CSN IV

Iniziative Specifiche Gr4 PD in 2022-23

CdS – 29 giugno 2022

Theoretical Group at INFN PD (Gruppo 4)

The Padova Theory Group has **around 120 members** (on June 24)
2019 - 80
2020 - 95
2021 - 100
PD group is the third among the largest theoretical groups in Italy after Trieste and Torino

The group composition, INFN Staff + Associated members (according the latest census):

10 - INFN Researchers
33 – Professors of the DFA Uni PD
10 – Uni PD Researchers (RTDB e RTDA)
1 – INAF Researcher
1 – High-School Teacher
30 – Post Doctoral Researchers (assegnisti) + 4 (under the process of association)
32 – PhD Students (in the Schools of Physics and Astronomy)

Budget of the Group «Dotazione 4» in 2022

(il budget 2023 non è stato ancora finalizzato)

Travel (modest): 25.000 + 4.000 (Collab. INFN-CNRS, S. Lenzi)

63.000 (Visitors, Seminars, Equipment) + 4.000 (TFI2022 conference)

Total: 96.000 (including 8.000 special funds) (Travel funds of ISs: ~ 110.000)

Comparison with 2019: Travel 34.600, other funds 48.500, **Total: 83.100**

10 Iniziative Specifiche del Gruppo IV PD

- Linea 1 - FIELD AND STRING THEORY
  - Gauge Theories, Strings and Supergravity, GSS (RL D. Cassani) – 10 FTE
  - String Theory and Fundamentel Interactions, ST&FI (RL D. Sorokin) – 9,3 FTE
- Linea 2 - PHENOMENOLOGY OF ELEMENTARY PARTICLES
  - Physics at the Energy, Intensity, and Astroparticle Frontiers , APINE (RN P. Paradisi) - 16,8 FTE
- Linea 3 - NUCLEAR AND HADRONIC PHYSICS
  - MOdeling Nuclear STructure and REactions, MONSTRE – 1,7 FTE
  - The strongly correlated nuclear systems, NUCSYS – 1 FTE
- Linea 4 – MATHEMATICAL METHODS
  - Quantum Systems: Entanglement, Simulations and Information , QUANTUM (RL S.Montangero) – 11,4 FTE
- Linea 5 – ASTROPARTICLE PHYSICS
  - Theoretical Astroparticle Physics , TASP (RL F. D'Eramo) – 6,9 FTE
  - Inflation, Dark Matter and the Large-Scale Structure of the Universe, InDark (RL N.Bartolo) – 13,9 FTE
  - TEoria delle ONde GRAVitazionali, TEONGRAV (RL M. Mapelli)– 13,6 FTE
- Linea 6 – STATISTICAL AND APPLIED FIELD THEORY
  - Learning Complex Networks, LINCLON (RN e L E. Orlandini) – 8,8 FTE

Gauge Theories, Strings and Supergravity (GSS) – 10 FTE

Staff: D. Cassani (RL), G. Dall'Agata, G. Inverso, L. Martucci, S. Massai
Post Docs: A. Emelin, F. Farakos + 1 in arrive in 2022-23
PhD Students: M. Morittu, N. Risso

Target: understand crucial aspects of Quantum Gravity, such as black hole microstates, existence of realistic vacua, and consistent low-energy Effective Field Theories, in controlled supergravity and string theory scenarios.

- derivation of consistent low-energy Effective Field Theories from string theory
- consequences of swampland conjectures in supergravity
- black hole microstate counting using the AdS/CFT correspondence and dual CFT partition functions
- construction of explicit black hole microstates
- new supergravity vacua and their stability in string theory
- new Exceptional Field Theories

String Theory and Fundamental Interactions (STEFI) – 9,3 FTE

Staff: K. Lechner, P. Marchetti, M. Matone, A. Sfondrini, D. Sorokin (RL), R. Volpato
Assegnisti: S. Giaccari + 2 in arrivo in 2022
Docente Istituto Scolastico: F. Sorge ((molto attivo in gravità e black holes)

Target: understanding of a rich structure and non-perturbative aspects of string theory and quantum field theories via the study of their symmetries, and their application for studying physical phenomena

- Spontaneous breaking of supersymmetry and other symmetries
- Mathematical structures in string theory
- AdS/CFT correspondence and holography, integrable models and conformal QFT
- New (modified) theories of electrodynamics and gravity (in collabroazione con InDark PD)
- Fundamental aspects of quantum field theory, Non-perturbative effects
- Application of QFT methods to statistical and condensed matter physics and quantum information (collaborazione con Linea 6)

Physics at the Energy, Intensity, and Astroparticle Frontiers, APINE – 16,8 FTE

Staff: A. Brignole, F. D'Eramo, L. Di Luzio, F. Feruglio, R. Grober, A. Masiero, P. Mastrolia, P. Paradisi **(RN)**, M. Passera, S. Rigolin, E. Salvioni, L. Vecchi, F. Zwirner
Assegnisti: V. Chestnov, Ling-Xiao Xu + 2 in arrive a novembre 2022
PhD : E. Balzani, G. Crisanti, S. Di Noi, G. Levati, H. Munch, A. Valenti

Target: Development of cutting-edge techniques and analytical tools for precise and more efficient calculations within and beyond the Standard Model and Cosmology, providing theoretical support for ongoing and new experiments

- collider phenomenology and model-building in particle and astroparticle physics
- study anomalies in B-physics and muon g-2
- construction of models that explain the origin of neutrino masses
- nature of dark matter, baryonic asymmetry of the Universe, inflation, and phase transitions during the cosmological evolution

MOdeling Nuclear STructure and REactions , MONSTRE – 1,7 FTE

Staff: L. Fortunato (RL), S. Lenzi , P. Lotti

Main goals: to implement an integral approach to the physics of atomic nuclei, nuclear reactions, and strongly interacting matter. To match the development of nuclear structure and reaction theory with the experimental progress in rare isotopes production, neutrino and electroweak interactions, neutrinoless double beta decay, dark matter detection etc.

- Modern nuclear interactions derived from chiral perturbation theory
- Many-body methods like the nuclear shell-model, density functional theory, optical potentials and algebraic models
- weakly bound systems at the edge of nuclear stability
- nuclear matter in different density conditions

The strongly correlated nuclear systems: effective interactions, models, reactions, fundamental symmetries and applications (NUCSYS) – 1FTE

Staff: L . Canton (RL) **Assegnista:** F. Barbaro

Main goals: Description of **exotics**, **weakly bound**, or **nucleon-emitting** medium-light **nuclei** at the edge of the drip lines and at the crossing between **nuclear structure** and **reaction theory.** Theory description of nuclear processes involved in **radioactive ion beams** experiments

- Search of efficient **cyclotron production** routes for innovative radio-nuclides in nuclear medicine.
- Provide theoretical guidance and support with **nuclear reaction-calculation** know-how and **nuclear data analysis** to radio-pharmaceutical research and **nuclear-medicine applications**, within **interdisciplinary groups** active in Italy and abroad.
- Production of innovative radio-nuclides for **multi-modal imaging** and for therapies and **theranostics**.

Quantum Systems: Entanglement, Simulations and Information, QUANTUM - 11.40 FTE

Staff: L. dell'Anna, S. Montangero (RL), L. Salasnich, F. Silvi, I. Siloi
Post Docs: G. Magnifico, S. Notarnicola, D. Jaschke, E. Gonzales Lazo
PhD: G. Cataldi, S. Cavinato, M. Ballarin, M. Rossignolo, A. Pagano, P. Majcen

Main objective: study of typical quantum mechanical effects and phenomena via three major, interrelated avenues: Entanglement and other Quantum Correlations, Quantum Simulation and Quantum Optimal Control

- application of tensor network methods to lattice gauge theories (confinement)
- application of tensor network methods to machine learning (for processing high-energy physics data)
- Analysis and control of scalable quantum systems for the implementation of programmable quantum devices, employing atoms, ions and solid-state qubits
- Emulation of quantum circuits and assessment of quantum algorithms performance with tensor network methods

Theoretical Astroparticle Physics (TAsP) – 6,9 FTE

Staff: F. D'Eramo (RL), M. Laveder, A. Masiero, S. Pascoli, P. Paradisi, M. Peloso, L. Vecchi

Post Doc: S. Bhattacharya, **F.** Hajkarim, S. Yun

Main goals: undertake research the crossroad of particle physics, astrophysics and cosmology covering: neutrino masses, mixings and interactions; dark energy and dark matter, axion phenomenology; the observed baryon asymmetry of the universe; the physics of high-energy cosmic rays and gamma rays, and their connections with gravitational waves in a multimessenger context.

- Dark Matter Particle Candidates (Wimps, Axions,…)
- Weakly-coupled light particles (light pseudo-scalar particles, sterile neutrinos)
- Early Universe (Inflation, Baryogenesis, Large scale structure)

Inflation, Dark Matter and the Large-Scale Structure of the Universe (InDark)-13.9 FTE

Staff: N. Bartolo (RL), D. Bertacca, M. Liguori, S. Matarrese, M. Peloso, A. Raccanelli
Post-docs: G. Domenech (Fellini), G. Jung, S. Libanore, A. Ravenni A. Ricciardone,
PhD: P. Bari, M. Elkhashab, A. Greco, G. Perna, D.L. Valbusa, E. Vanzan

Main goal: investigate crucial aspects of the standard cosmological model and its extensions, and their connection with particle physics. This includes models of inflation in the early Universe, nature of dark matter and dark energy, properties of neutrinos and other light relics, the viability of modified gravity models, properties of the stochastic gravitational wave background, cosmological tests of fundamental physics

- inflationary predictions, primordial non-Gaussianity, Gravitational Waves/Cosmology
- forecasts for DE/modified gravity; Large Scale Structure (LSS) modelling
- implementations of statistical tools to various data-sets to measure primordial non-Gaussianity, CMB and LSS physics
- Coordination roles: N. Bartolo co-leader of the Project Team “Tests of Cosmic Inflation” (liteBIRD collaboration); D. Bertacca co-leader of WP-9 “LSS Relativistic effects” & A. Raccanelli co-leader of WP-10 “New Observational Probes” (Euclid); S. Matarrese, PD coordinator of ASI-LiteBIRD project; M. Peloso: co-leader of LISA-cosmology working group; A. Ricciardone, co-leader of ET Cosmology division

Gravitational Wave Emission from Astrophysical Sources (TEONGRAV) – 13,6 FTE

Staff: M. Mapelli (RL), R. Ciolfi, M. Spera
Post Docs: M. Arca Sedda, M. C. Artale, A. Ballone, G. Costa, G. Escobar, G. Iorio, J. Kalinani, M. Pasquato, C. Périgois, S. Rastello
PhD: M. Dall'Amico, A. Pavan, F. Santoliquido, C. Sgalletta, S. Torniamenti

MAIN GOAL: Study of gravitational waves and their sources

Binary black hole and neutron star populations:
- Merger rate evolution of black holes and neutron stars across cosmic time
- Constraints on black hole spins from hierarchical Bayesian analysis
- Dynamical formation of intermediate-mass black holes (with N-body and semi-analytic models)

Magneto-hydrodynamical simulations of neutron star mergers:
- jet propagation in binary neutron star merger environments
- development of the general relativity magneto-hydrodynamic code Spritz

Learning Complex Networks, LINCOLN – 8,8 FTE

Staff: S. Azaele, M. Baiesi, F. Baldovin, E. Locatelli, A. Maritan, E. Orlandini (RN), S. Suweis, F. Seno, A. Trovato
PhD: A. Borghetto, F. Mambretti, G. Nicoletti , P. Padbanabha , E. Pigani, L. Sicari

Main goals: Dynamical and topological properties of artificial and polymer networks using techniques of Theoretical Physics.

- Physics of neural networks and machine learning algorithms
- Physical properties of entangled polymer networks
- Protein contact networks and effective interactive potentials
- Networks in neuroscience and statistical approaches to the physics of brain
- Dynamics of social networks