The theory group at APC

The group is composed by

University researchers (8)
Pierre Binétruy
Jean-Pierre Gazeau (emeritus)
Eric Huguet
Jihad Mourad
Francesco Nitti
Jacques Renaud
Julien Serreau
Daniele Steer

CNRS researchers (6)
Nathalie Deruelle,
Elias Kiritsis
Marc Lachièze-Rey
David Langlois
Dimitry Semikoz
Cristina Volpe

Postdocs: Euihun Joung, **F.** Piazza (PCCP), R. Sayto

PhD students: Jibril Ben Achour, Maxime Guilleux, Alexis Helou, Wenliang Li, Mauro Pieroni, Andréas Tresmontant

Associates: Chiara Caprini (IPhT CEA), Karim Noui (U. Tours), B. van Tent (LPT Orsay)

A large number of visitors and of students every year.

The theory group at APC

The research activity is closely linked to observations and focussed on fundamental theories, addressing crucial issues at the forefront of :

- **Astroparticle physics**
- **Cosmology**
- **Gravity**
- **Quantum Field Theory (QFT) and String Theory**

Holography

- **Gauge/Gravity Duality and its applications (Kiritsis, Nitti, Li)**

study of strongly coupled Quantum Field Theories (QFT)
see e.g. «Holographic renormalisation group flow and the Quantum Effective Action», Kiritsis, Li, Nitti, arXiv:1401.0888

- QCD

Development of a holographic model for QCD : calculation of the finite temperature and finite density phase diagrams, as a function of the number of flavors and prediction of a new QCD phase at finite density and T=0

- condensed matter
- cosmology of strongly coupled QFT

Gravitation

- General Relativity and modified Gravity (Deruelle, Kiritsis, Langlois, Mourad, Steer)

  - models of gravity with higher derivatives : f(R) and «Galileon» models
  - «massive gravity » (ghost-free formulation)
    see e.g. Mourad and Steer, JCAP 1312 (2013) 004.

  - Publication of the book «Théories de la Relativité» - J.P. Uzan and N. Deruelle

- Loop Quantum Gravity (Lachièze-Rey, Noui, Ben Achour)

Cosmology

- Inflation and cosmological perturbations (Binetruy, Deruelle, Kiritsis, Langlois, Piazza, Steer)

- Dark Energy (Langlois, Piazza)

  New approach to dark energy, incorporating most of the existing models and allowing to explore systematically new regions of the effective parameters space

  see e.g. « Essential building blocks of dark energy», Gleysez, Langlois, Piazza, Vernizzi, JCAP 1308 (2013) 025

- Gravitational waves from the early Universe (Binetruy, Deruelle, Steer, Caprini), Topological defects (Deruelle, Steer)

  in connection with LIGO/VIRGO, eLISA/NGO

  see e.g. «Doing science with eLISA», GW Notes 6 (2013) 4.

- Cosmological neutrinos (BBN epoch) (Semikoz, Volpe)

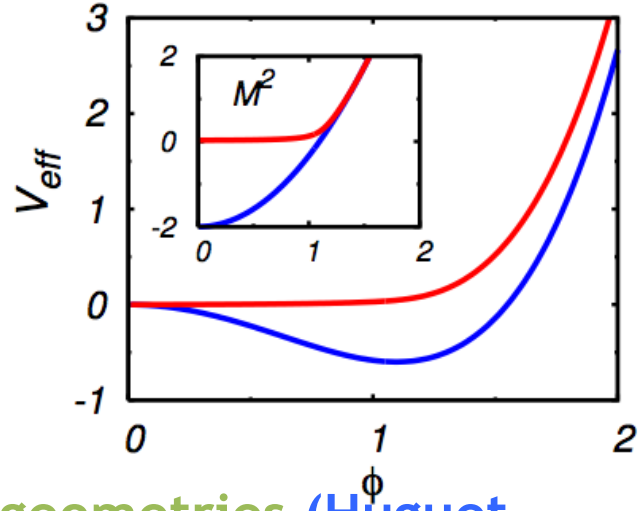
  see e.g. «CP violation effects on the neutrino degeneracy parameters», Gava and Volpe, Nucl.Phys. B837 (2010) 50.

Quantum Field Theory

- Quantum Field Theories in curved spacetime (Huguet, Kiritsis, Renaud, Serreau)
- Interacting fields in de Sitter space (Serreau, Guilleux)

symmetry restoration from quantum corrections induced by the curvature

J. Serreau, PRL 107 (2011)
J. Serreau, Phys.Lett. B730 (2014)



- Conformal methods for fields in curved geometries (Huguet, Renaud, Ben Achour)

See e.g. Huguet and Renaud, Phys.Rev. D88(2013)
Huguet and Renaud, J. Math Phys. 54 (2013)

- Higher Spin Theories (Mourad, Joung)
- Integral quantization of geometries (Gazeau)

J.P. Gazeau "Coherent States in Quantum Physics » (2009)

Cosmic rays, neutrino (astro)physics

- Cosmic rays : Develop theoretical models for spectrum, composition and sources of UHECR, propagation of UHECR in the intergalactic medium (Semikoz)

  see e.g. «Explaining the knee by cosmic ray escape from the Galaxy», Giacinti, Kachelriess, Semikoz, arXiv:1403.3380

- UHE neutrinos (Semikoz)

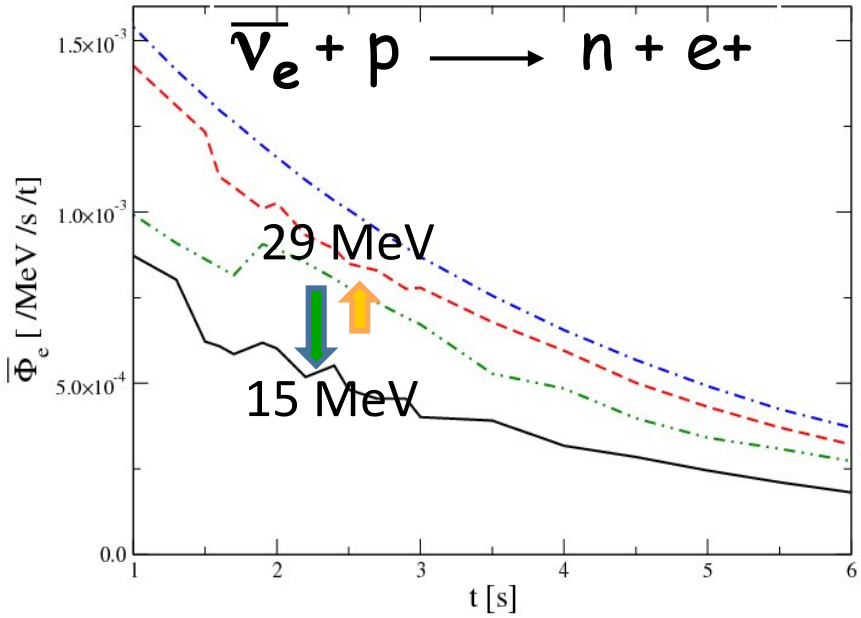
  see e.g. «PeV neutrinos from interactions of cosmic rays with the interstellar medium in the Galaxy», Neronov, Semikoz, Tchemin, Phys.Rev. D89 (2014) 103002.

- Proposing experiments with low energy neutrinos - low energy beta-beams and spallation sources (Volpe)

  see e.g. Volpe, J.Phys. G34 (2007) R1-R44.

Neutrino (astro)physics

- Investigations of neutrino flavor conversion in astrophysical environments, such as **core-collapse supernovae** (Volpe)



If the neutrino hierarchy inverted in ex. JUNO

Gava, Kneller, Volpe, McLaughlin, PRL (2009) arXiv:0902.0317

- Establishing the connection between flavor conversion in media and **other domains**, e.g. nuclei,clusters, condensed matter (Volpe)

see Volpe, Väänänen, Espinoza, Phys.Rev. D87 (2013) 11, 113010


Thank you