# Gruppo IV

## Proposte delle nuove Iniziative Specifiche 2021 - 2023

CdS – 16 giugno 2020

# 10 Iniziative Specifiche del Gruppo IV PD

- Linea 1 - FIELD AND STRING THEORY
  - Gauge Theories, Strings and Supergravity, GSS (RL D. Cassani) – 9 FTE
  - String Theory and Fundamentel Interactions, ST&FI (RL D. Sorokin) - 6 FTE
- Linea 2 - PHENOMENOLOGY OF ELEMENTARY PARTICLES
  - Open problems in the Standard Model, (ex HEPCUBE) (RN P. Paradisi) - 14 FTE
- Linea 3 - NUCLEAR AND HADRONIC PHYSICS
  - MOdeling Nuclear STructure and REactions, MONSTRE (ex STRENGTH) (RL L. Fortunato) – 5 FTE
  - The strongly correlated nuclear systems, NUCSYS (ex FBS) (RL L. Canton) – 1 FTE
- (Linea 4 – Mathematical methods – non è presentata formalmente)
- Linea 5 – ASTROPARTICLE PHYSICS
  - Theoretical Astroparticle Physics , TASP (RL F. D'Eramo) – 5,1 FTE
  - Inflation, Dark Matter and the Large-Scale Structure of the Universe, InDark (RN N. Bartolo) – 9.4 FTE
  - TEoria delle ONde GRAVitazionali, TEONGRAV (RL M. Mapelli)– 115 FTE
- Linea 6 – STATISTICAL AND APPLIED FIELD THEORY
  - Learning Complex Networks, LINCLON, (ex PlexNet) (RN e L E. Orlandini) – 10,7 FTE

  Nuova Quantum Systems: Entanglement, Simulations and Information , QUANTUM (RL S.Montangero) – 8,9

# Gauge Theories, Strings and Supergravity (GSS)

**Staff:** D. Cassani (RL), G. Dall'Agata, S. Giusto, L. Martucci, G. Inverso
**Post Doc:** G. Dibitetto, F. Farkos **PhD Students:** M. Morittu, D. Partipilo

Target: further understanding of string theory, quantum gravity and gauge theories at strong coupling, with a specific focus on computations of black hole entropies and supergravity derived scenarios for early universe cosmology

- String Theory, M-Theory, Supergravity
- Perturbative and non-perturbative properties of Gauge Theories
- Supersymmetric Black Holes, Holography and Microstate Counting
- Models of supersymmetry breaking in Inflationary Cosmology and Particle Physics

# String Theory and Fundamental Interactions (STEFI)

K. Lechner, P. Marchetti, M. Matone, A. Sfondrini, D. Sorokin (RL), R. Volpato

**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, Integrabld models and conformal QFT
- Modified theories of 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 (ex HEPCube)

**Staff:** A. Brignole, F. D'Eramo, F. Feruglio, R. Grober, A. Masiero, P. Mastrolia, P. Paradisi **(RN)**, M. Passera, S. Rigolin, L. Vecchi, F. Zwirner
**Post Doc:** M. K. Mandal, C. Cornella, **PhD :** F. Gasparotto, A. Guerrera, L. Mattiazzi

**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 (ex STRENGTH)

**Staff:** L. Fortunato (RL), S. Lenzi , P. Lotti, Jesus Casal, A. Vitturi
**Post Doc:** G. Singh

**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)

**Staff:** L . Canton (RL) **Post Doc:** F. Barbaro

**Main goals:** Sviluppo dei metodi a canali accoppiati applicati alla fisica con fasci radioattivi come collisioni nucleone-nucleo alle basse energie e collisioni cluster-nucleo alle basse energie. Calcoli di reazioni nucleari di interesse medico: Produzione di radiofarmaci, produzione di radionuclidi teranostici e per l'imaging multimodale

- study various new unstable nuclear systems that can be studied in particular with radioactive ion beam
- provide the nuclear reaction calculation know-how to radio-pharmaceutical research going-on in INFN-LNL, Arronax (Nantes, France), and HIL (Warsaw, Poland)

# Theoretical Astroparticle Physics (TAsP)

**Staff:** F. D'Eramo, M. Laveder, A. Masiero, S. Pascoli, P. Paradisi, M. Peloso, L. Vecchi
**Post Doc:** R. Nagai

**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)

**Staff:** N. Bartolo (RL), D. Bertacca, M. Liguori, S. Matarrese, M. Peloso, A, Raccanelli
**Post Doc:** G. Domenech (Fellini), G. Jung, M. Zarei; **PhD:** P. Bari, S. Libanore

**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, the properties of neutrinos and other light relics, and the viability of modified gravity models.

- inflationary predictions, primordial non-Gaussianity, Gravitational Waves and Cosmology (Stochastic Gravitational Wave Background);
- forecasts for DE/modified gravity; Large Scale Structure modelling and non-linear evolution of perturbations;
- implementations of statistical tools to various data-sets to measure primordial Non-Gaussianity, CMB physics.

# Gravitational Wave Emission from Astrophysical Sources (TEONGRAV)

**Staff:** M. Mapelli (RL), M. Branchesi, R.Ciolfi
**Post Doc:** A. Ballone, Y. Bouffanais, G. Costa,, N. Giacobbo, G. Iorio, S. Rastello, M. Spera, S. Torniamenti **PhD:** J. Kalinani, A. Pavan, F. Santoliquido

**Main goal:** Study of gravitational waves and their sources. Test general relativity and alternative models of gravity.

- Modelling of gravitational wave sources (numerically and analytically)
- Study of the dynamics of black hole formation
- Study of the interior structure of neutron stars
- Study of electromagnetic counterparts of gravitational wave signals

# Learning Complex Networks, LINCOLN (ex PlexNet)

**Staff:** M. Baiesi, F. Baldovin, A. Maritan, E. Orlandini **(RN)**, S. Suweis, F. Seno, A. Trovato
**PhD:** G. Nicoletti, S. Garlaschi, R. Sanson, I. Di Terlizzi

**Main goals:** Develop new techniques to exploit and control the properties of complex networks and the processes on them. Study of dynamical systems on networks using techniques of Theoretical Physics.

- Physics of artificial neural networks in machine learning algorithms
- Physical properties of entangled polymer networks
- Protein contact networks and topology
- Networks in neuroscience

# Quantum Systems: Entanglement, Simulations and Information, QUANTUM (nuovo nodo di PD)

**Staff:** L. dell'Anna, S. Montangero (RL), L. Salasnich
**Post Docs:** L. Arceci, G. Magnifico, S. Notarnicola
**PhD:** T. Felser, P. Rembold, M. Rossignolo

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

- application of tensor network methods to lattice gauge theories (confinement)
- application of tensor network methods to machine learning (for processing high-energy physics data)