



RESEARCH GROUPS CATALOGUE

DEPARTMENT OF MATHEMATICS AND PHYSICS

Split, 2026

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GROUP FOR THE DEPARTMENT OF PHYSICS (ASTROHEP)

Head of the Group:

Assoc. Prof. Damir Lelas, PhD

<https://www.croris.hr/osobe/profil/27649?lang=en>

Scientific Fields:

Natural Sciences/Physics

Brief Description of the Research Group:

The research group operates in the fields of experimental and theoretical particle physics and astrophysics, participating in the international CMS collaboration at CERN, as well as the MAGIC and CTA-LST collaborations. Research activities include measurements of the properties of the Higgs boson, searches for new physics and leptoquarks, the development and maintenance of advanced detector systems, and the study of sources of very-high-energy cosmic rays. In theoretical physics, the group develops models of physics beyond the Standard Model, including Grand Unified Theories, proton decay, and the flavor dynamics of quarks and leptons.

1. RESEARCH TEAM

Faculty members in teaching and research positions:

- Prof. Ivica Puljak, PhD

Other faculty researchers:

- Ana Šćulac, MSc in Engineering
- Toni Šarić, MSc in Physics
- Mijo Matković, MSc in Physics
- Ivica Sorić
- Luka Palada, PhD

2. EXPERTISE AND KNOW-HOW

- Particle Physics – CMS group
- Astrophysics – MAGIC and CTA-LST groups
- Theoretical Particle and Field Physics

Research in experimental particle physics and very-high-energy gamma-ray physics is conducted within the CMS collaboration at CERN (<http://cms.web.cern.ch/>), the MAGIC collaboration (<http://magic.mppmu.mpg.de/>), and the CTA collaboration (<https://www.cta-observatory.org/>) within the working group building the Large Size Telescope (LST) (<http://www.lst1.iac.es/>).

Members of the CMS collaboration are actively involved in measuring the properties of the Higgs boson, studying aspects of left-right (LR) symmetric theories of electroweak interactions, and searching for leptoquarks at the Large Hadron Collider (LHC). In addition to direct research activities, the group is involved in the operation and development of the electromagnetic calorimeter of the CMS detector, as well as the HGCAL project, which is aimed at developing the future forward calorimeter of CMS.

The group's activities within the MAGIC collaboration are related to data quality assessment for the MAGIC telescopes and the search for Galactic sources of the highest-energy cosmic rays (PeV). This is enabled by the detection of gamma rays with energies above 100 TeV through the development of observation techniques at large zenith angles.

Within the CTA consortium, we participate in the working group responsible for building the largest telescope, the Large Size Telescope (LST). Our group is responsible for the design, construction, commissioning, and maintenance of systems for precise measurement, calibration, and correction of the telescope's pointing.

Theoretical research in particle and field physics focuses on aspects of leptoquark production and measurement at the LHC, proton decay phenomenology, Grand Unified Theories, and the flavor dynamics of quarks and leptons.

3. RESEARCH INFRASTRUCTURE

Laboratories

- Laboratory for Photodetector Characterization

Equipment

- Computer-controlled temperature chamber
- Keithley 6485 picoammeter
- Keithley 6487 voltage source/picoammeter
- Keithley 2000 multimeter
- CAEN N478 programmable power supply
- CAEN silicon photomultiplier package
- Equipment for testing and precision calibration
- Two CCD cameras with partially overlapping fields of view (for the needs of the CTA consortium, specifically the LST working group)

4. KEY PROJECTS AND REFERENCES

- ZCI ACROSS–DataScience – Centre of Excellence for Data Science and Cooperative Systems, 2015–2023; project leaders S. Lončarić and I. Petrović; researchers N. Godinović, D. Lelas, T. Šarić, A. Šćulac.
- Very High Energy Gamma-Ray Astronomy with MAGIC and CTA Telescopes, 2017–2021; Croatian Science Foundation (HrZZ) project; project leader N. Godinović; collaborator D. Lelas.
- Measurement of the Properties of the Higgs Boson and Search for New Physics with the CMS Detector, 2014–2018; Croatian Science Foundation (HrZZ) project; project leader I. Puljak; collaborators I. Doršner, N. Godinović, D. Lelas.
- Very High Energy Gamma-Ray Astronomy with the MAGIC Telescopes, 2012–2016; Croatian Science Foundation (HrZZ) project; project leader N. Godinović; collaborator D. Lelas.
- Search for the Higgs Boson and New Physics with the CMS Detector, 2007–2013; Ministry of Science, Education and Sports (MZOŠ) project No. 023-0982887-3064; project leader I. Puljak; collaborators N. Godinović and D. Lelas.

5. COLLABORATION OPPORTUNITIES

The ASTROHEP research group offers broad opportunities for collaboration through joint scientific research projects, technology transfer, and expert consulting in the following key areas:

- Experimental Physics and Data Analysis: Collaboration on the processing of large datasets (Data Science), analysis of physical processes within the CERN-CMS collaboration, and astrophysical measurements of the highest-energy gamma rays (MAGIC/CTA).
- Detector Systems Development: Joint work on the design, construction, integration, and maintenance of advanced calorimetric and optical systems for precision measurements.
- Theoretical Modeling: Development and phenomenological testing of theoretical models beyond the Standard Model, including flavor physics, Grand Unified Theories (GUT), and simulations of particle production and decay at the LHC.
- Photodetector Characterization: Use of specialized laboratory infrastructure for precise current-voltage characterization of silicon photomultipliers (SiPMs) and optical calibration in a computer-controlled temperature chamber.
- Interdisciplinary Projects: Combining expertise in particle physics with advanced computing (HPC/AI) and with industrial partners interested in high-tech equipment development.

6. CONTACT

Head of Research Group: Damir.Lelas@fesb.hr

General Contact: projekti@fesb.hr

GROUP FOR MATHEMATICAL RESEARCH (VISTAE)

Head of the Group:

Prof. Anita Matković, PhD

<https://www.croris.hr/osobe/profil/9737?lang=en>

Scientific Fields:

Natural Sciences / Mathematics

Brief Description of the Research Group:

The research group develops new theoretical and applied knowledge in the fields of mathematics, statistics, and information systems. Its activities focus on advancing mathematical inequalities and integral formulas for convex functions, investigating topological spaces through rough shape and finite rough shape theory, and developing the corresponding invariants. The group also applies advanced statistical methods to assess future extreme precipitation events and develops and validates extended technology acceptance models that incorporate organizational factors, user knowledge, and intelligent system features. In addition, the group conducts research in mathematics education, with a particular emphasis on diagnosing students' misconceptions of key concepts and developing modern teaching methodologies.

1. RESEARCH TEAM

Faculty members in teaching and research positions:

- Prof. Josipa Barić, PhD
- Assist. Prof. Ivančica Mirošević, PhD

Other faculty researchers:

- Marina Dajaković, PhD, Senior Assistant
- Ivana Grgić, Senior Lecturer
- Dajana Dujić, Lecturer

2. EXPERTISE AND KNOW-HOW

- **Convexity Theory and Functional Inequalities:** Expertise in developing new classes of convex functions (harmonic, reciprocal, strong convexity) and deriving, generalizing, and improving fundamental inequalities (Jensen, Jensen–Mercer, Hermite–Hadamard), including their multidimensional extensions.
- **Mathematical Analysis on Time Scales and Mean Value Theory:** Experience in applying delta calculus and multiple Lebesgue delta integration to unify continuous and discrete models, as well as in the construction, characterization, and monotonicity analysis of new generalized means.
- **Applications in Probability Theory:** Development of inequalities for the expected value of random variables, analysis of probabilistic models using convexity methods and functional inequalities, and development of models for estimating future maximum short-duration precipitation values using extreme value theory.

- **Applications in Information Theory:** Expertise in deriving new bounds for Shannon entropy, f-divergences, and other information measures, including the development of new lower bounds and improvements of existing results.
- **Multidimensional Analysis and Abstract Spaces:** Development of results in general multidimensional settings and their applications in mathematical analysis, information theory, and related fields.
- **Mathematics Education:** Diagnosing students' misconceptions of key mathematical concepts and developing contemporary teaching methods.
- **Rough Shape and Finite Rough Shape Theory:** Study of topological spaces within the framework of rough shape and finite rough shape theory, including rough shape and finite rough shape invariants. Investigation of finite rough shape path connectedness and characterization of finite rough shape isomorphisms.
- **Technology Acceptance Models:** Development and testing of extended TAM/UTAUT models in business and educational contexts.

3. RESEARCH INFRASTRUCTURE

Laboratories

- One laboratory (classroom) for organizing seminars and workshops.

Equipment

- R, SPSS, Stata, and Overleaf.

4. KEY PROJECTS AND REFERENCES

- Climate and Extreme Weather Conditions in Croatia's Natural and Urban Environments (IP-2022-10-4144)

5. COLLABORATION OPPORTUNITIES

The research group achieves scientific results through continuous collaboration with researchers from national and international universities and research institutions. Such cooperation includes the joint development of new theoretical results, preparation of scientific publications, application for and implementation of research projects, and the exchange of knowledge and research experience. The group is open to collaboration in the fields of mathematical analysis, convexity theory, functional inequalities, probability theory, information sciences, time scale theory, and other related areas. Particular emphasis is placed on interdisciplinary research that connects mathematical methods with applications in information theory, computer science, engineering, and other scientific disciplines. Collaboration opportunities include joint research projects, scientific publications, participation in national and international projects, organization of scientific conferences and workshops, researcher mobility programs, and mentoring of early-career researchers and doctoral students. Collaboration with higher education institutions and schools also includes projects aimed at improving teaching practices, curriculum development, and the implementation of modern e-learning tools in mathematics education.

6. CONTACT

Head of Research Group: Anita.Matkovic@fesb.hr

General Contact: projekti@fesb.hr

GROUP FOR NUMERICAL MATHEMATICS (NumMath)

Head of the Group:

Prof. Ivan Slapničar, PhD

<https://www.croris.hr/osobe/profil/23580?lang=en>

Scientific Fields:

Natural Sciences / Mathematics

Brief Description of the Research Group:

The research group develops the theory and algorithms of numerical linear algebra for different number systems, including real, complex, quaternionic, and bicomplex structures. It focuses on efficient methods for solving eigenvalue and singular value problems, QR decompositions, structured matrices, and perturbation theory. The developed algorithms are applied to least-squares problems, image processing and classification, computation of generalized inverses, and finding polynomial roots. Additional research includes operator theory, optimization of damping in oscillatory systems, discrete evolutionary models, and the analysis of symmetric polynomials and their combinatorial applications.

1. RESEARCH TEAM

Faculty members in teaching and research positions:

- Assoc. Prof. Nevena Jakovčević Stor, PhD
- Assoc. Prof. Anita Kujundžić, PhD

Other faculty researchers:

- Dr. Petra Marija De Micheli Vitturi, Senior Assistant
- Marija Čatipović, M.Sc. Math., Lecturer

2. EXPERTISE AND KNOW-HOW

- Generic numerical linear algebra for matrices with entries in one of eight number systems – real numbers, complex numbers, quaternions, reduced bicomplex numbers, and dual numbers derived from the previously listed systems, including: točni i brzi matrični algoritmi,
 - accurate and fast matrix algorithms,
 - QR decomposition ,
 - algorithms for structured matrices,
 - perturbation theory for the above problems
- Application of generic algorithms to:
 - least-squares problems
 - image processing and classification
 - computation of generalized inverses
 - computation of polynomial roots
- operator theory,
- fast optimization of damping in oscillatory systems,
- discrete evolutionary models for periodic organisms,

- analysis of symmetric polynomials and their combinatorial interpretations and applications.

3. RESEARCH INFRASTRUCTURE

Laboratories

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Equipment

- Four computers and two workstations

4. KEY PROJECTS AND REFERENCES

- Synergy of Mathematics and Physics in Engineering (SYMPHA), project IP-UNIST-11, MZOM, principal investigator: Damir Lelas, collaborators: Ivan Slapničar, Nevena Jakovčević Stor, Anita Kujundžić, Petra Marija De Micheli Vittur, Marija Čatipović, <https://www.croris.hr/projekti/projekt/17953>
- Matrix Algorithms in Noncommutative Associative Algebras (MANAA), project IP-2020-02-2240, Croatian Science Foundation, 2021–2024, principal investigator: Ivan Slapničar, collaborator: Nevena Jakovčević Stor, <http://manaa.fesb.unist.hr>
- Optimization of Parameter-Dependent Mechanical Systems (OptPDMechSys), project 9540, Croatian Science Foundation, 2015–2019, principal investigator: Ninoslav Truhar, University of Osijek, collaborators: Ivan Slapničar and Nevena Jakovčević Stor
- Fast and Accurate Matrix Algorithms and Applications, project 0023002, Ministry of Science, Education and Sports, 2002–2013, principal investigator: Ivan Slapničar, collaborator: Nevena Jakovčević Stor

5. COLLABORATION OPPORTUNITIES

Numerical linear algebra, matrix algorithms and applications, image analysis, analysis of symmetric polynomials and their combinatorial interpretations and applications.

6. CONTACT

Head of Research Group: Ivan.Slapnicar@fesb.hr

General Contact: projekti@fesb.hr