Theory group

APC

List of people Theory group

1. **Head of group Dmitri Semikoz, vice-head Eric Huguet**

2. **Budget (without projets): 38 000**

3. **List of permanent:**

- **13+3 permanents [Name, Status (Emeritus, PR, DR, MCF, CR, IR-Chercheur), (HDR)**
- CNRS

Caprini Chiara	DR
Kiritsis Elias	DR
Langlois David	DR
Semikoz Dmitri	DR
Vennin Vincent	CR / ***HDR***
Volpe Cristina	DR

University Paris 7

Huguet Eric	MCF/ ***HDR***
Mourad Jihad	PR
Neronov Andrii	PR
Nitti Francesco	PR
Renaud Jacques	PR
Serreau Julien	MCF/ ***HDR***
Steer Danièle	PR

Emeritus

Deruelle Nathalie	DR
Gazeau Jean-Pierre	PR
Lachièze-Rey Marc	DR

List of people Theory group

Associated

K.Noui (Tour U.) 2-3 days/week
F. Vernizzi (Saclay) 1 day/week
U.Reinosa (Polytechnique) 1 day/week
Julien Grain (IAS) 1 day/week
Brando Bellazzini (Saclay)
Christos Charmousis (Orsay)
Blaise Gouteraux (Ecole Polytechnique)
Monica Guica (Saclay)
Hervé Bergeron (Orsay)

List of people Theory group: postdocs

- **4 Postdocs now: [Name, Project name, financial source, starting date, final date]**
- Panagiotis Betzios ERC Advanced Grant, 09/2020-09/2021
- Alberto Mangiagli IN2P3 2/2021-2/2023
- Alberto Roper Pol ANR 10/2020-10/2022
- Marius Ramsoy ANR 11/2020-11/2022

List of people Theory group

- **11 PhD students: [Name, PhD subject, financial source, PhD advisor, coadvisor, common PhD with, starting date, final date]**

Auclair Pierre	Cosmology with Gravitational Waves	E. Polytechnique	D.Steer/ Ch. Caprini	Oct 2018 Oct 2021
Bouyahiaoui Makarim	Models of multi-messenger sources of cosmic-rays, gamma-rays and neutrinos	Paris7	D. Semikoz	Oct 2018 Oct 2021
Gatelet Yoann	Multimessenger astrophysics with Neutrinos	Paris 7	A.Neronov	Oct 2019 Oct 2022
Korochkin Alexander	Gamma-ray astronomy	Vernadskii (cotutelle Russie	D. Semikoz G.Rubtsov)	Oct 2018 Oct 2021
Papanikolaou Theodoros	Constraining the early Universe with Primordial BH	Paris7	V. Vennin /D.Langlois	Oct 2018 Oct 2021
Roussille, Hugo	Modified gravity models	ENS Ulm	D.Langlois	Oct 2019 Oct 2022
Jani Kastikainen	Holography	cotutelle Helsinki	F.Nitti	June 2020 June 2022
Edwan Préau	Holography		E.Kiritsis	Oct 2020 Oct 2023
Valentin Nourry	Holography.		F.Nitti	Oct 2020 Oct 2023
Thomas Colas	Cosmology	co-tutelle with Orsay.	V.Vennin	Oct 2020 Oct 2023
Konstantin Leyde	Cosmology		D.Steer	Oct 2020 Oct 2023

PhD thesis defended in theory group

- **PhD defended in period (2018-2021)**
- **Name, PhD subject, financial source, PhD advisor, starting date, final date...**

Chatelain Amélie	Neutrino propagation in dense astrophysical environments : beyond the standard frameworks	ENS	Cristina Volpe	Sept 2016 Sept 2018
Gallo Rosso Andrea	Analys of supernova neutrino fluxes and neutron star properties	GSSI/Aquila U.	Cristina Volpe (F. Vissani)	Sept 2016 Avr 2019
Ghosh Jewel Kumar	Aspects of holographic RG flows on curved manifolds	ERC	Elias Kiritsis/F.Nitti	Sept 2016 Sept 2019
Liu Hong Guang	Modified Gravity	CPT Marseille	Karim Noui /A.Perez	Sept 2016 Sept 2019
Pimenta Leandro,	Holography	Paris 7,	Kiritsis+Nitti,	9/2015-8/2018
Félix-Louis Julié,	the problem of motion in, modified theories of gravity	bourse de thèse	N.Deruelle	9/2015-9/2018
Maelger Jan	Transitions de Phases en QCD	Paris7	Julien Serreau	Oct 2016 Oct 2019
Moreau Gabriel	Champs quantiques en espace-temps courbe	Paris 7	Julien Serreau	Oct 2017 Oct 2020

Activities of theory group

- **Collaboration with following institutes:**

1) Albert Einstein Institute Potsdam
2) Aquila University, Italy
3) ASU, PHOENIX, Arizona, USA
4) Brokhaven National Lab
5) Carnegie Mellon University, USA
6) CERN
7) CPHT-X
8) Dept Histoire and Philosophy of Sciences, Univers. Paris Diderot
9) Dept de mathématiques, Univ Paris Diderot
10) DESY Hamburg
11) Ecole Normale Supérieure
12) Geneva Observatory
13) GSSI, Italy
14) Institut d'Astrophysique de Paris
15) Institute d'Astrophysique Spatiale
16) Institute of Cosmology and Gravitation, University of Portsmouth (Angleterre)
17) IFFI, Montevideo, Uruguay
18) ICTP Trieste
19) INFN Florence
19) INFN Milan and Milano University
20) INR, Moscow
21) IPMU Tokyo
22) IPHC (Strasbourg)
23) IPM Tehran, Iran

Activities of theory group

- **Collaboration with following institutes:**

24) Laurentian University
25) L2C (Montpellier)
26) LPTMC, Sorbonne Université
27) Leiden Univ.
28) Max Planck Institute fur Physik, Munich
29) Novosibirk University
30) Osaka University
31) Perimeter Institute, Canada
32) RIKEN, Japon
33) Stanford University
34) Simon Fraser, Vancouver
35) Trondheim University, Norway
36) UCL, Louvain La Neuve, Belgique
37) Université Libre de Bruxelles, Belgique
38) University of Barcelona
39) University of Crete
40) University of Heildelberg
41) University of Helsinki
42) University of Lanzhou, China
43) University of McGill
44) University of Milano
45) University of Nottingham
46) Université d'Orsay

Activities of theory group

- **Collaboration with following institutes:**

47) University of Padova
48) University of Roma II
49) University of Stavanger (Norway)
50) University of Sussex
51) University of Trieste
52) University of Taiwan
53) University of Vienna
54) University of Utrecht
55) University of Winskonsin
56) Warsaw University, Pologne
57) Waseda University
58) Yukawa Institute for Theoretical Physics, Kyoto, Japon

Activities of theory group

Long term visitors, 1 month or more

M.Kachelriess (Trondheim U) Nov-Dec 2017
- Hamza Boumaza (2 mois)

Andrea Gallo Rosso (Aquila U) two months 2017

Panos Betzios (U of Crete) Nov. 2018
Yuta Hamada (U. of Crete) Oct-Nov 2018
Olga Papadoulaki (ICTP Trieste) Nov 2018
M.Kachelriess (Trondheim U) Nov-Dec 2018
Francesco Vissani (Aquila U.) - one month 2018
Morgan Le Delliou december-january and july-october 2018

- Tanmay Vachaspati June, Sept 2019

M.Kachelriess (Trondheim U) Nov-Dec 2019
- Kenta Ando (Tokyo University, ICRR, May-July 2019)

Christopher Ganz (Padova U.) Sept-Dec 2019
- Jibril Ben Achour (Beijing University), March 15 – July 30, 2019
- Matti Jarvinen (Utrecht)
- Morgan Le Delliou december 2018-january 2019 and december 2019 - present

We also have in average 30+ short term visitors per year (before covid 19)

Activities of theory group

•Participation in popularisation of science:

- Ch.Caprini "Ondes gravitationnelles", seminar for high-school students, Lycee Albert Schweitzer, Le Raincy (France), 2017 //"Gravitation, Virgo et trous noirs", Bar de Sciences, Paris 2017
- N.Deruelle 2 books+second edition "Les ondes gravitationnelles", ND et Jean-Pierre Lasota, Odile Jacob, Février 2018 // "Relativity in Modern Physics", ND et JP Uzan, traduction anglaise de "Théories de la Relativité", Oxford University Press, août 2018 "Théories de la Relativité", ND et Jean-Philippe Uzan, Seconde Edition revue et augmentée, Belin 2019
- E.Huguet Conference grand publique « Qu'est ce que l'espace temps », mars 2019, Paris
- E.Kiritsis 2 popular physics presentations
- F.Nitti: Responsable Physique de la Fête de la Science et Journées Portes Ouvertes (2016-2018)/ Organisation d'ateliers interdisciplinaires pour les lycéens (depuis 2015)/Comité de redaction site web UFR physique U. Paris Diderot
- D.Semikoz popular lecture at Moscow High-Economics School on 'Modern Astrophysics'
- J.Serreau exposé grand public à la journée "Physique quantique, physique magique", association Fêtes le Savoi
- D.Steer presentation to school children at CERN (2018)
- V.Vennin 2018 and 2019: School workshop (age 13-14) at "collège Evariste Galois", France 2018: Radio show "La me´thode scientifique", France Culture 2020: enseignement dans l'Université Ouverte de Paris Université2019: Radio show "La meéthode scientifique", France Culture 2019: High school conference (age 16-18), "Demain la Terre", organised by Paris Diderot University 2019: Interview for the "Causa Mundi" think tank
- C.Volpe Interventions dans une classe de CM2 (2h) pour presenter "Comment "meurent" les supernovae ?

Activities of theory group

Responsibilities without projects

Ch.Caprini, Coordinator of the Science Investigation Work Package of the LISA Science Group

Member of the Groupe thématique “Astroparticle physics” for the prospective 2020-2030 of the in2p3

Member of the Astronomy Working Group of the European Space Agency,

Member of the Groupe de Travail Physique Fondamentale of the French Space Agency CNES

Member of the Advisory Board of the Mainz Institute for Theoretical Physics

Director of the Groupement de Recherche Ondes Gravitationnelles of CNRS IN2P3, since 2017 (200 members)

N.Deruelle membre du Conseil Scientifique du CNRS 2017-2018

J-P.Gazeau Honorary member of the Standing Committee of the International Colloquium on Group Theoretical Methods in Physics (ICGTMP) (2015-) Member of the European Science Foundation College of Expert Reviewers // Member of the Selection Committee for the Wigner Medal (2018-2020), and Chairman for 2018

E.Huguet Responsable adjoint du groupe Theorie

E.Kiritsis Membre Conseil du laboratoire APC, Before 2019 deputy chair of the EuropeanPhysical Society, High Energy Physics Board.

D.Langlois Member of the ERC Panel 9 for Consolidator Grants (2012-2018) / Président de comité HCERES (CPHT Polytechnique) /Membre commission de recrutement du département de physique de l’Ecole polytechnique

F.Nitti Directeur adjoint UFR Physique U. Paris Diderot/ Responsable Locaux et logistique Batiment Condorcet

D.Semikoz Responsable du groupe Theorie

J.Serreau membre du CNU 2015-2019 , comité de sélection de l’ED STEP-UP (pour les bourses doctorales); HCERES (IPhT 2019, LAPTH 2020) ; correspondant APC pour le Bureau des Théoriciens de Physique des Particules (BTP2) de l’in2p3

D.Steer member of CNU. Member of different university councils, including the teaching comité (CENS) / convener Cosmology group *GdR “Ondes Gravitationnelles”*

V.Vennin Membre du conseil de laboratoire de l’APC / Comité de suivi de these de Pierre Augier (APC) / convener Cosmology group *GdR “Ondes Gravitationnelles”*

C.Volpe Responsable du groupe Théorie de APC up to 2017, Membre du comité Editoriale pour Journal Of Physics G, Membre du Conseil Scientifique APC, Membre du conseil de la FRIF (depuis 2015), convener du GDR Neutrino

Activities of theory group

•**Organization of schools, workshops, conferences (2017-2020)**

•**APC**

COSMO17 200 participants
"infrared QCD", nov 8-10 2017, 20 participants (J.Serreau)
The Universe as a Quantum Lab (September 2018, 75 participants) (V.Vennin)
Assemblée Générale of the GdR in APC October 2018 200 participants (Ch.Caprini)
Galactic Cosmic Rays (December 2018) 70 participants (D.Semikoz,A.Neronov)
S.low.SUGRA meeting (March 2019)
Paris Primordial Cosmology Meetings (3 meetings per year) (V.Vennin)
colloque Jean Marie Souriau, Univ. Paris Diderot, mai 2019
APC -Perimeter-Brussels conference "Cosmological Frontiers in FundamentalPhysics", APC, May 2020 (E.Kiritsis)
Cosmic rays and astrophyiscal neutrinos (Dec 2020) 100 participants (D.Semikoz, A.Neronov)

•**Other location**

-2017 European Physical Society Conference on High Energy Physics ``EPSHEP 2017 », 5-12 juillet, 2017 at Venice, Italy

- ``9th Crete Regional Meeting on String Theory", 10-15 Jully 2017, Kolymbari, Crete. (E.Kiritsis)
- ``GRAVITY, COSMOLOGY \& PHYSICS BEYOND THE STANDARD MODEL", 11-15 June 2018, Paris, France.
- Perimeter-Brussels-APC conference "Cosmological Frontiers in FundamentalPhysics", Brussels, 14-16 May 2018, (E.Kiritsis)

Activities of theory group

•Organization of schools, workshops, conferences (2017-2020)

- V.Vennin

  from 2019 PPCM (Paris Primordial Cosmology meetings) 3 meetings per year:

  2018: Organiser of the international conference “The Universe as a Quantum Lab”:
  2018 - now: Organiser of APC colloquia
  2016 - 2017: ICG theoretical cosmology seminar organiser

-

- C.Volpe 2019 Membre du International Advisory Committee de 45th Erice workshop et du "Symposium Large TPCs for low energy rare event detection" (2018).

- J-P Gazeau Co-organizer (with R. Beneduci) of a special session on ``The role of Symmetry in the foundations of quantum physics" (SYMQP) at the 32th ICGTMP Conference in Prague, July 2018.

- Ch.Caprini Gravitational waves: a new messenger to explore the Universe”, long-termworkshop at the Institut Henri Poincar´e (Paris), March-April 2021

- “LISA Cosmology Working Group Workshop”, regular meetings taking place twice a year: MITP Mainz (October 2017), University of Helsinki (June 2018), UniversidadAutononoma de Madrid (January 2019), Università di Padova (September 2019), APC Paris (July 2020)

- “Assemblée Générale du GdR Ondes Gravitationnelles”, regular annual meeting of the Groupement de Recherche Ondes Gravitationnelles: APC Paris (October 2018), IPNL Lyon (October 2019)

- “PONT d’Avignon – Progress on Old and New Themes in cosmology”, regularconferences taking place every three years in Avignon (France): April 2011, April 2014, April 2017, April 2020

- “School on Gravitational Waves for Cosmology and Astrophysics”, Benasque(Spain), May 2017

-

Activities of theory group

•Seminars:

1) Regular theory seminars every week.
2) Before covid Journal clubs every second week
3) Days of PhD students and postdocs with talks of young members of group 2 times per year

Workshops:

Members of theory group organize in APC 2-3 workshops per year with subject related to activity of group

last one Dec 2020

Cosmic Rays and Neutrinos in the Multi-Messenger Era

https://indico.in2p3.fr/event/20789/timetable/#20201207

200+ participants

next one Mai 2021

COSMOLOGICAL FRONTIERS IN FUNDAMENTAL PHYSICS 2021

https://indico.in2p3.fr/event/19568/

Projet #1 String theory and Holography

Scientist responsible for project : E.Kiritsis,F.Nitti

List of researchers in the project:

- **2 permanent [Name, %ETPT in projet, (status)]**
  - Elias Kiritsis 100% (responsable)
  - Francesco Nitti 50% (co-responsable)
- **2 postdocs [Name, %ETPT in projet, (status)]**
  - Panagiotis Betzios 100% research
- **3 PhD students: [Name, %ETPT in projet, (status)]**
  - Edwan Préau 100% research
  - Valentin Nourry 83% research
- **Important scientific results in project (2017-2020)**
  - Understanding at the nonlinear level the holographic models of the self-tuning of the cosmological constant, and building phenomenologically viable models.
  - Analysis of holographic Renormalization Group Flows on curved spacetimes and in particular their relation to cosmology.
  - Determination of the QCD equation of state at finite density using Holography. Determination of associated transport coefficients. Computation of static neutron stars and neutron star mergers and study of the related GW signals.
  - Computation of weak processes in dense strongly coupled media (like neutron stars) and study of related phenomenology using semi-holography.
- **Important publications (2017-2020)(3 max) :**
  - Holographic self-tuning of the cosmological constant Christos Charmousis (Orsay, LPT), Elias Kiritsis (APC, Paris & Crete U.), Francesco Nitti (APC, Paris). Apr 17, 2017. 99 pp. Published in **JHEP 1709 (2017) 031**
  - Brane cosmology and the self-tuning of the cosmological constant A. Amariti (INFN, Milan), C. Charmousis (Orsay, LPT), D. Forcella (APC, Paris), E. Kiritsis (APC, Paris & Crete U.), F. Nitti (APC, Paris) . 67 pp. e-Print: **arXiv:1904.02727**
  - Holographic RG flows on curved manifolds and the F-theorem Jewel Kumar Ghosh (APC, Paris), Elias Kiritsis (Crete U. & APC, Paris), Francesco Nitti, Lukas T. Witkowski (APC, Paris). Oct 29, 2018. 83 pp. Published in J**HEP 1902 (2019) 055** e-Print: a**rXiv:1810.12318 [hep-th]**

25 papers in journals published + 1 preprints

Projet #1 String theory and Holography

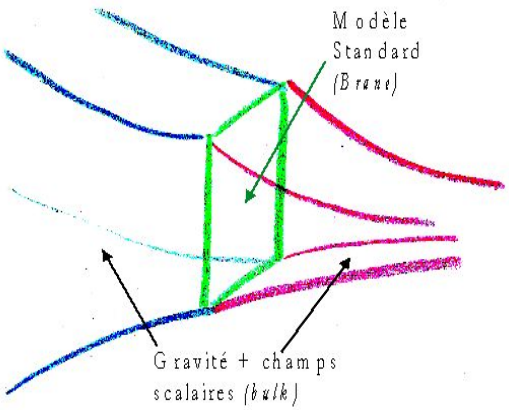
E.Kiritsis, F.Nitti, D.Forcella, L.Witkowski, J.K. Ghosh,L.Pimenta

Holographie, constante cosmologique et gravité modifié

Problème de la constante cosmologique:
pourquoi l'énergie de vide quantique du Modèle Standard TQC ne semble pas contribuer à la courbure de l'espace-temps ?

Universe Branaire holographique à 5d

C. Charmousis, E. Kiritsis, F. Nitti, JHEP 1709 (2017) 031



- Le modèle standard (localisé en 4d) intéragit avec un *bulk* courbé à 5d;
- Mécanisme d'annulation automatique de la constante cosmologique à 4d (*self-tuning*);
- Modifications de la gravité à grande et/ou courte distance (duale: *gravité émergente*)

Projet #2 Quantum field theory

List of researchers in the project:

- **4 permanents [Name, %ETPT in projet, (status)]**
  - J-P. Gaseau 100%
  - E.Huguet 50%
  - M.Lachieze-Rey 100%
  - J.Mourad 50%
  - J.Renaud 50%
- **Important scientific results in project (2017-2020)**
- Covariant integral quantization of various classical systems.
- Quantum field theory in (anti) de Sitter space from conformal six dimensional space,
- Study of breaking of Supersymmetry
- Teleparallel Equivalent of General Relativity (TEGR): not a gauge theory of the translation group, formulation with a Cartan connection
- **Important publications (2017-2020)(3 max) :**

From Classical to Quantum Models: The Regularising Rôle of Integrals, Symmetry and Probabilities
Jean-Pierre Gazeau (APC, Paris & Rio de Janeiro, CBPF). Jan 8, 2018. 20 pp.
Published in **Found.Phys. 48 (2018) no.11, 1648-1667**

Teleparallel gravity equivalent of general relativity as a gauge theory: Translation or Cartan connection?
M. Fontanini, E. Huguet (APC, Paris), M. Le Delliou (Lanzhou U.). Nov 9, 2019. 11 pp.
Published in **Phys.Rev. D99 (2019) no.6, 064006**

Teleparallel theory as a gauge theory of translations: Remarks and issues.
M. Le Delliou (Lanzhou U.) , E. Huguet (APC, Paris), M. Fontanini . Jan 31, 2020. 6 pp.
Published in **Phys.Rev. D101 (2020) , 024059.**

Massive scalar field on (A)dS space from a massless conformal field in R6,
E. Huguet (APC, Paris), J. Queva (Corse U.) and J. Renaud (APC, Paris) May 21, 2020. 6 pp.
Published in **J. Math. Phys. 61 (2020), 053506.**

On Classical Stability with Broken Supersymmetry
I. Basile (INFN, Pisa & Pisa, Scuola Normale Superiore), J. Mourad (APC, Paris), A. Sagnotti (INFN, Pisa & Pisa, Scuola Normale Superiore).
Nov 28, 2018. 59 pp. Published in **JHEP 1901 (2019) 174**
15 papers in journals published

Projet #3 QFT and QCD

Scientist responsible for project : J.Serreau

List of researchers in the project:

- **1 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Julien Serreau 50% (responsable)

- **2 PhD studens: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
  Maelger Jan Transitions de Phases en QCD %100
  Moreau Gabriel Champs quantiques en espace-temps courbe %100

- **Important scientific results in project (2017-2020)**
  -development of nonperturbative renormalization group methods to compute the effect of gravitationally enhanced quantum fluctuations during inflation study of backreaction of quantum fluctuations on spacetime expansion and of quantum stability of de Sitter spacetime

  -analytical computation of the phase diagram of QCD with modified perturbation theory (massive extension of Landau gauge = Curci-Ferrari model) semi-analytical computation of dynamical breaking of chiral symmetry with the CF model
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(3 max) :**

Perturbative study of the QCD phase diagram for heavy quarks at nonzero chemical potential: Two-loop corrections J. Maelger (Ecole Polytechnique, CPHT & APC, Paris), U. Reinosa (Ecole Polytechnique, CPHT), J. Serreau (APC, Paris). Oct 5, 2017. 26 pp. Published in Phys.Rev. D97 (2018) no.7, 074027

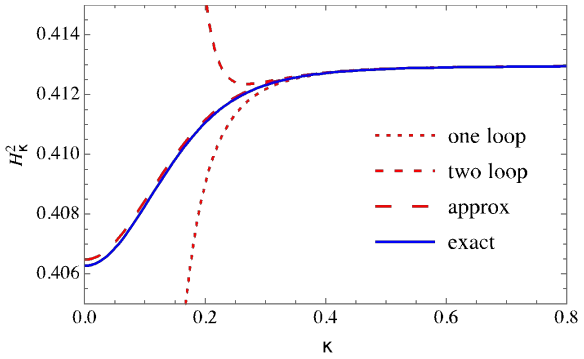
Stability of de Sitter spacetime against infrared quantum scalar field fluctuations G. Moreau, J. Serreau (APC, Paris). Aug 1, 2018. 5 pp. Published in **Phys.Rev.Lett. 122 (2019) no.1, 011302**

Rainbows in the QCD phase diagram J. Maelger (Ecole Polytechnique, CPHT & APC, Paris), U. Reinosa (Ecole Polytechnique, CPHT), J. Serreau (APC, Paris). Mar 11, 2019. 5 pp. e-Print: **arXiv:1903.04184**

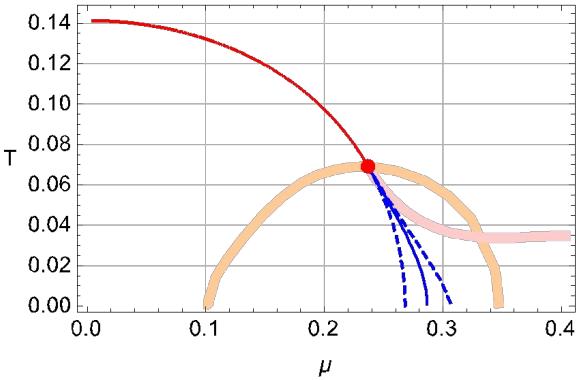
10 papers in journals published+ 1 preprint

J.Serreau, J.Maelger , G.Moreau

Quantum field theory in curved spacetime :
development of nonperturbative renormalization group methods to compute the effect of gravitationally enhanced quantum fluctuations during inflation
study of backreaction of quantum fluctuations on spacetime expansion and of quantum stability of de Sitter spacetime



- Infrared regime of Quantum Chromodynamics
analytical computation of the phase diagram of QCD with modified perturbation theory (massive extension of Landau gauge = Curci-Ferrari model)
semi-analytical computation of dynamical breaking of chiral symmetry with the CF model



the red line is a line of second order (corresponding to chiral symmetry restoration), the dot is a tricritical point and the blue line is a line of first order transition

Projet #4 Modified Gravity and Dark Energy

Scientist responsible for project : D.Langlois

List of researchers in the project:

- **2 permanents+1 accosie [Name, %ETPT in projet, (status)]**
- David Langlois 100% (responsable)
- Karim Noui 50%
- Danièle Steer 30%

- **Important scientific results in project (2017-2020)**

study scalar-tensor theories; development of the most general class of such theories: DHOST (Degenerate Higher-Order Scalar-Tensor) theories obtained in 2015 (Langlois & Noui).
-> cosmological evolution for DHOST models of dark energy : background + perturbations
-> analysis of the perturbations of black holes in some DHOST theories

Observational constraints on modified-gravity theories from gravitational wave propagation, using LIGO-Virgo data (Steer et al, 2020)

- **Important publications (2017-2020)(3 max) :**

Scalar-tensor theories and modified gravity in the wake of GW170817
David Langlois (APC, Paris), Ryo Saito (Yamaguchi U., Grad. School of Sci. Eng.), Daisuke Yamauchi (Kanagawa U.), Karim Noui (APC, Paris & Tours U., CNRS). Nov 20, 2017. 6 pp. Published in **Phys.Rev. D97 (2018) no.6, 061501**

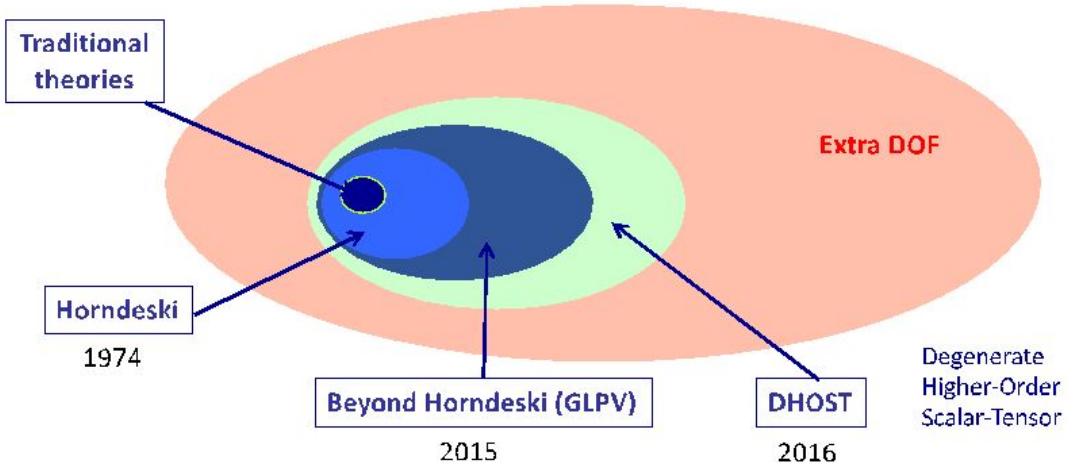
Cosmological evolution in DHOST theories M. Crisostomi (IPhT, Saclay & AIM, Saclay & Orsay, LPT), Kazuya Koyama (Portsmouth U., ICG), D. Langlois (APC, Paris), K. Noui (APC, Paris & Tours U., CNRS), D.A. Steer (APC, Paris). Oct 29, 2018. 17 pp.
Published in **JCAP 1901 (2019) no.01, 030**

Dark energy and modified gravity in degenerate higher-order scalar–tensor (DHOST) theories: A review
David Langlois (APC, Paris). Nov 15, 2018. 38 pp.
Published in **Int.J.Mod.Phys. D28 (2019) no.05, 1942006**

Projet #4 Modified gravity and Dark Energy

D.Langlois, K.Noui, D.Steer

- Traditional scalar-tensor theories: $\mathcal{L}(\nabla_\lambda\phi, \phi)$
- Generalized theories: $\mathcal{L}(\nabla_\mu\nabla_\nu\phi, \nabla_\lambda\phi, \phi)$



study of a new class of theories: DHOST (Degenerate Higher-Order Scalar-Tensor) theories obtained in 2015 (Langlois & Noui). Cf review DL, 1811.06271

Constraints from GW propagation in modified gravity (Steer et al), 2010.04047, 2004.01632

Projet #5 Gravity theory and GW

Scientist responsible for project : N.Deruelle

List of researchers in the project:

- **1 permanents [Name, %ETPT in projet, (status)]**
  - Nathalie Deruelle 100% (responsible)
    Danièle Steer 10%
- **2 post-doctorants [Name, %ETPT in projet, (status)]**

Marcela Cardenas, 100% black hole thermodynamics
Nelson Merino, 100% conserved charges in gravity theories

1 Doctorants: [Name, %ETPT in projet, (status)]

- Félix-Louis Julié, 100%
- **Important scientific results in project (2017-2020)**
- Extension de l' "approche effective à un corps" (EOB) au problème du mouvement aux théories modifiées de la gravitation (avec Félix-Louis Julié et, en partie, avec Marcela Cardenas.
- **Important publications (2017-2020)(3 max):**

Two-body problem in Scalar-Tensor theories as a deformation of General Relativity : an Effective-One-Body approach
Félix-Louis Julié, Nathalie Deruelle (APC, Paris). Mar 15, 2017. 19 pp.
Published in **Phys.Rev. D95 (2017) no.12, 124054**

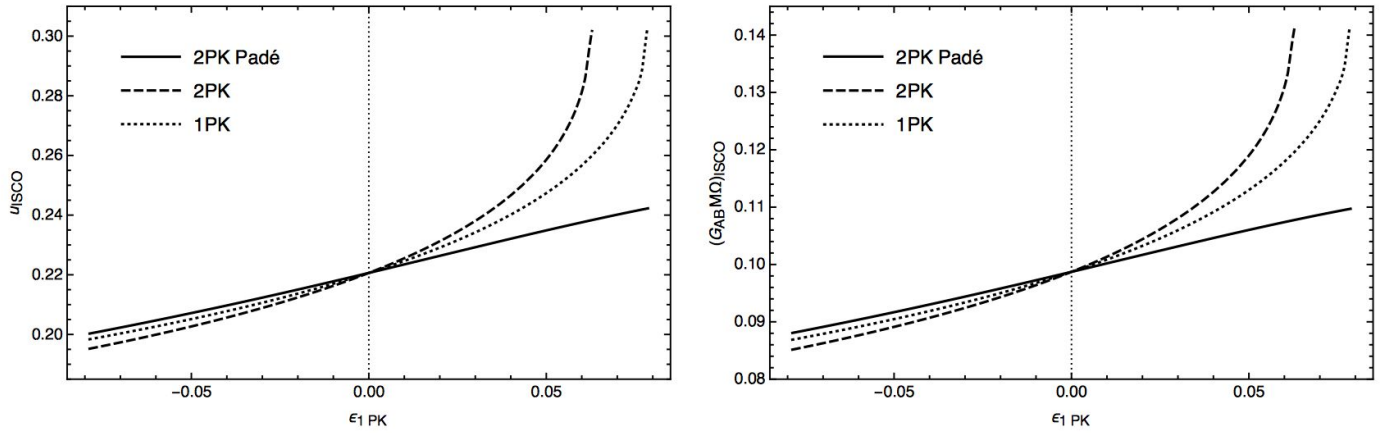
Relativity in Modern Physics
Nathalie Deruelle, Jean-Philippe Uzan. 2018. 704 pp.

5 papers in journals published

Projet #5 Gravity theory and GW

N.Deruelle, N.Merino, M.Cardenas, F.Julie

Figure 1: Scalar-Tensor corrections to the ISCO location in Droste coordinates (left panel) and associated frequency (right panel) versus $\epsilon_{1\mathrm{PK}}$ for $\nu = 0.25$ and for $\epsilon^0_{2\mathrm{PK}} + \nu\,\epsilon^{\nu}_{2\mathrm{PK}} = \epsilon_{1\mathrm{PK}}$. General Relativity is recovered when $\epsilon_{1\mathrm{PK}} = 0$. The first (dotted lines) and second (dashed lines) PK corrections quickly lead to divergences. The overall Padé resummation (solid line) cures them efficiently. The table gathers a few numerical values in the 2PK Padé resummed case ; $x \equiv G_{AB}M\Omega_{ISCO}/(G_{AB}M\Omega_{ISCO})_{GR}$.



From F.Julie et N.Deruelle, **Phys.Rev. D95 (2017) no.12, 124054**

Projet #6 Cosmology and GW

Scientist responsible for project : Ch.Caprini, D.Steer

List of researchers in the project:

- **2 permanents [Name, %ETPT in project, (status)]**
  - Chiara Caprini 80% (co-responsible)
  - Danièle Steer 40% (co-responsible)

- **1 Doctorants: [Name, %ETPT in project, (status)]**
  - Pierre Auclair, 100% GWs from phase transitions and cosmic strings

- **2 post-doctorants**
  - Alberto Roper Pol, 100% GWs from magnetic fields and turbulence
  - Alberto Mangiagli, 100% GWs as standard sirens with LISA

- **Important scientific results in project (2017-2020)**
  - Stochastic GW background and GW bursts from cosmic strings
  - Stochastic GW background in first order PT, compared with the estimated sensitivity curve of the interferometer LISA
  - Stochastic GW background from magnetic fields as the explanation of the NANOGrav signal
  - Tests of cosmology (Hubble constant and modified gravity) with GWs

- **Important publications (2017-2020)(3 max)**
  - **First Measurement of the Hubble Constant from a Dark Standard Siren using the Dark Energy Survey Galaxies and the LIGO/Virgo Binary–Black-hole Merger GW170814** DES and LIGO Scientific and Virgo Collaborations (M. Soares-Santos (Brandeis U.) *et al.*). Jan 6, 2019. 15 pp. Published in **Astrophys.J. 876 (2019) no.1, L7**
  - **Cosmic string loop production functions** Pierre Auclair (APC, Paris), Christophe Ringeval (Louvain U.), Mairi Sakellariadou (King's Coll. London), Daniele Steer (APC, Paris). Mar 15, 2019. 30 pp. e-Print: **arXiv:1903.06685 [astro-ph.CO] | PDF**
  - **Cosmological Backgrounds of Gravitational Waves** Chiara Caprini (APC, Paris), Daniel G. Figueroa (EPFL, Lausanne, LPPC). Jan 12, 2018. 149 pp. Published in **Class.Quant.Grav. 35 (2018) no.16, 163001**

C. Caprini et al., "Detecting gravitational waves from cosmological phase transitions with LISA: an update", [arXiv:1910.13125 [astro-ph.CO]]
C. Caprini et al., "Reconstructing the spectral shape of a stochastic gravitational wave background with LISA", JCAP 1911 (2019) no.11, 017, LISA-CosWG- 19-02 [arXiv:1906.09244 [astro-ph.CO]]

11 papers in journals published + 4 preprints

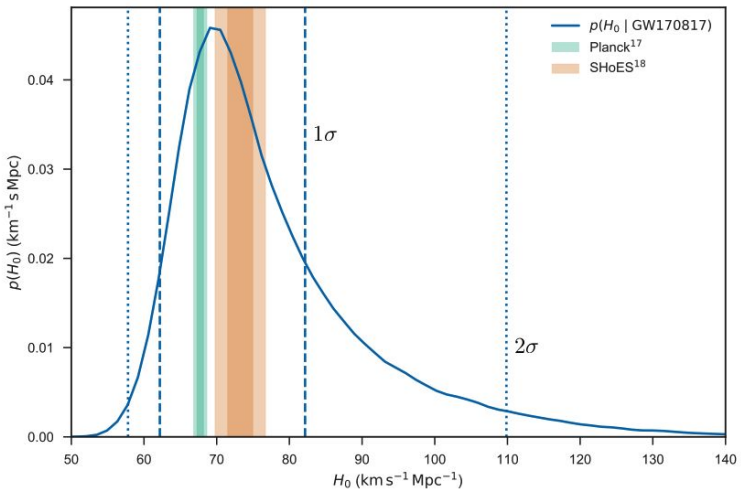
Projet #6 Cosmology and GW

D.Steer

• New member of LIGO-Virgo collaboration —> important efforts in this direction, especially on *cosmology aspect* (standard siren measurements of the Hubble constant, for instance) as well as constraints on *cosmic strings*

Nature 551 (2017) no.7678, 85-88.

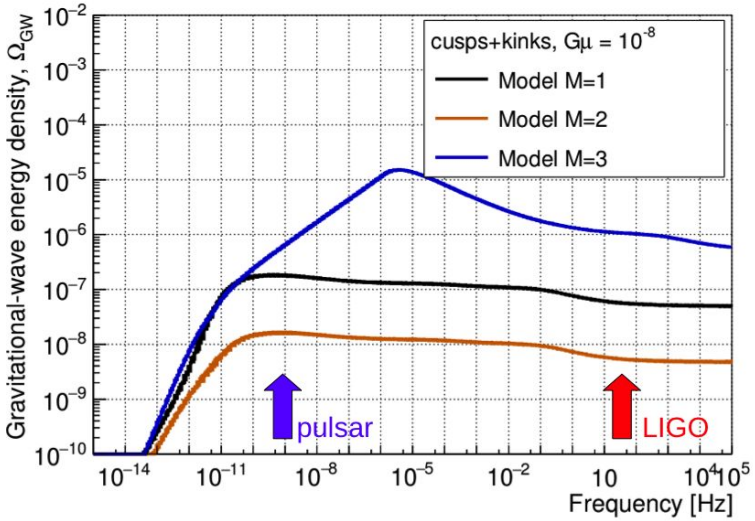
Marginalized posterior density for H_0



$$H_0 = 70.0^{+12.0}_{-8.0}\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$$

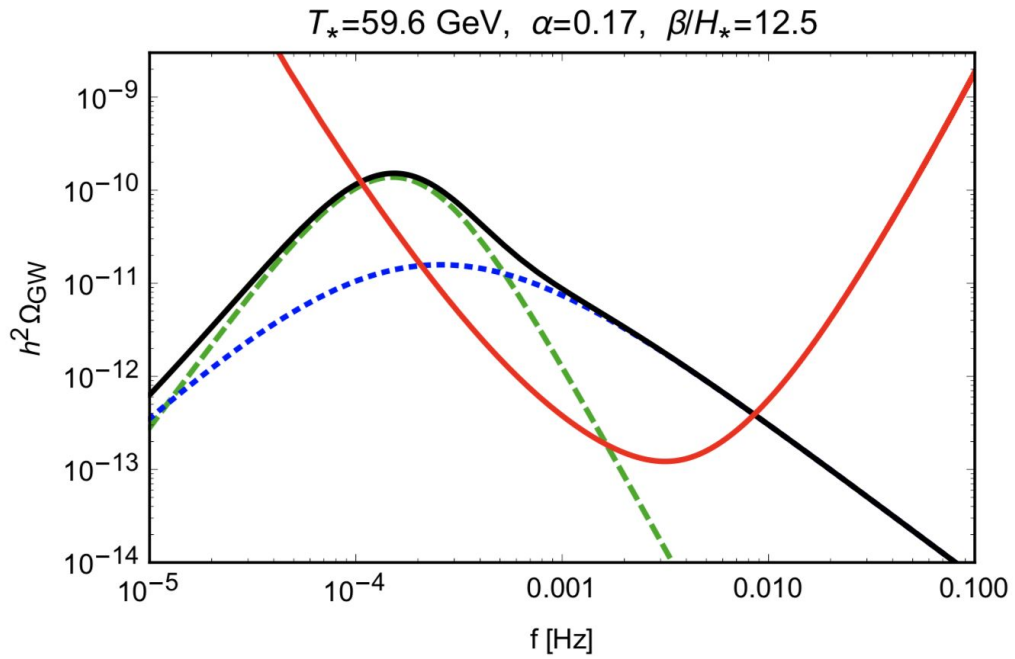
Phys.Rev. D97 (2018) no.10, 102002.

Stochastic GW background from Cosmic Strings



+ 2 theoretical papers on cosmic strings

Ch.Caprini
Gravitational waves can be used to perform cosmological tests:
they can bring us direct information on the status of the universe at very early times
they can be used to test the accelerated expansion of the universe at late times
7 papers on this subject in last 2 years + Primordial MF



SGWB in first order PT, compared with the estimated sensitivity curve of the interferometer LISA from **arXiv:1801.04268**

Projet #7 Inflation models

Scientist responsible for project : V.Vennin

List of researchers in the project:

- **1 permanents [Name, %ETPT in projet, (status)]**
  - Vincent Vennin 100% (responsible)
- **2 Doctorants: [Name, %ETPT in projet, (status)]**

- Christopher Pattison, Quantum back reaction effects in the early Universe, financement STFC (Angleterre), codirection avec David Wands, depuis Sep 2015
- Theodoros Papanikolaou, Primordial Black Holes, ED STEPPUP, financement fondation CFM, codirection avec David Langlois, depuis Septembre 2018

- **Important scientific results in project (2017-2020)**
- Decoherence of cosmological perturbations during inflation
- Observational signatures of the quantum origin of cosmological perturbations
- **Important publications (2017-2020)(3 max) :**

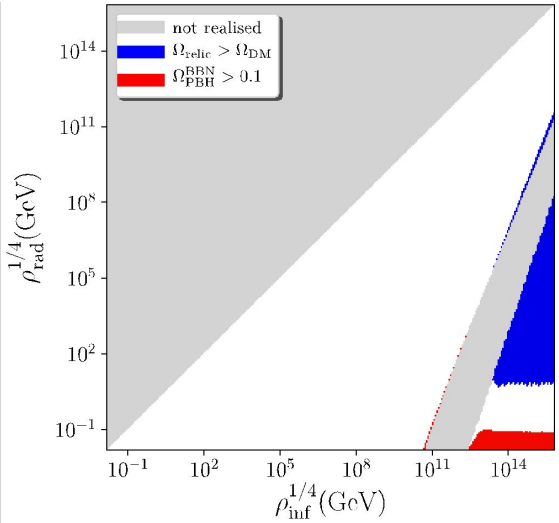
Quantum diffusion during inflation and primordial black holes
Chris Pattison (Portsmouth U., ICG), Vincent Vennin (APC, Paris & Portsmouth U., ICG), Hooshyar Assadullahi (Portsmouth U. & Portsmouth U., ICG), David Wands (Portsmouth U., ICG). Jul 3, 2017. 43 pp.
Published in **JCAP 1710 (2017) no.10, 046**

Observational constraints on quantum decoherence during inflation
Jerome Martin (Paris, Inst. Astrophys.), Vincent Vennin (APC, Paris). Jan 30, 2018. 76 pp.
Published in **JCAP 1805 (2018) 063**

Primordial black holes from the preheating instability
Jérôme Martin (Paris, Inst. Astrophys.), Theodoros Papanikolaou (APC, Paris), Vincent Vennin (Paris, Inst. Astrophys. & APC, Paris)
Published in **JCAP 2001 (2020) no.01, 024**

21 papers in journals published + 1 preprint+ book chapter

- **Inflation**
  - Stochastic Inflation
  - Observational signatures of the quantum origin of cosmological perturbations
  - Dynamical collapse models of the wavefunction in cosmology
  - Quantum decoherence of cosmological perturbations
  - Inflation model building in supergravity
- **PBH**
  - Primordial Black Holes from reheating instabilities with **Th.Papanikolaou**



Energy density of the universe during inflation (horizontal axis) and reheating (vertical axis) leading to too abundant primordial black holes (red) or Planckian relics (blue) from the metric preheating instability. This instability is universal and present in all single-field models of inflation.

Projet #8 Neutrinos et astrophysique des neutrinos

Scientist responsible for the project : M.C.Volpe

List of researchers in the project :

1 permanent [Name, %ETPT in projet, (status)]

-- Maria Cristina Volpe, 100% (responsable)

1 postdocs [Name, %ETPT in projet, (status)]

-- Sajad Abbar, 100% research, CDD IN2P3 (2017-2019). (Postdoc à MPI Münich, 2020--)

2 PhD students : [Name, %ETPT in projet, (status)]

-- Andrea Gallo Rosso, 100% research, "Analys of supernova neutrino fluxes and neutron star properties", C.Volpe/ F. Vissani, GSSI, 2016-2019 (financement GSSI). (Postdoc à Laurentian University (2019-2021) et Stockholm University(2021--).)

-- Amelie Chatelain (2016-2018), 100% research, "Neutrino flavour conversion in dense environments : beyond the standard frameworks", Paris 7 U. Bourse ENS. (CDI, chercheuse, Start-up Light On.)

-- Andrew Santos, Fulbright fellow et Polytechnique (LLR), "The diffuse supernova neutrino background", M1 stage 2020-21 (6 months)

Important scientific results (2018-2021)

- Approches non-standard de l'évolution des neutrinos dans les milieux astrophysiques, effets sur leurs saveur et sur la nucléosynthèse des éléments lourds (r-process)
- Première mise en évidence de modes "fast" (modes de très courte échelle) dans les simulations multi-dimensionnelles des supernovae à effondrement gravitationnel

Important publications (2018-2021)(3 max):

« Neutrino propagation in binary neutron star mergers in presence of nonstandard interactions », Amélie Chatelain, Maria Cristina Volpe, Phys.Rev. D97 (2018) 2, 023014.

« On Fast Neutrino Flavor Conversion Modes in the Nonlinear Regime », Sajad Abbar, Maria Cristina Volpe, Phys.Lett. B790 (2019) 545.

« Neutrino decoupling including flavor oscillations and primordial nucleosynthesis», Julien Froustey, Cyril Pitrou, Maria Cristina Volpe, JCAP 12 (2020) 015.

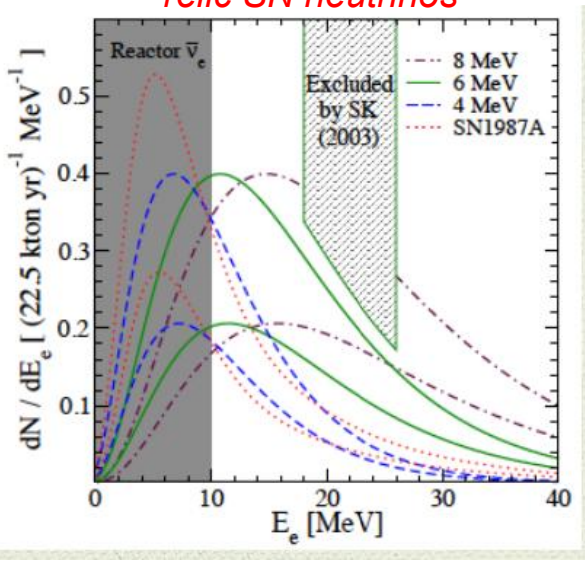
7 published papers in refereed journals, 1 review article in preparation

Projet #8 Neutrinos et astrophysique des neutrinos

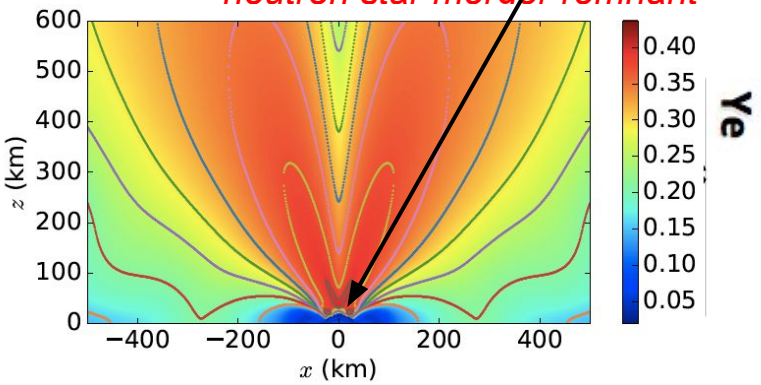
M.C.Volpe, S.Abbar, A.Chatelain, A. Gallo Rosso

- New flavor mechanisms in dense astrophysical environments (binary compact objects remnants, core-collapse supernovae).
- Astrophysical neutrinos tell us about unknown neutrino properties or star properties (location, explosion mechanisms, mass-radius relation,…).
- Understanding flavor evolution important for future core-collapse supernova observations (SNEWS), identifying the sites for the r-process, or for the diffuse supernova neutrino background observation (DSNB) -- Super-K+Gd, Hyper-K, JUNO.

relic SN neutrinos

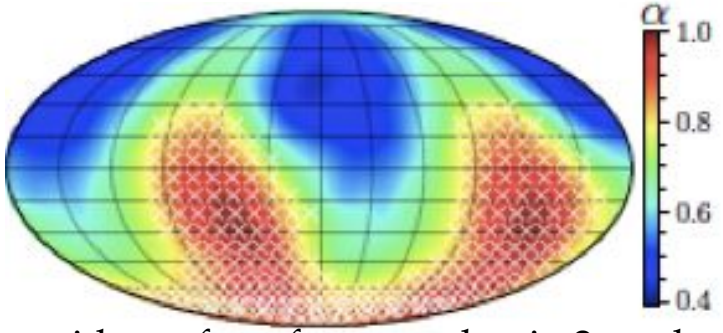


neutron star merger remnant



l-resonance location

core-collapse supernova



Example : non-standard interactions can impact r-process elements abundances

Chatelain and Volpe, PRD97(2018)

First evidence for « fast » modes in 2- and 3-dimensional supernova simulations.

Abbar, Duan, Sumiyoshi, Takiwaki, Volpe, PRD 101 (2020) 4, 043016

Projet #9 Cosmic rays

Scientist responsible for project : D.Semikoz

List of researchers in the project:

- **2 permanents [Name, %ETPT in projet, (status)]**
-
    - Dmitri Semikoz 40% (responsible)
    - Andrei Neronov 15% (co-responsible)
- **1 Doctorants[Name, %ETPT in projet, (status)]**
    - M.Bouvahiaoui, 100% Cosmic ray models

- **Important scientific results in project (2017-2020)**
- New anisotropic cosmic ray diffusion models was developed
- Knee in cosmic rays was explained by anisotropic diffusion model

- **Important publications (2017-2020)(3 max) :**

Reconciling cosmic ray diffusion with Galactic magnetic field models
G. Giacinti (Heidelberg, Max Planck Inst.), M. Kachelriess (Norwegian U. Sci. Tech.), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Oct 23, 2017. 18 pp. Published in **JCAP 1807 (2018) no.07, 051**

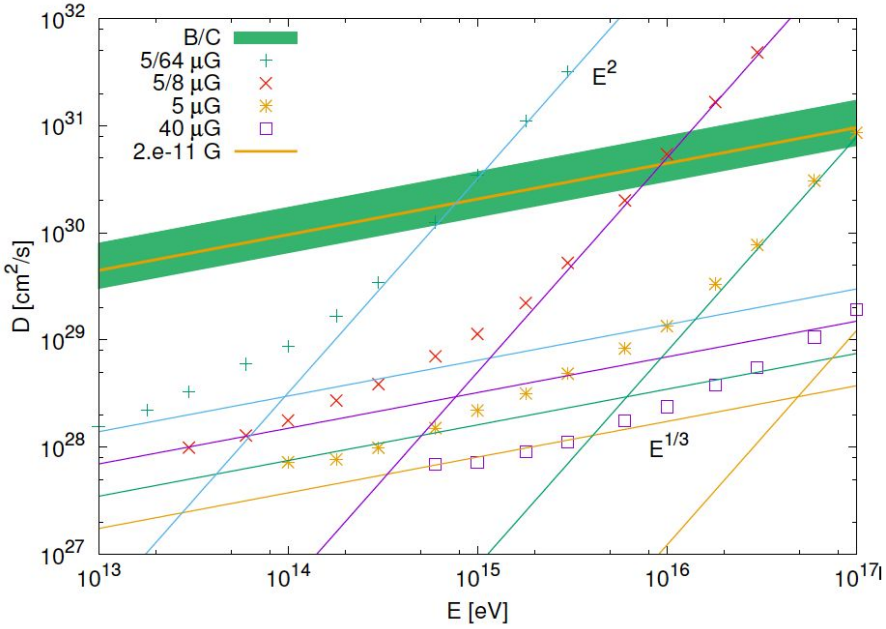
Cosmic ray signatures of a 2–3 Myr old local supernova
M. Kachelriess (Norwegian U. Sci. Tech.), A. Neronov (ISDC, Versoix), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Feb 26, 2018. 10 pp. Published in **Phys.Rev. D97 (2018) no.6, 063011**

Vela as the Source of Galactic Cosmic Rays above 100 TeV
M. Bouyahiaoui (APC, Paris), M. Kachelriess (Norwegian U. Sci. Tech.), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Dec 9, 2018. 11 pp. Published in **JCAP 1901 (2019) 046**

10 papers in journals + review on cosmic ray models

Projet #9 Cosmic rays

D.Semikoz, A.Neronov, M.Bouvahiaoui



Old simplified isotropic galactic diffusion model contradict to many recent observations, including B/C ratio for microGauss magnetic field, change of particle spectra at 200 GeV, change of p/He ratio, positron excess, antiproton-positron ratio, dipole anisotropy of cosmic rays (amplitude and phase), etc.

New anisotropic theory of cosmic ray diffusion, which explain all observations was developed in our group. Recent result: explanation of knee by nearby source Vela.

Projet #10 Multimessenger physics with high energy gamma-rays and neutrinos

Scientist responsible for project : A.Neronov

List of researchers in the project:

- **2 permanents [Name, %ETPT in projet, (status)]**
  - Andrei Neronov 35% (responsible)
  - Dmitri Semikoz 20% (co-responsible)
- **1 Doctorants [Name, %ETPT in projet, (status)]**
  - A.Korochkin, 100% gamma-ray astronomy
  - Y. Gatelet 100% neutrino astronomy

- **Important scientific results in project (2017-2020)**
- New galactic component in diffuse gamma-rays at TeV eneries was discovered in Fermi LAT data. Ths component is consistent with IceCube excess at multi-TeV energies and with HESS excess in electron+positron+diffuse gamma at high energy
- Global analysis of IceCube data was performed with both Galactic and extragalactic source contributions
- New EBL model was constructed, consistensy between optical observations and gamma-ray constraints was tested
- **Important publications (2017-2020)(3 max):**

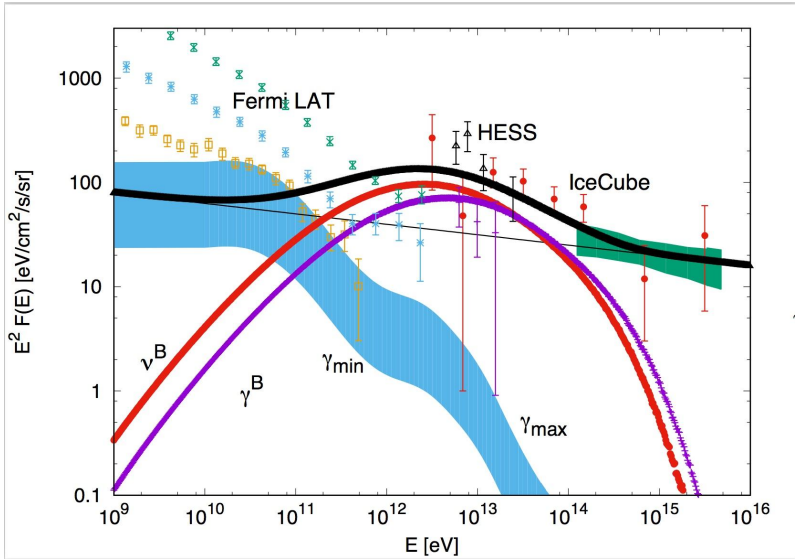
Multimessenger gamma-ray counterpart of the IceCube neutrino signal
A. Neronov (ISDC, Versoix), M. Kachelrieß (Norwegian U. Sci. Tech.), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Feb 27, 2018. 10 pp. Published in **Phys.Rev. D98 (2018) no.2, 023004**

Sensitivity of a proposed space-based Cherenkov astrophysical-neutrino telescope
A. Neronov (ISDC, Versoix), D.V. Semikoz (APC, Paris), L.A. Anchordoqui (Lehman Coll.), J. Adams (U. Alabama, Huntsville), A.V. Olinto (Chicago U., Astron. Astrophys. Ctr.). Jun 11, 2016. 15 pp.
Published in **Phys.Rev. D95 (2017) no.2, 023004**

Self-consistent model of extragalactic neutrino flux from evolving blazar population
A. Neronov (APC, Paris & ISDC, Versoix), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Nov 15, 2018. 16 pp.
e-Print: arXiv:1811.06356

11 papers in journals + 2 preprints + 15 experimental papers FACT,CTA

Projet #10 Multimessenger physics with high energy gamma-rays and neutrinos
A.Neronov, D.Semikoz, A.Korochkin



Discovery of new gamma-ray Component in Fermi LAT complimentary to IceCube neutrinos: origin from heavy DM or Galactic halo CR or Local Bubble CR.

Possible complimentary signature in HESS, will be tested by LHAASO

Indirect DM
New diffused gamma-ray component at TeV was discovered.
Heavy dark matter
Axion-like particles
Sterile neutrinos

Global analysis of astrophsyical neutrino data
Minimal model of UHECR and neutrinos
Source population studies

IACT
New EBL model // A.Korochkin
Application to EBL/intergalactic magnetic fields // CTA
FACT // A.Neronov

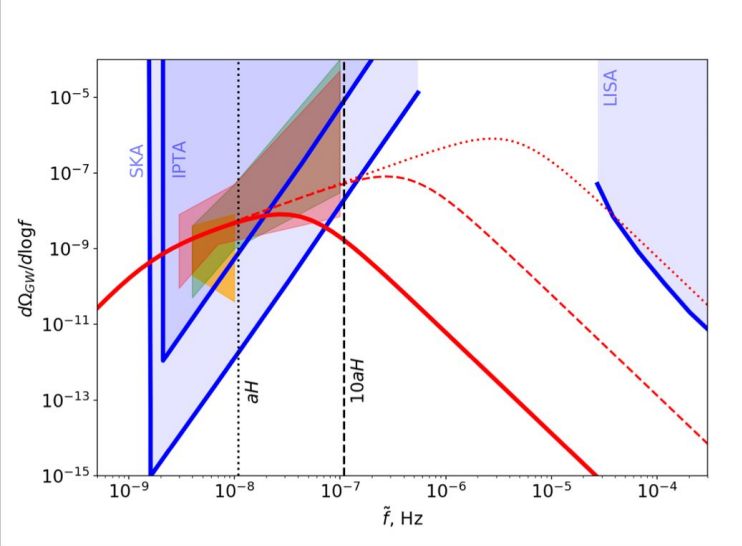
ANR with Russia Multimessenger Universe Avril 2020- March 2023

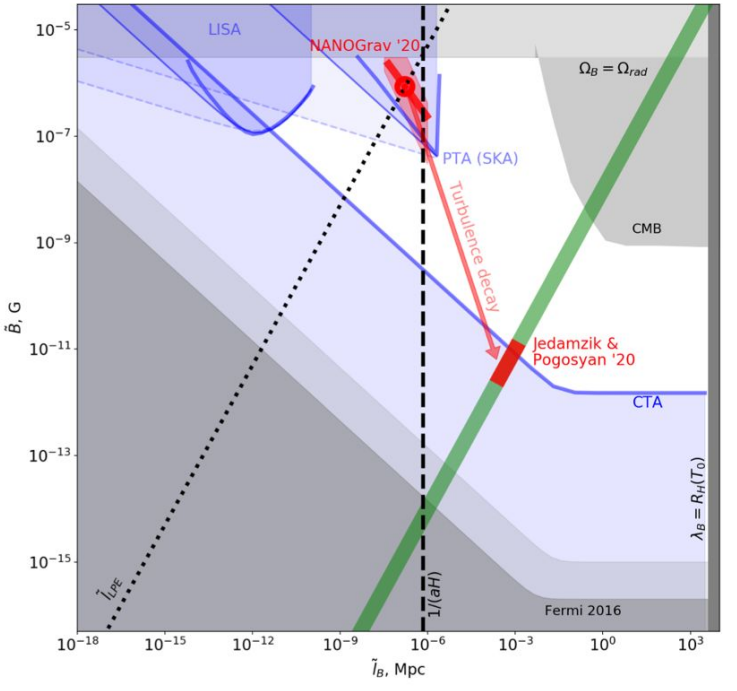
- **3 permanents [Name, %ETPT in project, (status)]**
  - Dmitri Semikoz 40% (responsible)
  - Andrei Neronov 15%
  - Ch.Caprini 20%

- **2 Postdocs[Name, %ETPT in project, (status)]**
  - Alberto Roper Pol, 100% production of GW and magnetic fields in cosmological models of phase transitions
  - Marius Ramsoy 100% 3-dimensional constraint simulations of magnetic field in local Universe

APC and IAP from France, INR, Moscow and Novosibirsk U. from Russia total 16 researchers
APC is the leading team in France

The goal of the project is to explore the possibility of opening new observational windows on the Early Universe (epochs before Big Bang Nucleosyntesis) using cosmological magnetic fields, gravitational waves and primordial black holes, all produced by primordial processes and surviving till the present epoch. We will assess the observational signatures of cosmological magnetic fields in the voids of the large scale structure and determine which information on their origin can be extracted from multi-messenger observational data (radio, gamma-ray, ultra-high-energy cosmic ray). The same type of processes leading to primordial magnetic seeds generates gravitational waves: we will assess their detectability by space-based detectors. We will test different scenarios of primordial black holes production and their observational signatures in multi-messenger astronomy data. Finally we will investigate the information on Early Universe physics that can be extracted from the joint detection of these observables.





Neronov et al 2009.14174
NANOGrav data can be explained as GW from Primordial Magnetic field in QCD epoch. Same PMF can solve H0 problem according to Jedamzik and Pogosyan. If exist, such PMF can be detected by CTA according to calculations of A.Korochkin et al, 2007.14331

Primordial black holes from cosmological inflation

Jan 2020- Dec 2022

V.Vennin

Title: Primordial black holes from cosmological inflation

with Portmsouth U.

Description:

Since the first detection of gravitational waves associated to black-hole mergers by the LIGO collaboration in 2015, the interest in the physics of primordial black holes (PBHs) has kept increasing. They may indeed explain the existence of progenitors for these events, and possibly play a role in the dark matter.

PBHs are expected to form from large density perturbations produced during inflation. We propose to include the back reaction of these inhomogeneities during inflation, with the formalism of stochastic inflation.

Preliminary works have indeed shown that the inclusion of stochastic effects can completely change the range of masses and abundances expected for PBHs. We plan to address realistic models where multi-field effects and deviations from slow roll are expected.

The production of PBHs from instabilities during preheating, and the associated production of gravitational waves, will also be studied in the light of the prospects offered by future missions such as LISA.

Evolution anticipée de l'équipe (3-5 ans)

- **Nouveaux projets en vue (inclus réponse aux appels ANR, Europe, appel d'offre locaux, …)**
- **IN2P3 Postdoc application**
- **M.C.Volpe** Title: *Neutrinos and the discovery of the diffuse supernova neutrino background*
- **E.Kiritsis and F.Nitti** Title: *Description holographique de la matière dense de la QCD avec applications aux étoiles à neutrons*
- **A.Neronov, D.Semikoz and V.Van-Elewyck (AHE)** Title: *Multi-messenger astronomy at PeV energy frontier*
- **ANR:**
- E.Parizot and 5 members of AHE with A.Neronov and D.Semikoz, ANR with Russia 'Neutrino and cosmic ray astronomy (NUCRA)'
- • A.Neronov (PI), D.Semikoz et 2 membres de AHE ANR with Geneva University (Switzerland) 'Probing PeV-EeV cosmic rays and heavy dark matter with Large High-Altitude Air Shower Observatory'
-

Maria Cristina Volpe

Title: *Neutrinos and the discovery of the diffuse supernova neutrino background*

Description:

Two decades of experiments have paved our knowledge of neutrino masses and mixings since the oscillation discovery and brought crucial observations for astrophysics and cosmology.

A new observational window is about to be opened with the much awaited discovery of the diffuse supernova neutrino background (DSNB) by the Super-Kamiokande+Gd experiment, currently taking data, the JUNO experiment under construction, and the approved Hyper-Kamiokande experiment. The DSNB will bring key information on the star formation rate, on failed supernovae and on fundamental neutrino and non-standard properties. Moreover, the kilonova associated with the unique GW170817 event constitutes crucial observation of r-process elements in the ejecta of a binary neutron star merger. The upcoming measurements of new binary neutron star mergers by gravitational wave detectors, and maybe kilonovae, will help solving the longstanding puzzle of where r-process elements are made.

The work will focus both on the the investigation of fundamental physics that we might learn from the upcoming discovery of the diffuse supernova neutrino background and on the understanding of novel flavor mechanisms in dense environments in relation with r-process nucleosynthesis, supernova explosions and future supernova observations.

IN2P3 Postdoc application (2021-2023)

E.Kiritsis and F.Nitti

Title: *Description holographique de la mati ère dense de la QCD avec applications aux étoiles à neutrons*

Description:

La correspondance holographique est une approche qui permet de décrire une théorie de jauge fortement couplée en terme d'une théorie gravitationnelle dans un espace ayant des dimensions supplémentaires. Dans ce contexte, on peut obtenir des informations sur la théorie de jauge par un calcul relativement simple de relativité générale dans le modèle dual gravitationnel.

Le but de ce projet est d'utiliser la correspondance holographique pour modéliser la matière de la QCD à une très haute densité, où d'autres méthodes perturbatifs et nonperturbatifs (comme la QCD sur les réseaux) ne sont pas applicables. Les modèles développés seront connectés aux observations provenant, d' un côté, des expériences de collisions relativistes de ions lourdes et, de l'autre côté, de l'astrophysique.

En particulier, nous allons utiliser les modèles de QCD holographique pour décrire des états à très hautes densité baryonique comme ceux qui on trouve dans les étoiles à neutrons. À partir du modèle dual holographique, nous calculerons l'équation d'état ainsi que les coefficients de transport qui gouvernent les états hors équilibre, ce qui permettra de contraindre le modèle à travers le diagramme de phase masse-rayon et de connecter les résultats aux observations des signaux d'ondes gravitationnelles provenant de la fusion de système binaires d'étoiles à neutrons. Il sera souhaitable que le chercheur recruté ait une expérience dans le contexte de la correspondance holographie, ainsi qu'une bonne connaissance de la QCD. Ce projet permettra d'établir une collaboration entre le groupe théorie et le groupe gravitation de l'APC, et impliquera aussi des experts de l'équation d'état des étoiles à neutrons du LUTH.

A.Neronov, D.Semikoz and V.Van-Elewyck (AHE)

Title: *Multi-messenger astronomy at PeV energy frontier*

Description:

Multi-messenger study of individual astronomical sources of 0.1-10 PeV gamma- rays and neutrinos will shed light on the nature of the knee of the cosmic ray spectrum. A combination of gamma-ray data of HAWC and LHAASO above 100 TeV with CTA below 100 TeV and km3net neutrino data will provide complementary insight via measurements of the variations of the position of the knee across the Galactic Disk.

We propose postdoc project between theory group and neutrino group on “astronomy at the PeV energy frontier”, aimed at the study of Galactic multi-messenger sources, understanding of the origin of Galactic cosmic rays and clarification of the nature of the knee of cosmic ray spectrum. Within this project we plan to model and observe sources of the highest energy multi-PeV Galactic cosmic rays, model and observe diffuse multi- messenger emission generated by interactions of multi-PeV cosmic rays during their propagation through the interstellar medium, model and observe or constrain the signal from decaying super-heavy dark matter particles in the Galactic halo.

ANR PRCI proposal with Russia: Neutrino and cosmic ray astronomy at high energy frontier

5 permamants AHE+ 2 permanents theory [Name, %ETPT in project, (status)]

- Etiene Parizot 30% (responsible)
- Denis Allard 10%
- Creusot Alexandre 10%
- Prevot Guillaume 10%
- Baret Bruny 10%
- Andrii Neronov 20%
- Dmitri Semikoz 10%
-

- **1 engineer [Name, %ETPT in project, (status)]**

APC from France, Moscow State University, Irkutsk University

The main goal of NUCRA project is to enable breakthroughs in the field of multi-messenger astronomy by pursuing three main objectives:
1. Enabling the opening of the field of Ultra-High-Energy Cosmic Ray (UHECR) astronomy with space-based detectors.
2. Exploring the energy dependence of the cosmic ray composition at the Galactic-toextragalactic transition around 100 PeV energy.
3. Enabling the extension of the energy frontier of neutrino astronomy towards the 100 PeV range, using a new detection technique targeting up-going Extensive Air Showers (EAS).
We will achieve these objectives through the development of a novel type of compact wide field-o fview air fluorescence and Cherenkov telescope.

ANR PRCI proposal with Swiss: Probing PeV-EeV cosmic rays and heavy dark matter with Large High-Altitude Air Shower Observatory

- **2 permanents theory + 2 permamants AHE [Name, %ETPT in project, (status)]**
  - Andrei Neronov 30% (responsible)
  - Dmitri Semikoz 10%
  - Stefano Gabici 10%
  - Etiene Parizot 10%

- **1 Postdocs+ 1 PHD[Name, %ETPT in project, (status)]**

APC from France, Geneva University from Swiss

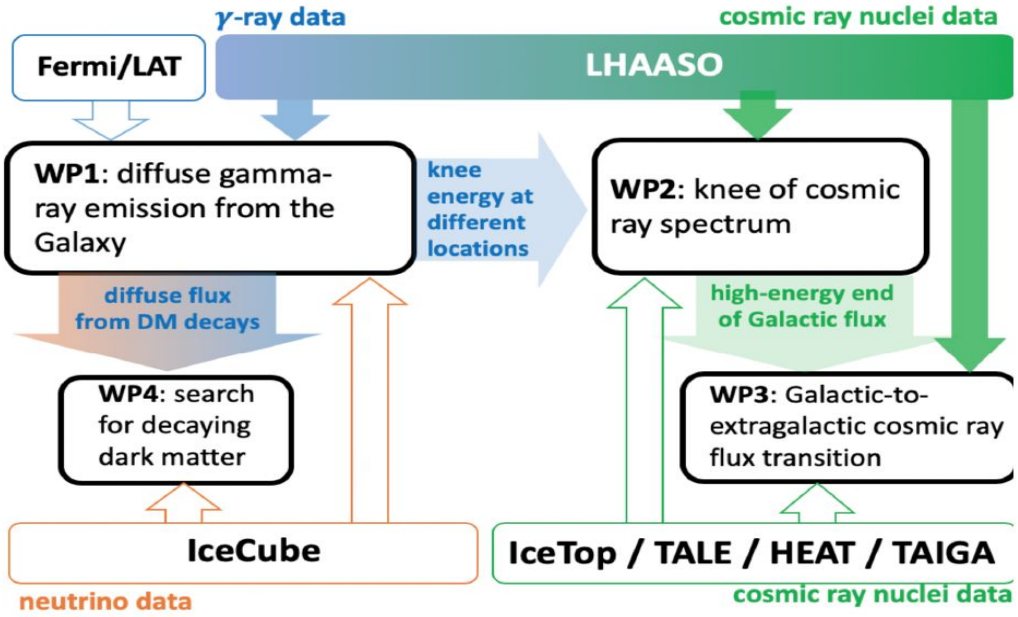


Figure 5. Project organization. Blue-, green- and orange-colored boxes show gamma-rays, CRs and neutrino data.

Evolution anticipée de l'équipe (3-5 ans)

- **Attente vis-à-vis de l'IN2P3:**
- **Possible participation of APC team in LHAASO data analysis**

BACKUP

Activity and plans of Scientific-Educational complex of Virtual Institute of Astroparticle physics (VIA)

VIA transmissions of talks at 38 APC Colloquiums; Online seminars of APC Theory group; 101 VIA online lectures; Distant presentations of 42 speakers at 15 Conferences; Online XXII and XXIII Bled Worshops"What comes beyond the Standard models?" (2019,2020) Satellite Workshop "A.D.Sakharov's legacy in Cosmoparticle physics" dedicated to 100th Anniversary of A.D. Sakharov (2021) on VIA platform. Open Online Course "Cosmoparticle physics" by M.Khlopov, D.Semikoz, M.Bucher, Fully distant Open Online Exams

VIA future plans include: transmissions of APC colloquiums and important seminar talks, support of presentations at distance at Conferences and Workshops, regular weekly VIA lectures from all other the world; Open Online Courses involving student's work on thesis on Forum with successive Open Online Exam with distant evaluation, …