# Quantum Fields, Gravity and Quantum Gravity

Transversal Team

The key scientific objectives of our team is the exploration of potential transversal collaborative axes between the other teams of IPHU and the pure theory research. The data coming from the frontier of particle physics experiments, astronomical observations including gravitational waves, and cosmological surveys present a series of puzzles offering potentially crucial insights for the advancement of theoretical understanding. Conversely, theoretical explorations might suggest new perspectives that could motivate experimental or observational research that would not be apparent without the conceptual standpoint that theoretical investigations open.

Our present standard model of particle physics and the concordance model of cosmology contain unsatisfactory aspects which drive efforts on the theoretical front. The fundamental understanding of the nature of dark energy and dark matter and of the primordial universe remain to a large extent open. Different models inspired in particle physics, and effective field theories have the potential of linking extensions of the standard model with the resolution of cosmological puzzles and produce rich phenomenology. Some of these problems could perhaps only be resolved if questions related to the quantum nature of gravity and matter at the Planck scale are better understood.

The interaction between experimental and observational scientists and theoreticians can suggest new grounds for collaborations in a bidirectional manner: on the one hand present theoretical models need the testing of their phenomenology via available data or possible new analysis of the data, on the other hand, understanding of what the data tell us about nature can offer empirical motivation for new theoretical speculation that could help in the construction of models beyond the established understanding in the areas of particle physics and quantum gravity.

*The key objective of our team is to foster interactions and cross fertilization between these two often too independent communities with the hope of producing progress on both the frontiers of observational and experimental physics and theoretical physics.*

# Quantum Gravity and Classical GR at CPT

- QG models for the origin of dark energy.
- Possible relation to the H-tension have been investigated.
- QG modifications of inflationary cosmology paradigm.
- Black hole anomalous diffusion could produce BH spin slowing down (implications for Ligo/Lisa).
- Phenomenology of primordial black holes, exploding BHs.
- GW modified theories of gravity, observables in standard GR.

# Cosmology at the CPT

- Modified gravity : theory  and phenomenology (Effective field theory approaches, LCDM discordant model)

- Dark matter and the large-scale structure of the Universe : Initial conditions & perturbation theory

- Geometrical tests of cosmology: cosmography, Copernican principle and alternative spacetimes.

# Astrophysics

- From Planck era to primordial inflation: [modelling from] QFT on curved space-time, SUSY/SUGRA, string/brane theories, LQ cosmology, ...
- Grand Unification and baryogenesis: electroweak baryogenesis, leptogenesis, Affleck-Dine mechanism, ...
- Primordial black holes, modelling of compact objects and gravitational waves.
- Signatures on big-bang nucleosynthesis, cosmic microwave background radiation, stochastic gravitational wave background,...

# Particle Physics

- precision measurement of the Standard Model and the search of Beyond Standard Model ``smoking guns" (muon's g-2, flavor physics, parton distribution functions, strong coupling constant)
- nucleon sigma term and its connection to Dark Matter
- non-perturbative studies of BSM models/technicolor/composite Higgs/ composite Dark Matter
- QCD phase diagram/ Equation of State/ bosonic stars
- axions
- Cosmic trajectory through the QCD phase diagram

- Short and long-term invited researchers.

F. Sannino (CP3 Denmark and Naples Uni)
G. Moore (T.U. Darmstadt)
G. Martinelli (Rome 1)
L. Rezzolla (Uni Frankfurt)
A. Kurkela (CERN),
Antonio Riotto (Univ Geneva & CERN theoretical division),
Vincent Desjacques (Haifa),
Mikhail Shaposhnikov (EPFL),
Massimo Pietroni (Univ Parma).

- Shared with other IPhU working groups: meetings in IPhU labs, regular announcements (publications, conferences, jobs) in IPhU Newsletter.

Thank you for your attention.