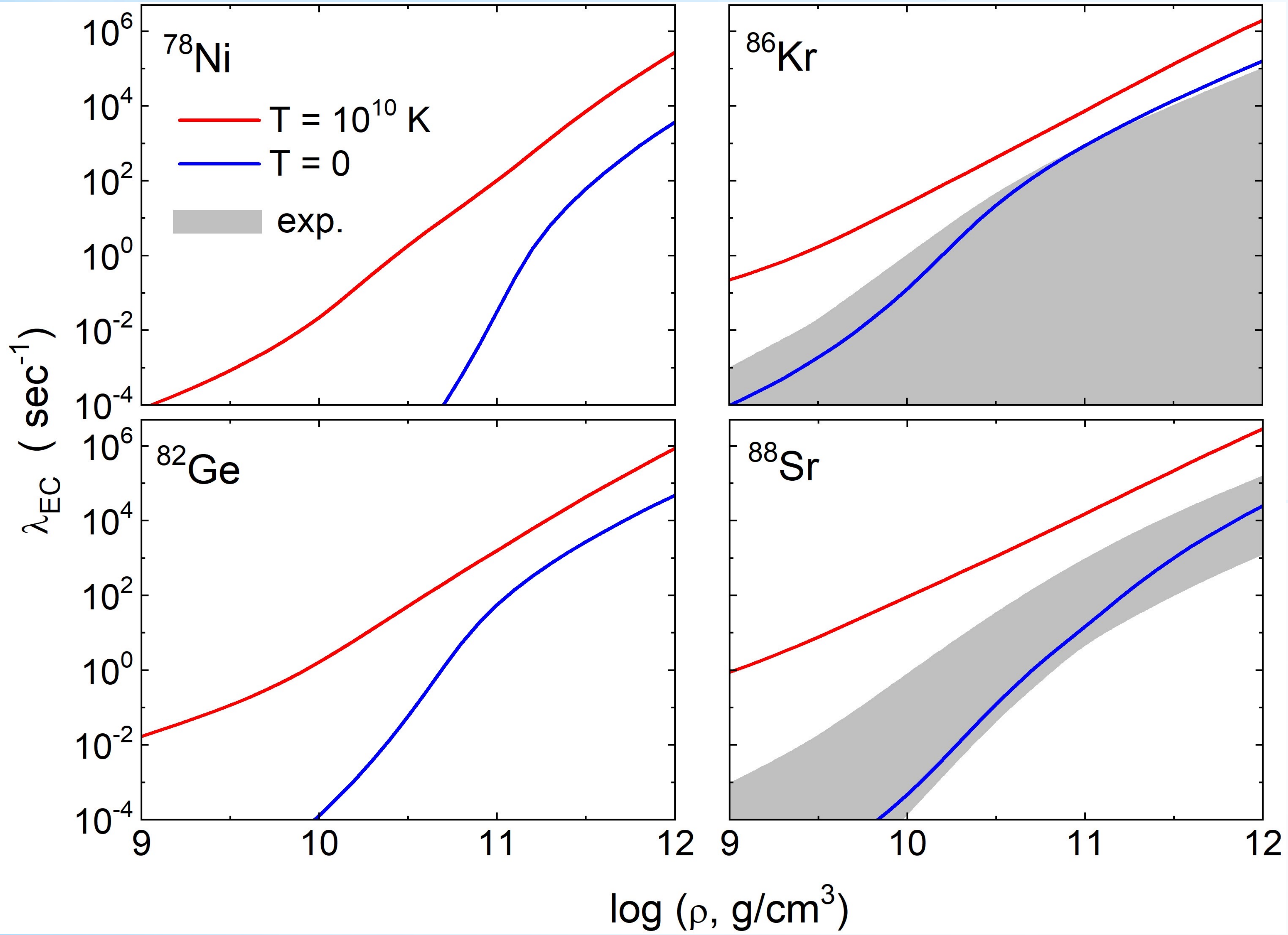
- It is shown that the collective Hamiltonian with a potential having spherical and deformed minima describes the spectra of the collective states and the electromagnetic transition probabilities. **The theoretical method was tested to be applied to superheavy nuclei in which shape coexistence is also expected.**

Nuclear Astrophysics

A.A. Dzhioev, K. Langanke, G. Martinez-Pinedo, A.I. Vdovin, Ch. Stoyanov

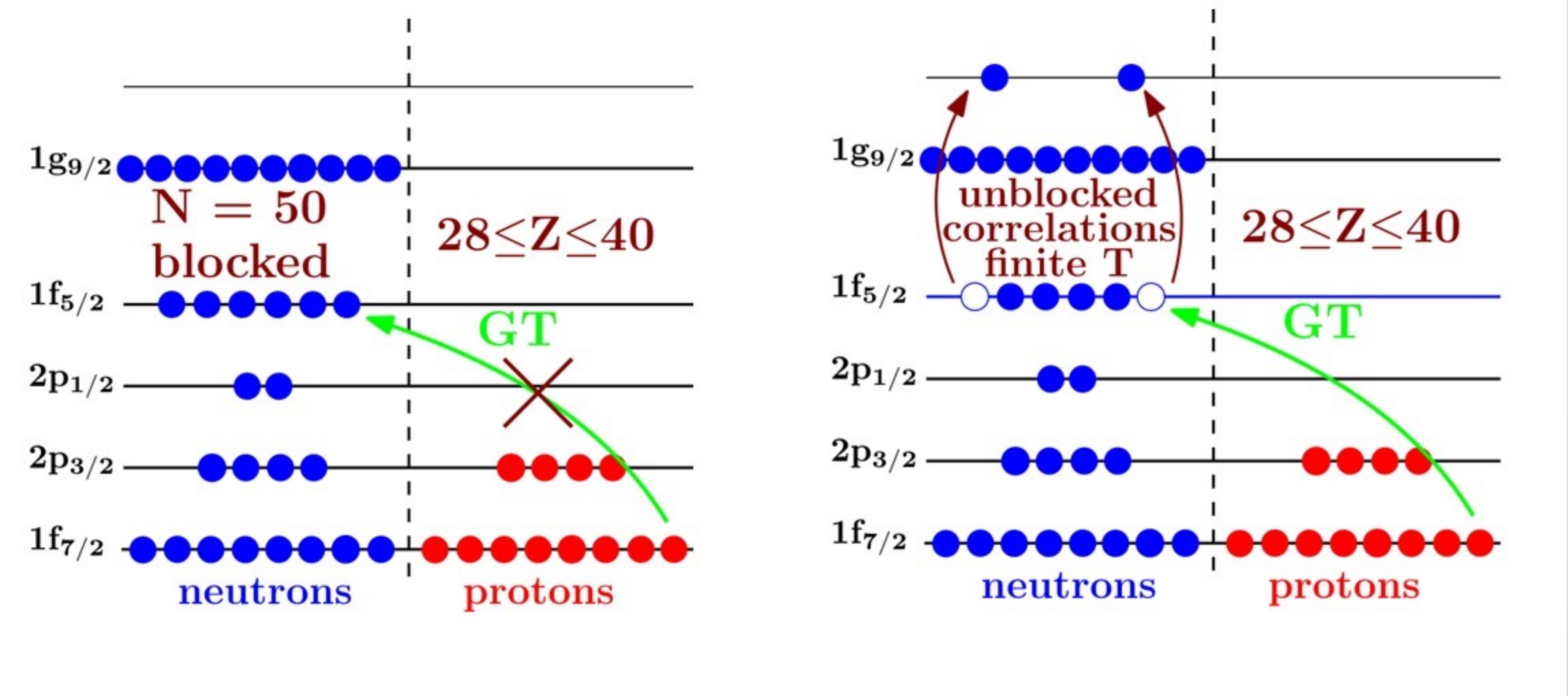
Unblocking of stellar electron capture rates for neutron-rich N = 50 nuclei at finite temperature

Phys. Rev. C 101 (2020) 025805



Electron capture rates as functions of core density during a supernova collapse.

Neutron-rich nuclei with N close to 50 are abundant in the core during a supernova collapse. The N = 50 shell gap could serve as an obstacle for electron captures in supernovae blocking GT transitions. **However, the finite-temperature calculations show that this blocking is overcome at finite temperatures due to thermal excitations.**

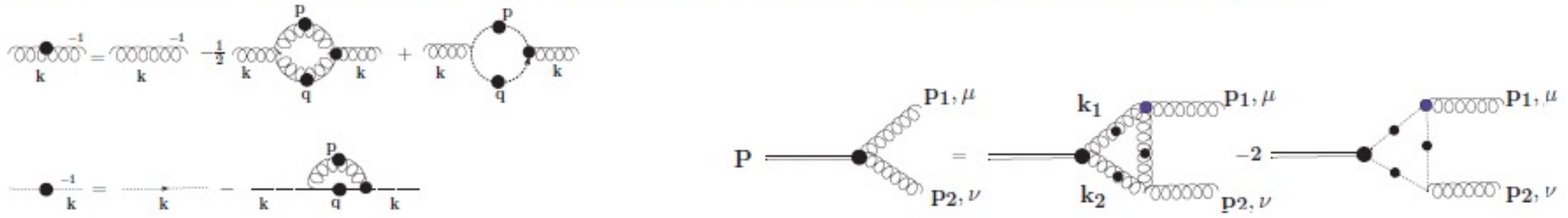


Relativistic Nuclear Physics

Mass spectrum of pseudo-scalar glueballs from a Dyson-Schwinger-Bethe-Salpeter approach.

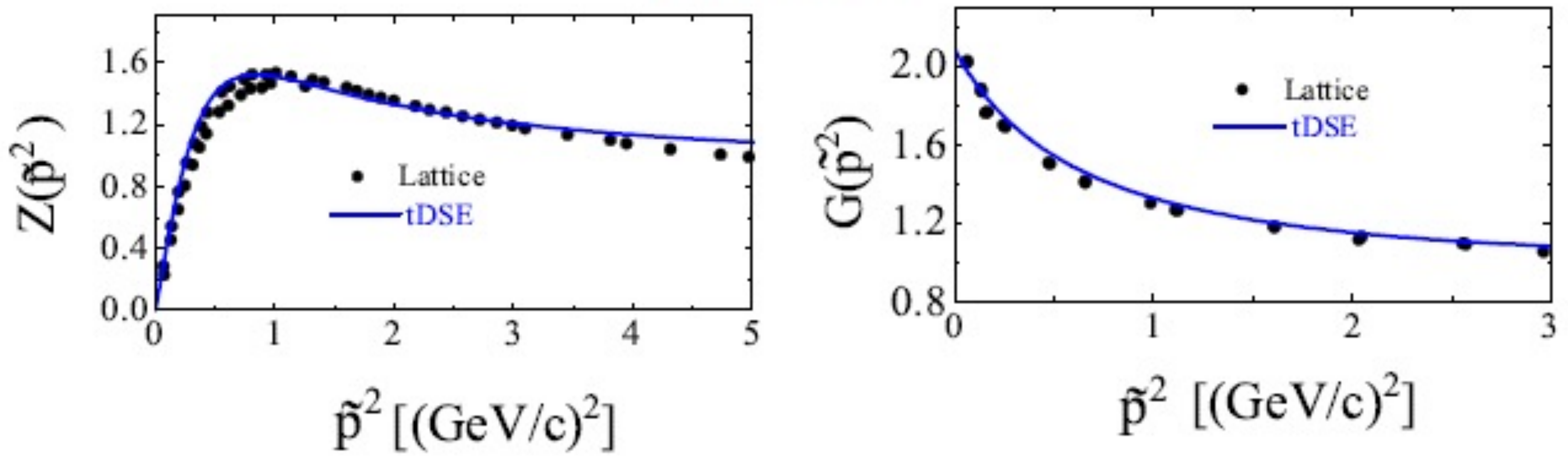
L.P. Kaptari, B. Kaempfer, Few Body Systems, 61, 28, 2020

The masses of the ground and excited states of pseudo-scalar glueballs have been calculated within a framework based on the rainbow approximation to the Dyson-Schwinger and Bethe-Salpeter equations with effective parameters adjusted to lattice data. The partial BS amplitudes have been calculated as well.



Dyson-Schwinger for gluon and ghost propagators (left panel); Bethe-Salpeter for glueballs (right panel)

RESULTS



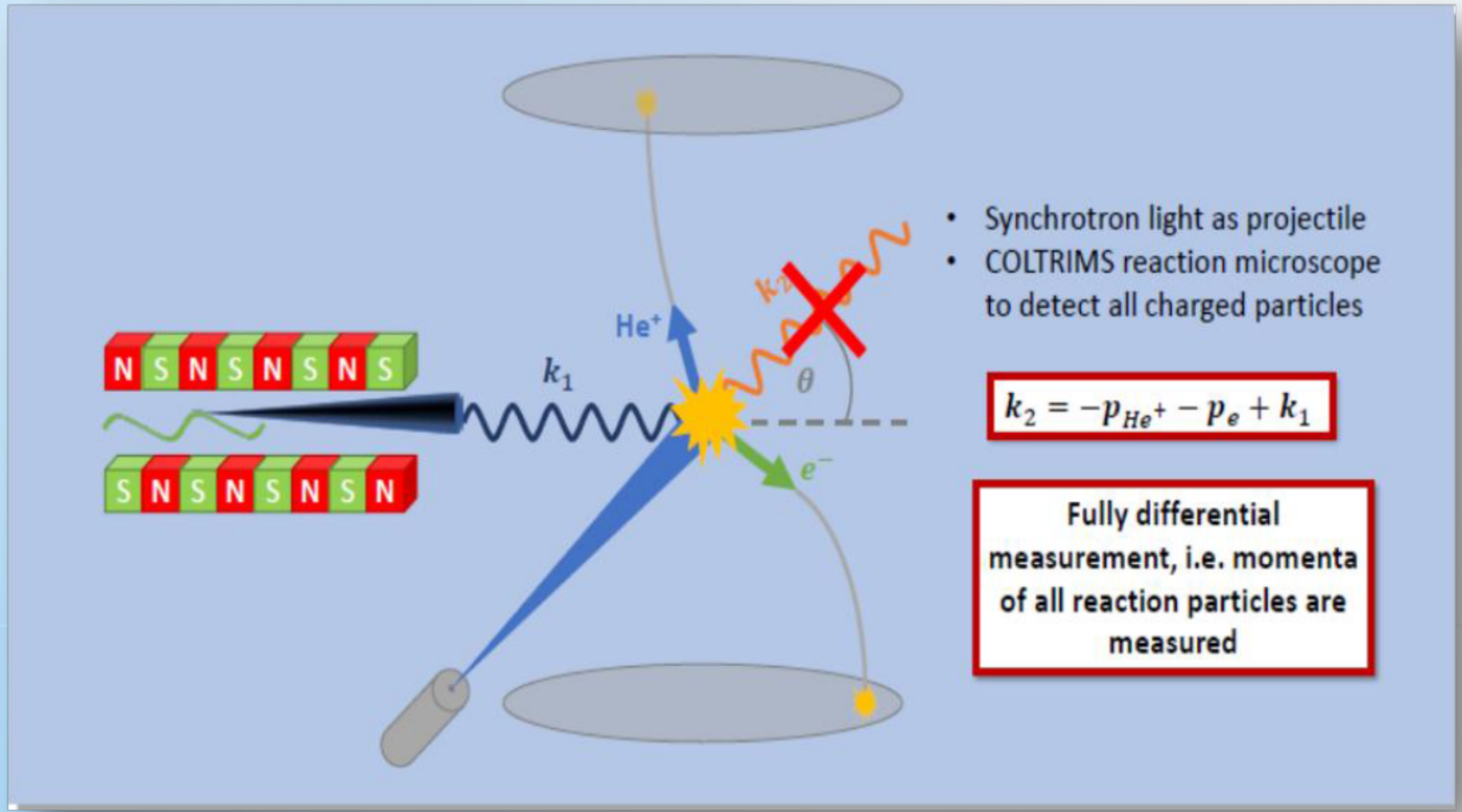
Solutions of the DS equations (solid lines) in comparison with lattice SU(2) calculations (filled circles). Left panel: gluon dressing function, right panel: ghost dressing function.

Atomic Physics

M.Kircher, … , Yu.V.Popov, O.Chuluunbaatar … et al.

Kinematically complete experimental study of Compton scattering at helium atoms near the threshold

Nature Physics 16 (2020), 756



The uniqueness of the experiments lies in measuring the distribution of helium ions instead of measuring the energy and scattering angle of the final photon, which has been done so far. In this case the photon momentum is restored from the energy and momentum conservation laws (see Figure).

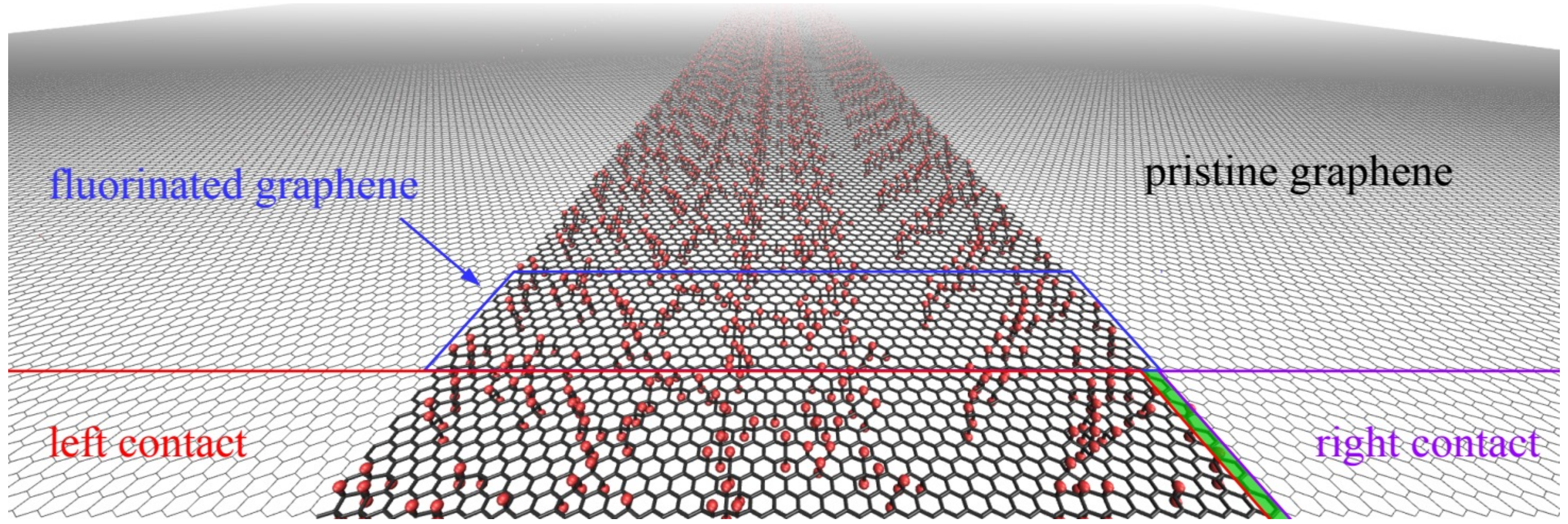
The task of theorists was to substantiate the use of the single Compton ionization as one more instrument of atomic spectroscopy, along with such powerful methods for studying the momentum distribution of an active electron in atoms and molecules, such as (*e*,2*e*), for example.

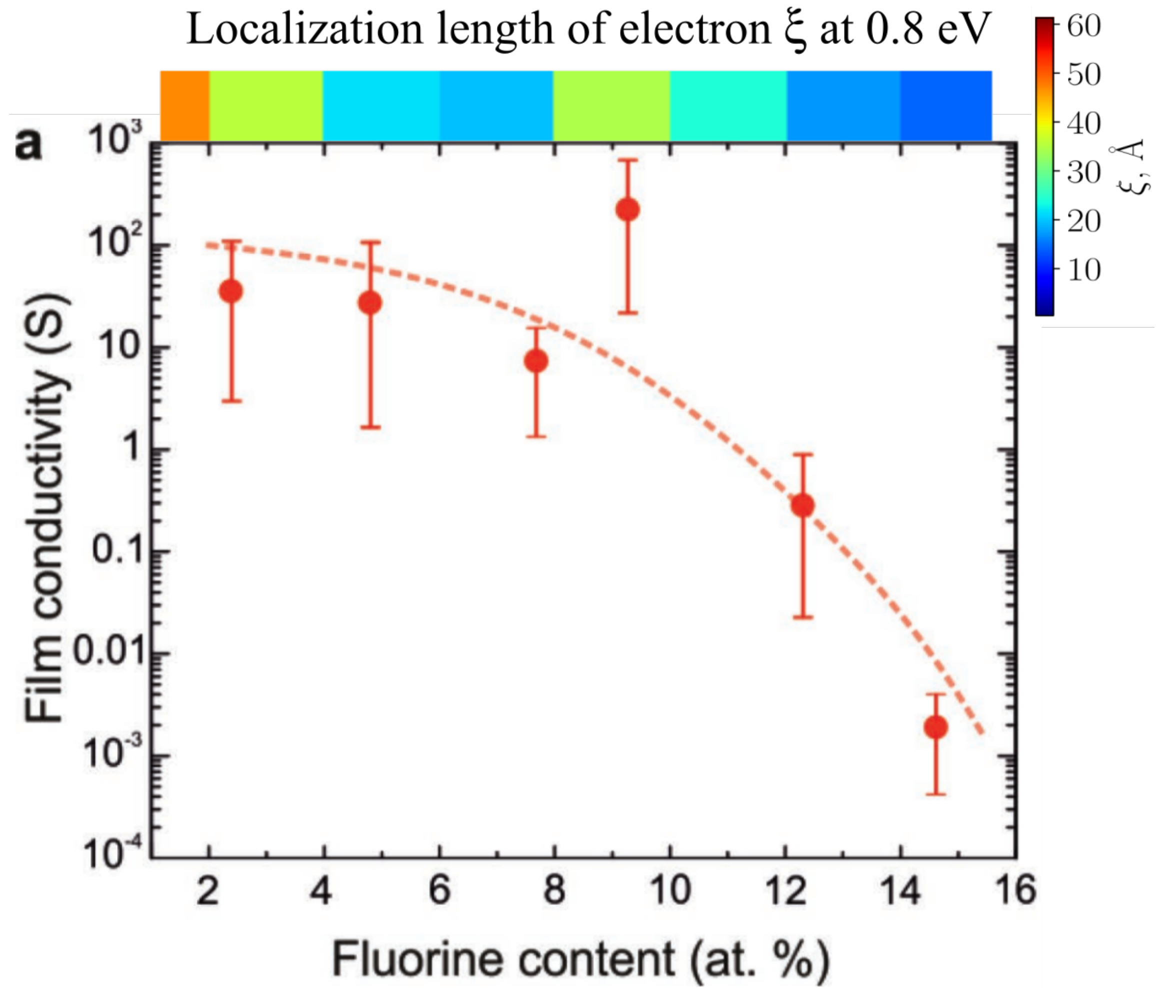
SELECTED SCIENTIFIC RESULTS' 2020

COND MATTER

Activity: Nanostructures and nanomaterials

Effect of fluorine patterns on electronic transport in fluorinated graphene





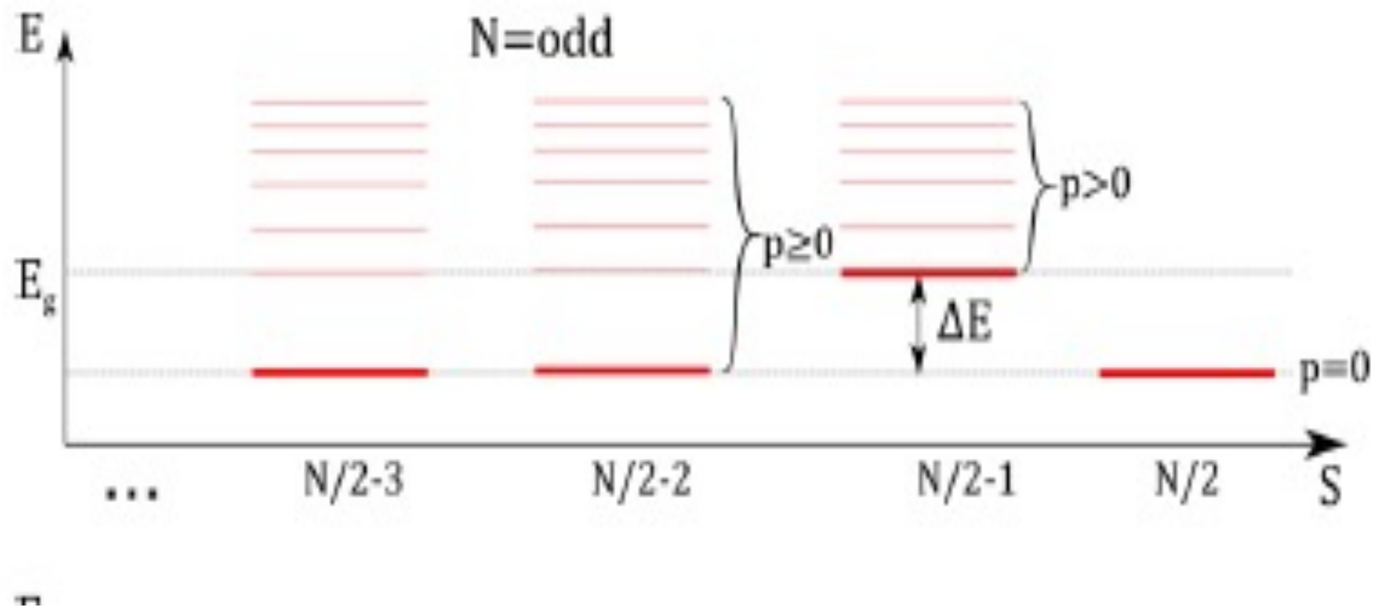
Within the framework of stochastic reactive molecular dynamics simulations a statistical method for generating ***fluorinated graphene*** structures with desirable fluorine distribution was developed. It was found a strong correlation between irregularities in fluorine distribution and electronic properties. In particular, proposed consideration ***allows one to reproduce*** both the ***experimentally observed*** electron-hole asymmetry in transport properties of fluorinated graphene and a recently revealed conductivity peak at 10% fluoride content resonance tunneling conditions at the fluorine concentration of about 10% (the marked increase in the localization length of electrons results in growing conductivity).

Ruslan D. Yamaletdinov, Vsevolod L. Katkov, Yaroslav A. Nikiforov, Alexander V. Okotrub, Vladimir A. Osipov, *Advanced Theory and Simulation* **3** 1900199 (2020)

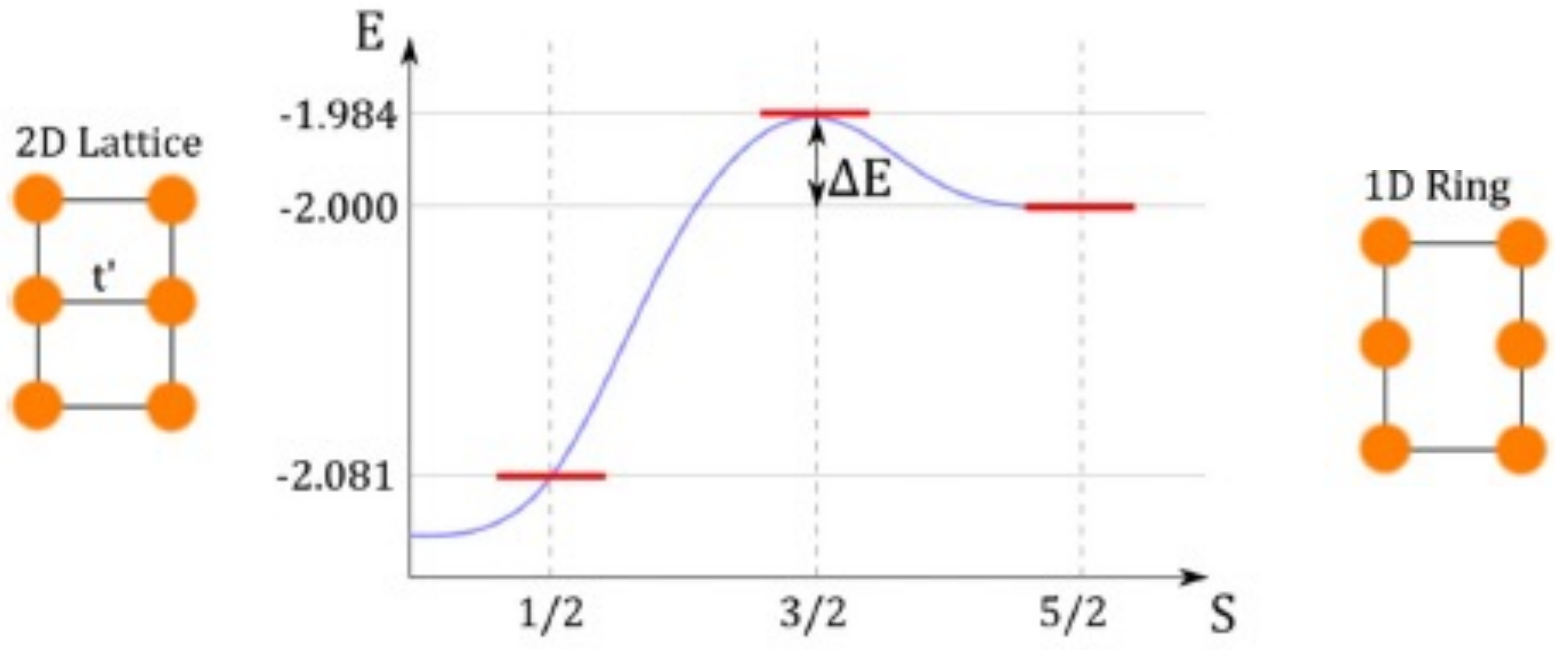
COND MATTER

Activity: Nanostructures and nanomaterials

Stable and Metastable Kinetic Ferromagnetism on a Ring



The ground-state energy structure for different electron numbers *N*.



The transition between stable and metastable Nagaoka ferromagnetism with a change in the topology of the quantum dot array from *2D* to *1D* (changing the *t'* value).

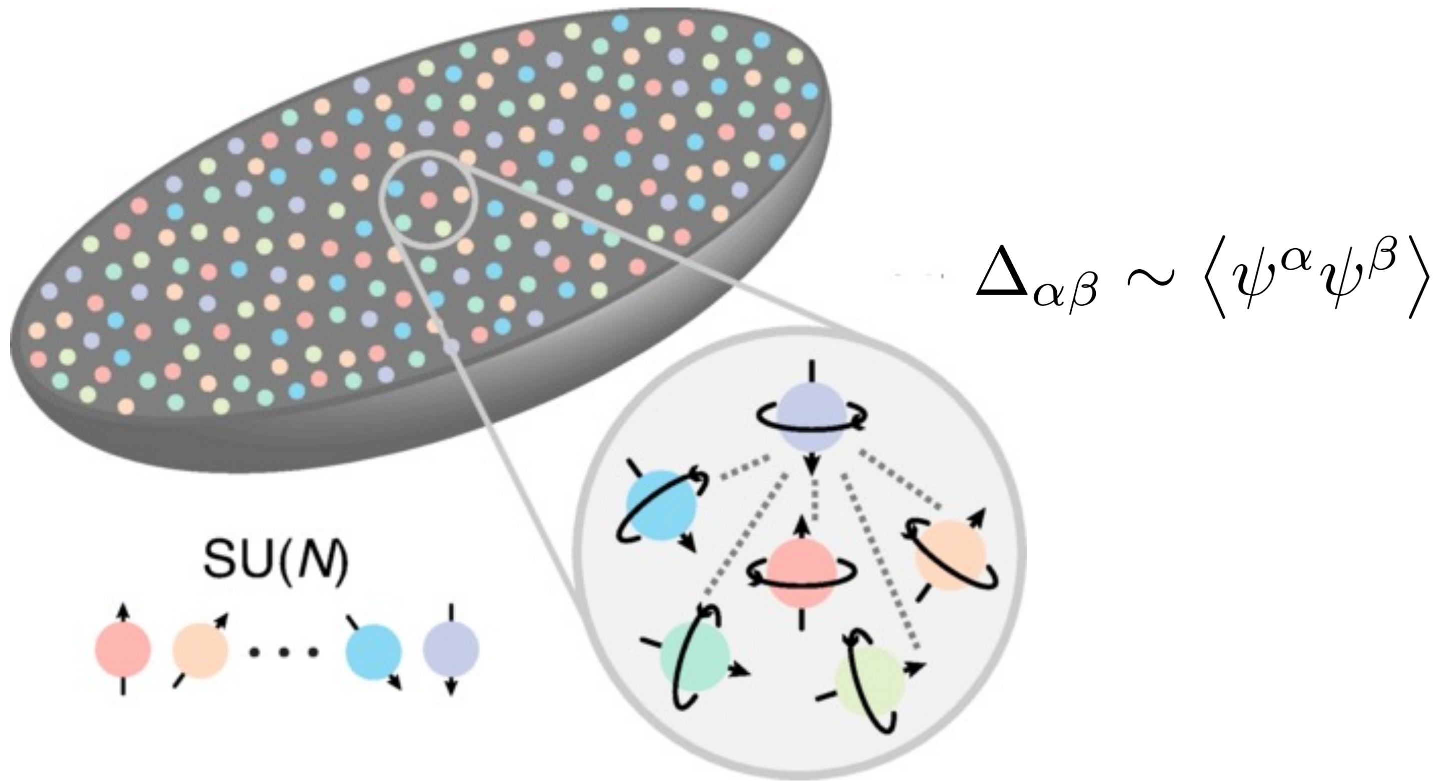
Performing an exact diagonalization of the effective spin problem, a ferromagnetic ground state of kinetic origin is shown to emerge in a system of *N* strongly correlated electrons on a *L*-site ring (*L* > *N*).

Ilya Ivantsov, Hernan B. Xavier, Alvaro Ferraz, Evgenii Kochetov, Physical Review B **101**, 195107 (2020)

Collective phenomena in large spin fermionic systems

Motivation: an attempt to shed light on superfluidity/superconductivity, «colored» phases and **SU(N)** physics of ultracold Fermi atoms which are now increasingly being used in laboratories [*Gorshkov et al., Nat. Phys (2010); Sonderhouse el al., Nat. Phys (2020)]*. The typical species being cooled down to quantum degeneracy: Yb-173 [**F=5/2**, SU(6)], *Taie et al., PRL (2010)* Sr-87 [**F=9/2**, SU(10)], *Song et al. Phys. Rev. X (2020).*

Aims: analyze strongly interacting regime in SU(N) Fermi gas, pair fluctuations, qualitative parameters of the phase transition and emphasize the role of dimensionality.



Decoupling of electronic angular momentum and nuclear spin ***F*** *gives rise to SU(****N=2F+1****) symmetric interparticle interaction*

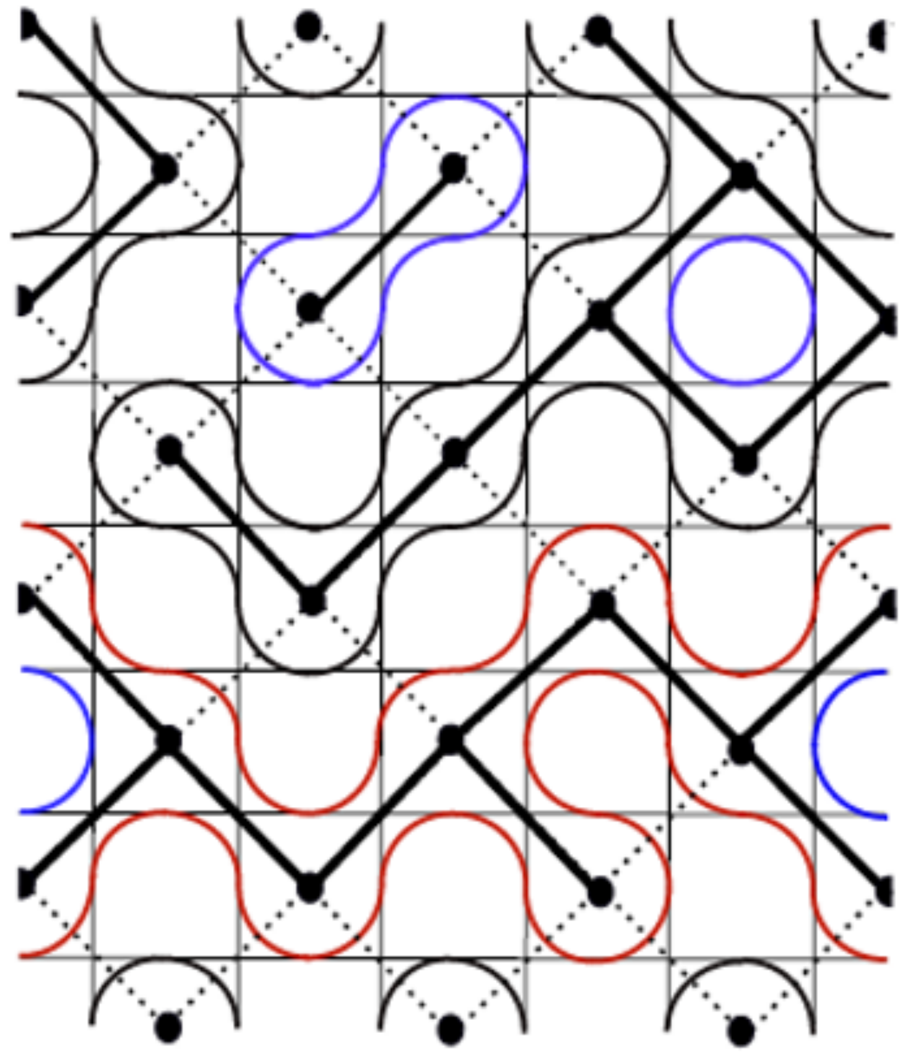
Methods: functional renormalization (fRG) enables to study nonuniversal physics, equation of state, the gap parameter and the superfluid transition temperature across a wide range of coupling constant [*Pawlowski et al., Phys. Rep. (2021)*].

Superfluidity ($\Delta_{\alpha\beta} \neq 0$) and magnetism ($\langle \psi^\dagger_\alpha \psi_\beta \rangle \not\sim \delta_{\alpha\beta}$) were considered within the mean field theory in [*Cherng et al., PRL (2007); Cazalilla et al., Rep. Prog. Phys (2014)].*
Within 5-loop e-expansion *[Kalagov et.al, Nucl. Phys. B 2018*] and analysis of composite operators in the respective matrix model it was established the absence of critical scaling and possibility of the first-order phase transition to superfluid state in 3D.
The appropriate fRG analytical and numerical machinery for matrix models were developed in *[Hnatic et.al, Nucl. Phys. B 2020*]. The fluctuation-induced first order phase transition to the ferromagnetic state was established.

SELECTED SCIENTIFIC RESULTS' 2020

COND MATTER

Exact densities of loops in O (1) dense loop model and of clusters in critical percolation on a cylinder *(A.M. Povolotsky, J. Phys A: Math. Theor. 54 (22), 22LT01)*



$$\nu_c(2N) = \frac{3\Gamma\left(\frac{N}{2}\right)\Gamma\left(\frac{3N}{2}+\frac{1}{2}\right)}{4\Gamma\left(\frac{3N}{2}\right)\Gamma\left(\frac{N+1}{2}\right)} + \frac{\pi^2 2^{-2N} 3^{2-3N}\Gamma(3N)}{\Gamma\left(\frac{N}{2}+\frac{1}{6}\right)^2\Gamma\left(\frac{N}{2}+\frac{5}{6}\right)^2\Gamma(N)} - \frac{5}{2}$$

$$= \frac{1}{8}, \frac{17}{160}, \frac{913}{8960}, \frac{3953}{39424}, \frac{14569}{146432}, \frac{3945737}{39829504}, \ldots$$

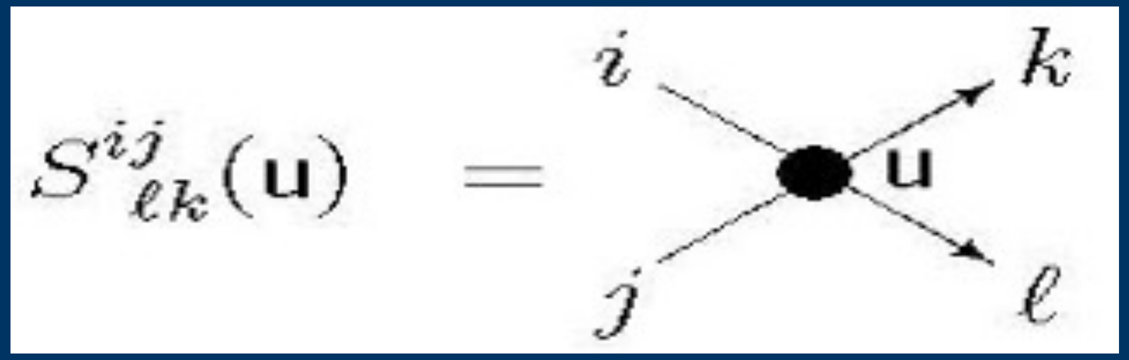
$$\nu_{nc}(2N) = \frac{2^{2(N-2)}\Gamma(N)}{N\pi^2\Gamma(3N)}\left(3^{3N}\Gamma\left(\frac{N}{2}+\frac{1}{6}\right)^2\Gamma\left(\frac{N}{2}+\frac{5}{6}\right)^2 - \frac{12\pi^2\Gamma\left(\frac{3N}{2}\right)^2}{\Gamma\left(\frac{N}{2}\right)^2}\right)$$

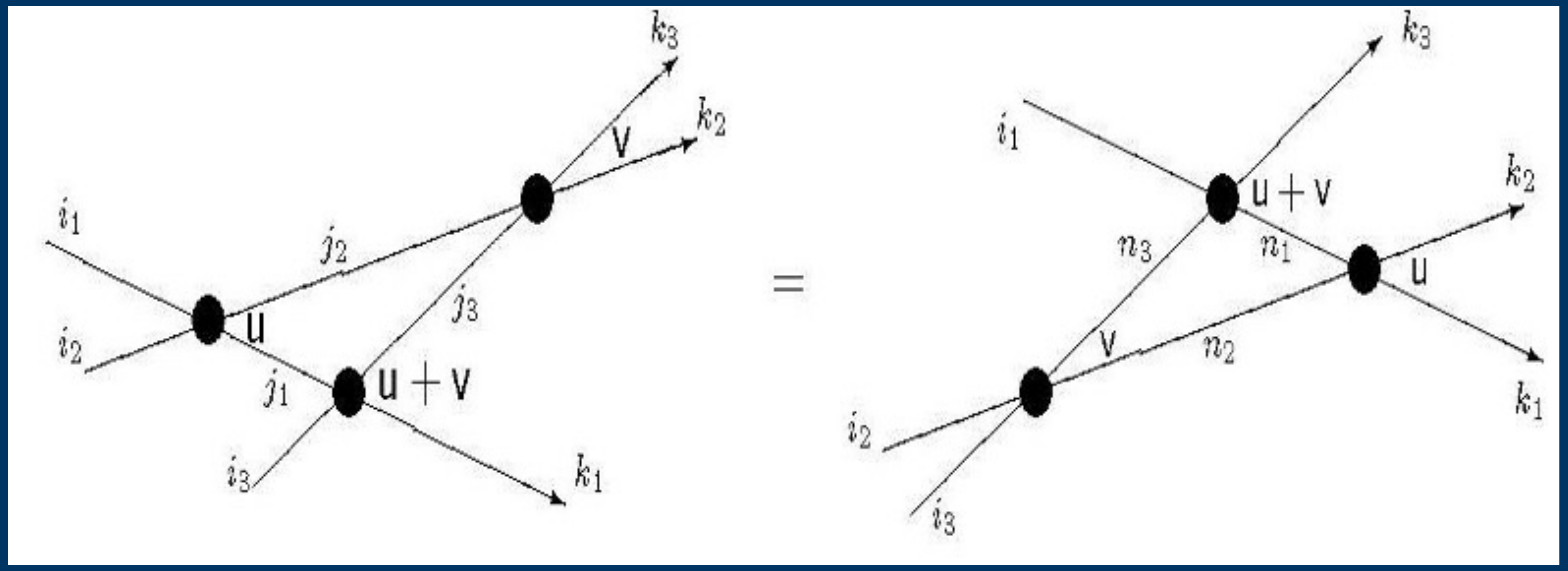
$$= \frac{1}{8}, \frac{11}{320}, \frac{421}{26880}, \frac{1403}{157696}, \frac{4189}{732160}, \frac{952067}{238977024}, \ldots$$

The O(1) dense loop model and related critical percolation model are paradigmatic models of statistical physics being a laboratory for studying critical phenomena. In particular, their observables demonstrate universal finite size behavior, which can be extracted from the exact solutions of these models in confined geometries. We obtain exact densities of contractible and non-contractible loops in the O(1) model on a strip of the square lattice rolled into an infinite cylinder of finite even circumference $L = 2N$. They are also equal to the densities of critical percolation clusters on forty five degree rotated square lattice rolled into a cylinder, which do not or do wrap around the cylinder respectively. The results are presented as explicit rational functions of N taking rational values for any N. Their asymptotic expansions in the large N limit have irrational coefficients reproducing the earlier results in the leading orders.

QFT beyond perturbation theory: Integrability (exactly solvable models of QFT)

Test models: 2-dimensional integrable quantum field theories.
The main object to study: solutions of Yang-Baxter equations which express 3-particle S-matrix via the product of three 2-particle S-matrices





New solutions of the YBE and related symmetries were obtained and investigated

A.P.Isaev, D.Karakhanyan and R.Kirschner, Yang-Baxter R-operators for OSp superalgebras, Nucl. Phys. B965 (2021)

Similar methods are applied to QCD at high energies and to SUSY models with maximal supersymmetry

JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956

MATH PHYSICS

SELECTED SCIENTIFIC RESULTS' 2020

SuperSymmetry - extension of Lorentz invariance of relativistic theory

$Q\,|\,boson>=|\,fermion> \qquad Q\,|\,fermion>=|\,boson>$

$[b,b]=0, \quad \{f,f\}=0 \;\Rightarrow$

$\{Q^i_\alpha, \overline{Q}^j_{\dot\beta}\} = 2\delta^{ij}(\sigma^\mu)_{\alpha\dot\beta}P_\mu$

- Extended SUSY is believed to be a unique exactly solvable QFT. The only self-consistent off-shell superfield formalism for extended super- symmetries was discovered in BLTP and is called the Harmonic Superspace Approach
- At present at BLTP this method is actively applied for exploring the quantum structure of gauge theories with extended supersymmetry in 4 and 6 dimensions. 6- dim theories are of special interest because they describe the low-energy dynamics of string theories.
- In N = (0,1) and N = (1,1), 6D supergauge theories within the HSA the two loop effective action is calculated and it is shown that in the gauge field sector the UV divergences vanish on shell

$$\Gamma^{(2)}_{\infty,gauge} = \frac{8f^2}{(4\pi)^6\epsilon^2}C_2^2 Tr\int d\zeta^{(-4)}du E^{++}\Box E^{++}$$

E.Ivanov et al Phys.Lett. B 820 (2021) 136516.

JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956

MATH PHYSICS

WDVV equation and its generalization

A celebrated mathematical structure common to several areas in geometry and mathematical physics is the Witten–Dijkgraaf–Verlinde–Verlinde (WDVV) equation

$$F^k{}_{ip}\ F^p{}_{jm} - F^k{}_{jp}\ F^q{}_{im} = 0,\ \ F_{ijk} = \partial_i\, \partial_j\, \partial_k\, F$$

for a real-valued function $F(x)$ of n real variables $x = (x_1, x_2, \ldots, x_n)$ which can be taken as coordinates of Euclidean space $\mathbb{R}^n$. We propose here a generalization of this equation to any Riemannian manifold $\mathcal{M}$ given by a metric $ds^2 = g_{ik}\,(x)\, dx^i\, dx^k$ and which we called the *curved WDVV equation* (N.Kozyrev, S.Krivonos, O.Lechtenfeld, A.Nersessian and A.Sutulin , *Phys. Rev. D 97, 085015 (2018))*

$$F^k{}_{ip}\ F^p{}_{jm} - F^k{}_{jp}\ F^q{}_{im} = -R^k{}_{mij}\,,\ \nabla_i\, F_{kjp} - \nabla_j\, F_{kip} = 0$$

Supersymmetric extension of n-particles rational Calogero model

In 2018 such models were constructed by two groups : E.Ivanov, S.Fedoruk, O.Lechtenfeld and S.Krivonos, O.Lechtenfeld and A. Sutulin. The main feature of these novel rational *n-particle Calogero model with an arbitrary even N number of supersymmetries* is the presence of $N \cdot n^2$ rather than $N \cdot n$ fermionic coordinates and increasingly high fermionic powers in the supercharges and the Hamiltonian.

MATH PHYSICS

SELECTED SCIENTIFIC RESULTS' 2020

A new class of special functions of mathematical physics

Table. CLASSICAL ORTHOGONAL SPECIAL FUNCTIONS

$\boxed{{}_2F_1}$ (Jacobi 1826) ⟶ ${}_2\varphi_1$ (Rogers 1894)

↓ ↓

${}_3F_2$ (Chebyshev 1875, Hahn 1949) ⟶ ${}_3\varphi_2$ (Hahn 1949)

↓ ↓

${}_4F_3$ (Racah 1942, Wilson 1978) ⟶ $\boxed{{}_4\varphi_3}$ (Askey, Wilson 1985)

↓ Self-dual orthogonal polynomials ↓

${}_9F_8$ (Wilson 1978, Rahman 1986) ⟶ ${}_{10}\varphi_9$ (Rahman 1986, Wilson 1991) ⟶ $\boxed{{}_{12}V_{11}}$ (Spiridonov, Zhedanov, 1999; Spiridonov, 2000)

Self-dual biorthogonal ↓ rational functions ↓

${}_{10}\varphi_9 \times {}_{10}\varphi'_9$ ⟶ $\boxed{{}_{12}V_{11} \times {}_{12}V'_{11}}$

Self-dual biorthogonal functions (Spiridonov, 2000)

V.P. Spiridonov discovered a principally new class of transcendental special functions – the elliptic hypergeometric functions (2000) and the elliptic Fourier transformation (2003). The elliptic beta integral evaluation serves as a confinement criterion in the sector of BPS-states of a simplest four-dimensional supersymmetric quantum field theory.

G. A. Sarkissian and V. P. Spiridonov, Rational hypergeometric identities, Functional Analysis and Its Appl. 55:3 (2021) 91

New rational limits of elliptic hypergeometric functions to complex hypergeometric functions

MATH PHYSICS

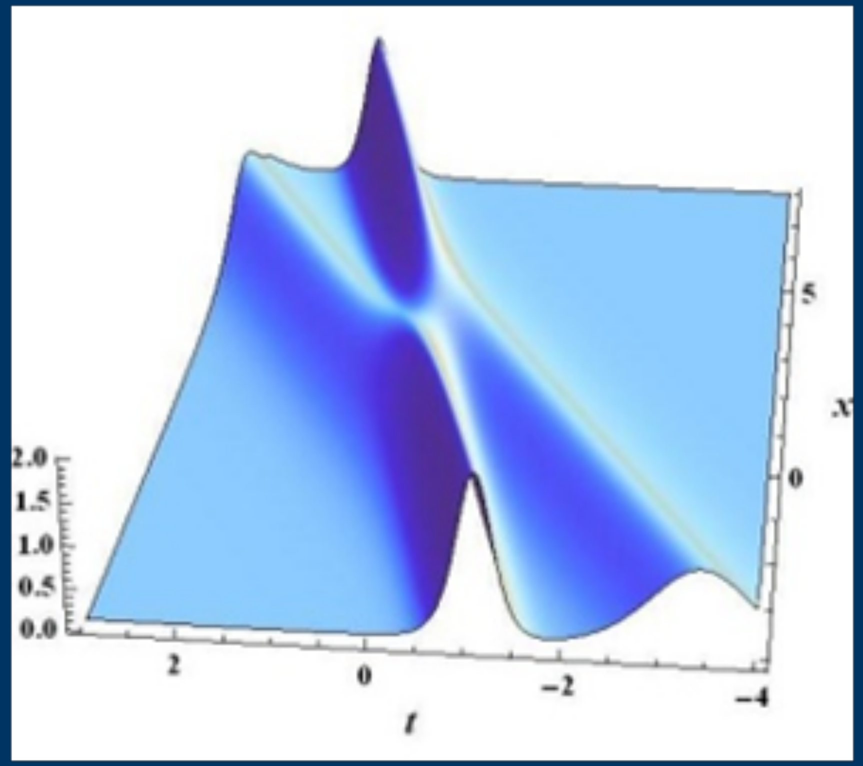
SELECTED SCIENTIFIC RESULTS' 2020

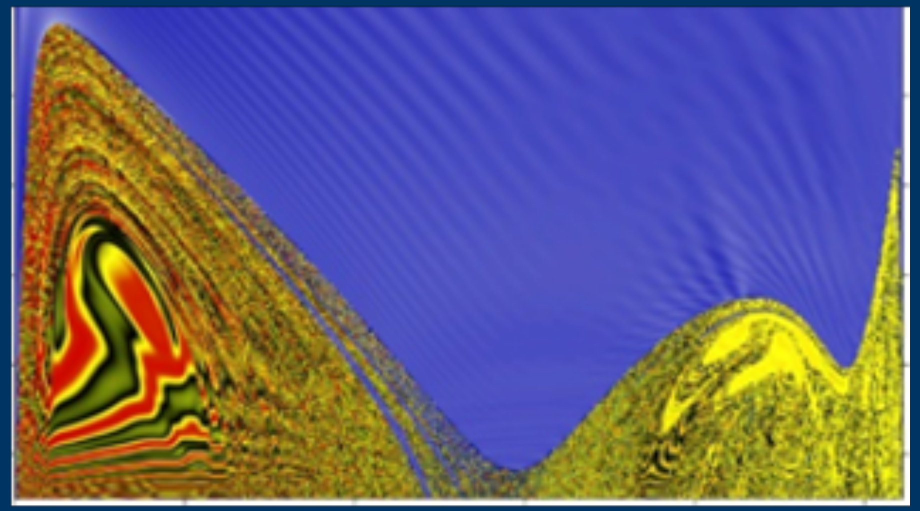
Topological and non-topological solitons

Ya.Shnir et al

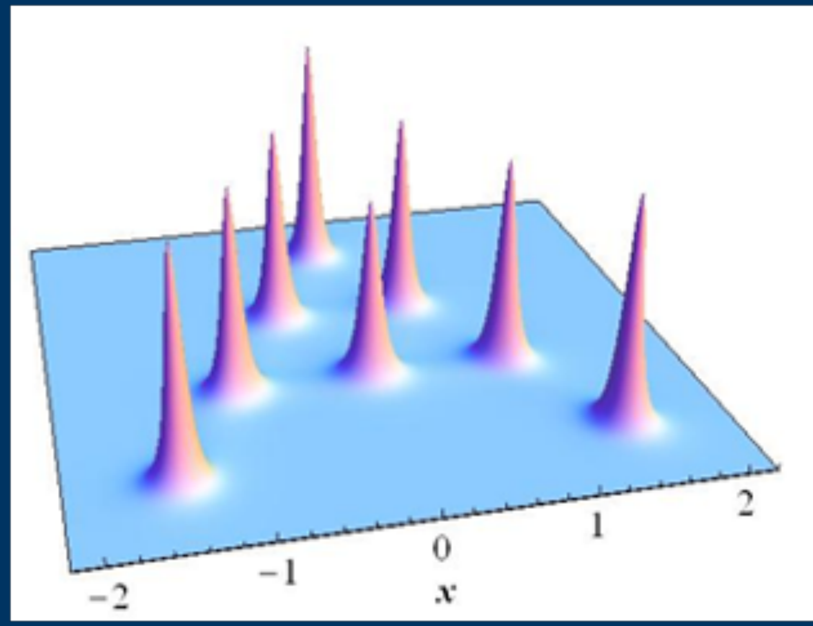
Phys. Lett.B 20', 21'

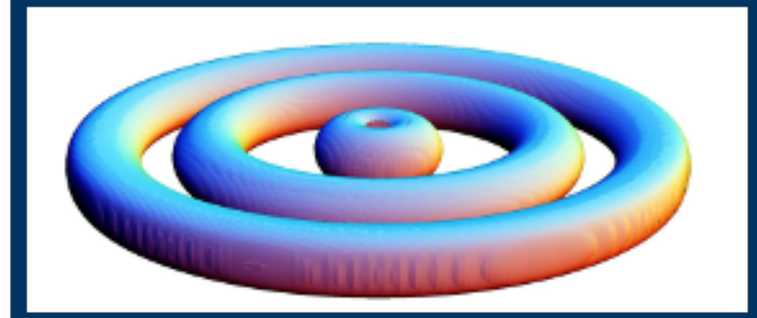
Kinks in 1+1 dim

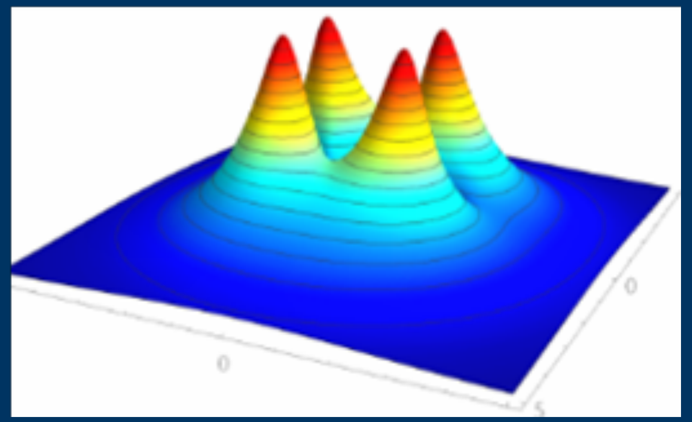




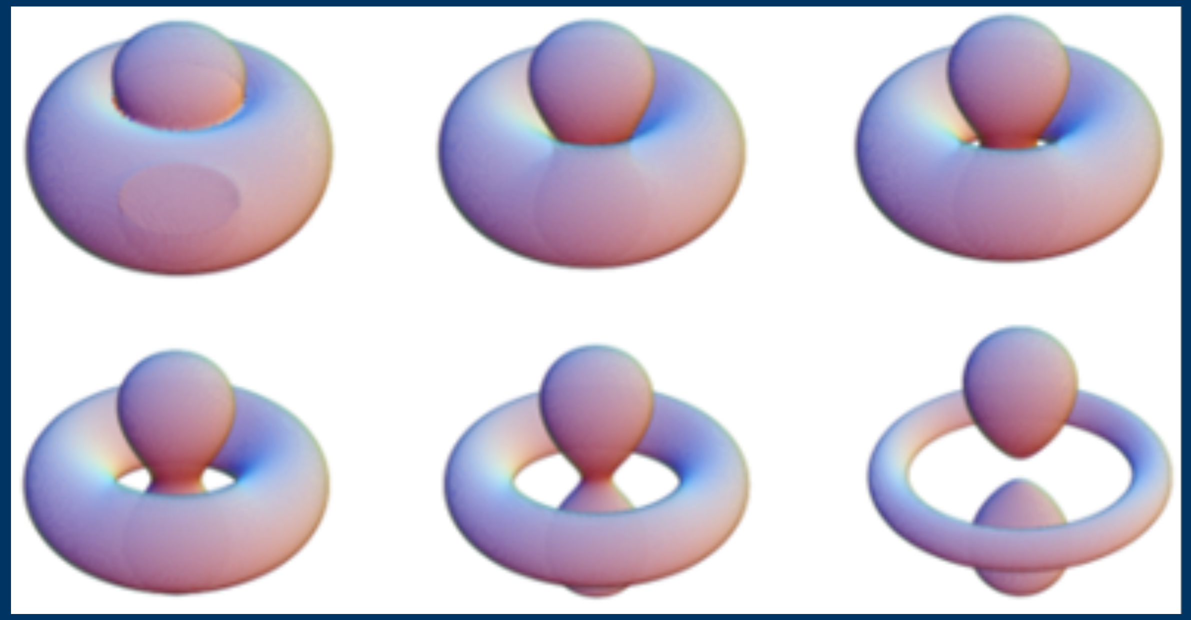
Q-balls

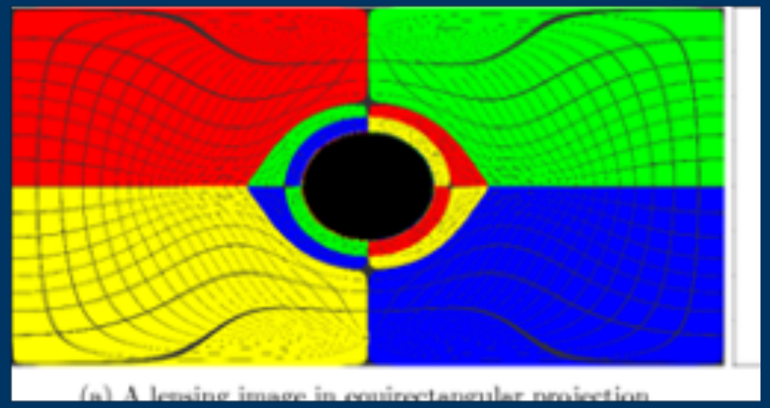




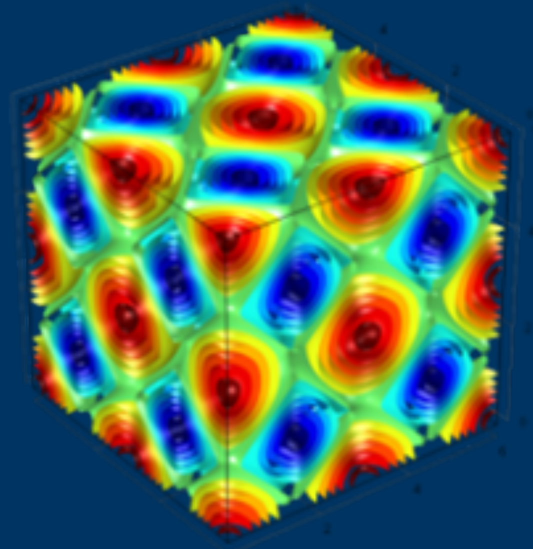


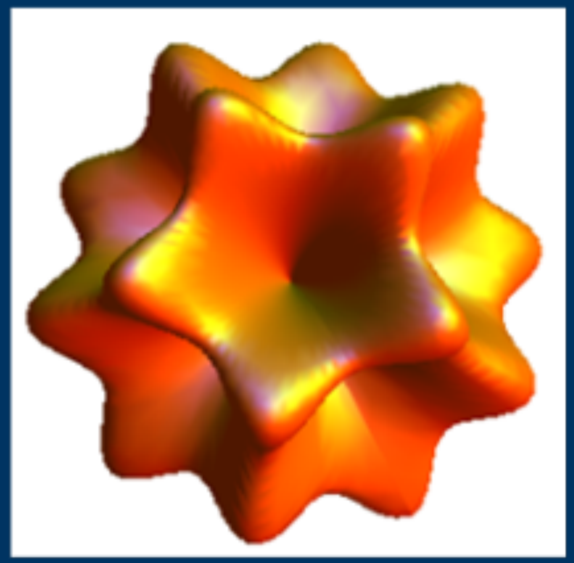
Boson stars and black holes

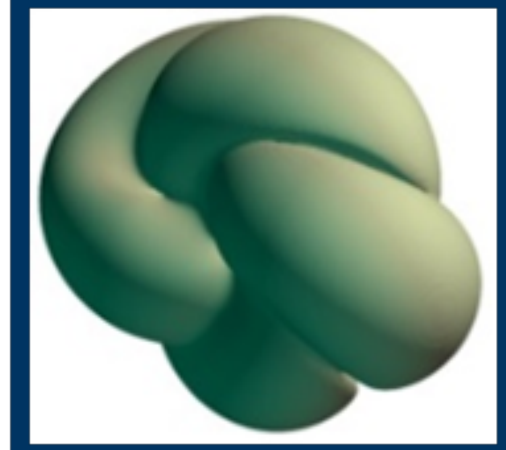




Skirmions & hophions







RESUME

Future development is based on:

- Large qualified personal
- Wide range of research directions
- Exceptional possibilities of an international center
- Basis for recruitment of young personnel
- Working infrastructure