

RECFA visit to Serbia

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HEP Theory in Serbia

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Overview

General: HEP-Th in Serbia

Community

University of Belgrade

University of Niš

International Projects and Collaborations

Outlook: +/-

General: HEP-Th in Serbia

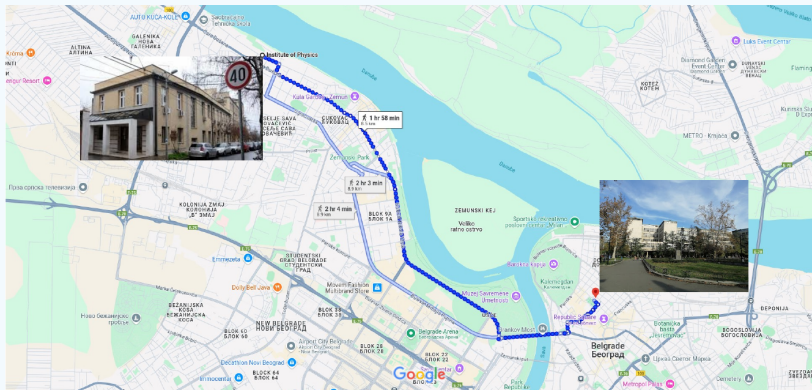
Research in Nuclear and Particle Physics started with the foundation of the [Vinča Nuclear Institute in 1948](#). Important contributions to the [HEP-Th field](#) from:

- [Djordje Živanović \(1934-1985\)](#), professor at the Faculty of Physics, University of Belgrade: quantum field theory, gravity and cosmology.
- [Milutin Blagojević \(1944-\)](#), professor at the Institute of Physics: non-Riemannian geometry and gauge theory of gravity.
- [Djordje Šijački \(1947-\)](#), professor at the Institute of Physics: particle physics, (super)symmetries and group representations.
- [Dragan Popović \(1949-2015\)](#), professor at the Institute of Physics: Standard model and quantization of gauge theories.

Today: HEP-Th community in Belgrade and Niš.

University of Belgrade

Belgrade HEP-Th community grouped in the **Group for GRAVITATION, PARTICLES and FIELDS (GPF)** at the Faculty of Physics and the Institute of Physics



$$\begin{aligned}
 f + \theta(x) &= e^{i\theta(x)} \left[f(\sigma) g(\sigma) \right]_{\text{new}} / D_{\text{new}} \psi^{\text{old}} = \sum_{\nu} \prod_{\mu} d(m_{\nu}) \prod_{\mu} W_{\nu}(\mu, \nu) \\
 R_{\text{new}} &= \frac{1}{2} g_{\mu\nu} R = 8\pi G T_{\mu\nu} \quad \mathcal{L} = \int d^4x \sqrt{-g} \left[\frac{1}{2} R - \frac{1}{4} F_{\mu\nu}^2 - \frac{1}{2} \partial_{\mu} \psi \partial^{\mu} \psi - V(\psi) \right] \\
 \mathcal{L} &= -\frac{1}{4} F_{\mu\nu}^2 + \frac{1}{2} \partial_{\mu} \psi \partial^{\mu} \psi + (D_{\mu} \psi)^{\dagger} (D_{\mu} \psi) - V(\psi) + \text{h.c.}
 \end{aligned}$$

GPF Welcome

The idea of a unified description of the basic physical interactions has its origin in Maxwell's unification of electricity and magnetism, matured in Weyl's and Kaluza's attempts to unify gravity and electromagnetism, and achieved its full strength in the unification of weak, electromagnetic and, to some extent, strong interactions. The biggest barrier to this attractive idea comes from a continual resistance of gravity to abide the concepts of unification and/or quantization, which seem so natural in the context of electroweak and strong interactions. Is gravity, by such a persistent behavior, making an ultimate effort to tell us something about the small-scale structure of spacetime and fundamental interactions?

For more than five decades, physicists have been trying to find an answer to this difficult question by focusing their attention on those aspects of gravity that are closely related to its quantization and unification with other fundamental interactions. Our group participates in this exciting undertaking by exploring dynamical and symmetry structure of:

- (a) alternative theories of gravity based on non-Riemannian geometry of spacetime,
- (b) strings and branes,
- (c) discrete spacetime models, and
- (d) noncommutative field theories in particle physics and gravity.

GPF Members

GPF group currently has: 9 senior researchers, 9 junior researchers, 10 PhD students, 1 master student

• Members



Maja Burić



Branislav Cvetković



Ljubica Davidović



Marija Dimitrijević Čirić



Dragoljub Gočanin



Ilija Ivanišević



Nikola Konjik



Duško Latas



Luka Nenadović



Biljana Nikolić



Bojan Nikolić



Danijel Obrić



Dragan Prekrat



Igor Prlina



Tijana Radenković



Voja Radovanović



Igor Salom



Dejan Simić



Marko Vojinović

• Emeritus members



Milutin Blagojević



Branislav Szadović



Đorđe Sijački



Milovan Vasičić

• Students



Milorad Bežanić



Bojana Brkić



Đorđe Bogdanović



Dušan Đorđević



Mihailo Đorđević



Stefan Đorđević



Ana Knežević



Petar Petrašinić



Danilo Rakonjac



Pavle Stipsić

Alternative theories of gravity:

-canonical dynamics, asymptotic symmetries, teleparallel theory, gravity with torsion

-near horizon symmetry of the extremal Kerr black hole within the framework of Poincaré gauge theory; motion of test particles in the spacetime of the plane-fronted (pp) waves with torsion in four-dimensions; black hole thermodynamics within Poincaré gauge theory.

Black hole physics:

-thermodynamics, entropy, AdS/CFT correspondence

-holographic duality in systems with torsion and/or in noncommutative geometry, generalization of the Ryu–Takayangi holographic entropy.

Symmetries and integrability:

-world spinors, Standard Model symmetries, integrable systems, spin chains, Bethe ansatz.

Noncommutative (quantum) field theories:

-NC gauge theories: braided BV quantization, NC gauge-gravity duality, construction of scattering amplitudes using the homological perturbation theory. Space-time symmetries in the braided NC field theories and conserved quantities.

-calculation of Lorentz violating scattering amplitudes using the spinor helicity formalism, little group scaling, BCFW recursion relation, double copy method. Lorentz violation is described via small quasi-tensors present in the Lagrangian.

Noncommutative gravity:

-NC cosmology, NC gravitational waves, quasinormal modes of NC black holes

-model noncommutative gravity through noncommutative geometry, in the context of noncommutative frame formalism. The main goals of research: describe a range of noncommutative (fuzzy) spaces relevant for cosmology, astrophysics and string theory, develop noncommutative (quantum) field theories on these spaces.

-calculate spinor, vector and gravitational QNM spectra of NC black holes obtained within the framework of noncommutative (NC) deformation of gauge field theory by twist and the Seiberg-Witten map.

String theory:

-canonical structure, T-duality, M-theory.

Loop quantum gravity:

-spin foam models, coupling of matter to gravity, higher gauge theory, higher category theory, numerical simulations

-construct a novel, more general QG models, which include matter fields. The method is based on the generalization of the notion of a symmetry group using category theory, specifically a mathematical framework called Higher Gauge Theory. This generalization allows us to treat gravity, gauge fields, fermions, and scalars on equal footing, using the algebraic structure called a 3-group, and perform the spinfoam quantization program for all fields simultaneously. The results could potentially provide novel ways to address longstanding open questions such as the resolution of cosmological and black hole singularities.

Foundations of quantum mechanics:

-quantum information theory, relativistic aspects, gravitational aspects, measurement problem in QM.

GPF Results

Published papers in ISI journals: \sim 15 per year

Conference presentations and proceedings: \sim 20 per year

National grants (financed by the Ministry of Science of Republic Serbia and the Science Fund of the Republic of Serbia:

- Physical implications of modified space-time (2010-2019),
- QUANTUM GRAVITY FROM HIGHER GAUGE THEORY (2022-2024),
- Holography, Information, Noncommutativity, Torsion (2023-2025).

Events organized by GPF

- 2025 Dragan Popović Memorial Conference
- 2024 11th Mathematical Physics Meeting: School and Conference on Modern Mathematical Physics
- 2024 HINT Workshop
- 2024 Quantum & Fuzzy Workshop
- 2023 Gravity, Holography, Strings and Noncommutative Geometry Workshop
- 2021 Series of lectures on interpretations of quantum physics
- 2020 Causality in Quantum Theory Workshop
- 2019 10th Mathematical Physics Meeting: School and Conference on Modern Mathematical Physics
- 2018 Gravity and String Theory: New ideas for unsolved problems III
- 2018 Gravity, Holography, Strings and Noncommutative Geometry Workshop
- 2017 9th Mathematical Physics Meeting: School and Conference on Modern Mathematical Physics

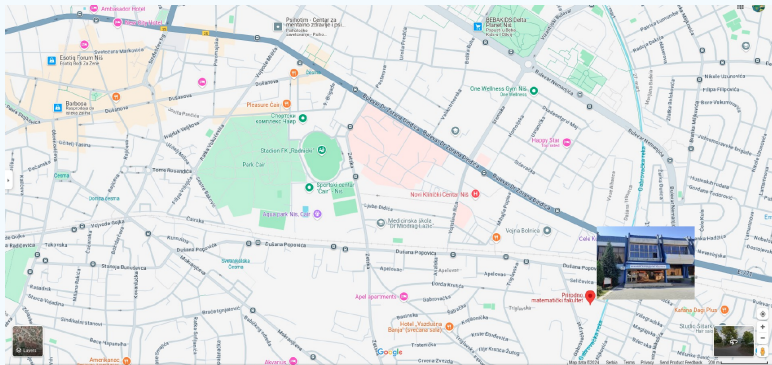
September 2022: Training school and workshop of the COST action COST CA18108.

Published papers in 2023

- Dušan Djordjević, Dragoljub Gočanin, Holographic aspects of even-dimensional topological gravity, *Phys. Rev. D* 108, 086022 (2023)
- Mihailo Djordjević, Tijana Radenković, Pavle Stipsić, Marko Vojinović, Henneaux–Teitelboim gauge symmetry and its applications to higher gauge theories, *Universe* 9, 281 (2023)
- Dragan Prekrat, Dragana Rankovic, Kristina Neli Todorovic-Vasovic, Samuel Kovacik, Juraj Tekel, Approximate treatment of noncommutative curvature in quartic matrix model, *JHEP* 01, 109 (2023)
- Aleksandar Mikovic, Marko Vojinovic, State-Sum Models of Piecewise Linear Quantum Gravity, World Scientific, Singapore (2023)
- Ricardo Faleiro, Nikola Paunkovic, Marko Vojinovic, Operational interpretation of the vacuum and process matrices for identical particles, *Quantum* 7, 986 (2023)
- M. Dimitrijevic Ciric, N. Konjik, V. Radovanovic, R. J. Szabo, Braided quantum electrodynamics, *JHEP* 08 (2023) 211.
- M. Dimitrijević Ćirić, N. Konjik, A. Samsarov, Noncommutative scalar field theory in a curved background: Duality between noncommutative and effective commutative description, *Int.J.Mod.Phys.A* 38 (2023) 32, 2343004.
- M. Dimitrijević Ćirić, N. Konjik, A. Samsarov, Propagation of spinors on a noncommutative spacetime: equivalence of the formal and the effective approach, *Eur.Phys.J.C* 83 (2023) 5, 387.
- I. Burić, M. Burić, A fuzzy black hole, *Int.J.Mod.Phys.A* 38 (2023) 32, 2343001.
- M. Burić, A road to fuzzy physics, *Eur.Phys.J.ST* 232 (2023) 23-24.
- Milutin Blagojević, Branislav Cvetković, Entropy of black holes coupled to a scalar field, *Phys.Rev.D* 107 (2023) 10, 104022.
- B. Cvetković, D. Rakonjac, Extremal Kerr black hole entropy in Poincaré gauge theory, *Phys.Rev.D* 107 (2023) 4, 044054.
- Milutin Blagojević, Branislav Cvetković, Thermodynamics of charged black hole with scalar hair, *Phys.Rev.D* 108 (2023) 12, 124012.

University of Niš

Niš HEP-Th community, **Niš Group for Cosmology and Astroparticle Physics**, grouped at the Faculty of Sciences and Mathematics at the University of Niš.



Niš Group members

Members:

- 2 senior researchers: prof. Dr Goran Djordjević, prof. Dr Dragoljub Dimitrijević,
- 2 junior researchers: Dr Milan Milošević, Dr Marko Stojanović
- external members.

Research Topics:

Research focuses on early Universe, cosmological inflation, nonarchimedean and noncommutative Quantum Theory, black holes, and extra dimension in the cosmological context. More specifically the group's subject of interest are:

- tachyon field dynamics,
- RSII and holographic inflationary models,
- PHBs production in non-canonical inflation scenario,
- dynamics of nonlinear systems (DBI) and non-archimedean black holes.
- cosmological inflation with two-field models and inflationary models with constant roll regime
- contribute to the international collaborations on QG, AEDGE-Atomic Experiment for Dark Matter and Gravity Exploration in Space and EuCAPT-The European Consortium for Astroparticle Theory.

Niš Group results

Published papers in ISI journals: ~ 2 per year

Marko Stojanovic, Neven Bilic, Dragoljub D. Dimitrijevic, Goran S. Djordjevic, Milan Milosevic, Tachyon constant-roll inflation in Randall-Sundrum II cosmology, IJMPA (2023).

Marko Stojanovic, Neven Bilic, Dragoljub D. Dimitrijevic, Goran S. Djordjevic, Milan Milosevic, Constant-roll inflation with tachyon field in the holographic braneworld, Class.Quant.Grav. 41 (2024) 16, 165013.

Conference presentations and proceedings: ~ 4 per year

Events organized:

Balkan Workshops and Schools: from 2003 every second year.

The last one: BWXX/BW2023 SEENET-MTP MEETING, August 2023, Vrnjačka Banja, Serbia

CERN-SEENET-MTP-ICTP PhD program: training schools for PhD and master students: active from 2015, 1-2 events per year.

The last one: Minischool Mathematical Methods in Gravitation and Cosmology 13 – 17 November 2024 (Bucharest-Magurele, Romania).

Niš Group has been the coordinating node of the [Southeastern European Network in Mathematical and Theoretical Physics \(SEENET-MTP\)](#) since 2003.

International Projects and Collaborations

Belgrade and Niš HEP-Th groups are closely connected and have well established international collaboration through:

- **SEENET-MTP network**

Founded in 2003, very important for collaboration in the Balkan region and for the education of junior researchers (students, postdocs).

- **Central European Exchange Program for University Studies (CEEPUS) network**

RS-1514-05-2425: Quantum Spacetime, Gravitation and Cosmology:
7 countries, 9 institutions.

- **COST actions**

MP1405: Quantum Structure of Spacetime (2015-2019)

CA18108: Quantum Gravity Phenomenology in the Multi-Messenger Approach (2019-2023)

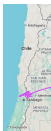
CA21109: Cartan Geometry, Lie, Integrable Systems, Quantum Group Theories for Applications (2022-present)

CA22113: Fundamental challenges in theoretical physics (2023-present)

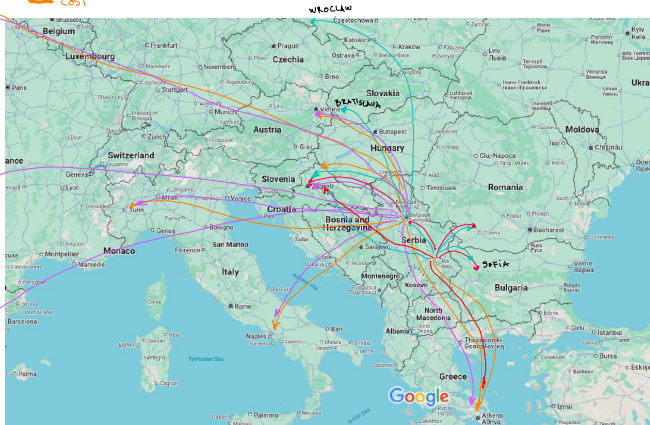
CA23130: Bridging high and low energies in search of quantum gravity (2024-present)

- **Bilateral projects, other**

with: Italy, Portugal, Austria, Croatia, UK, Chile.



— SEEHET-MTP
— CEEPUS
— COST
— BILATERAL, OTHER



Outlook: +/-

HEP-Th in Serbia:

- + **Very active** community.
- + International collaborations.
- + Modest funding available.
- + **Female and junior researchers** included.
- Less and less students enrol physics studies every year. At the Faculty of Physics, University of Belgrade:
2014/15: 176 students, 2019/20: 85 students, 2024/25: 63 students.
- Current **funding not enough**.
- Calls for grants of the Ministry of Science and the Science Fund of the Republic of Serbia not adjusted (**disfavour**) **fundamental research**. So far: in 5 calls only 2 grants were awarded to the projects in HEP-Th research field.