

# Theory group

## APC

# Composition de l'Equipe Theorie APC

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1. Responsable scientifique de l'équipe Dmitri Semikoz, adjoint Eric Huguet

2. Budget Annuel Soutien Equipe (hors budget projets): 38 000

3. Liste des chercheurs de l'équipe:

• **13+3 permanents** [Prénom, Nom, Qualité (Emérite, PR, DR, MCF, CR, IR-Chercheur), (HDR)]

• CNRS

Caprini Chiara CR / **HDR**

Kiritsis Elias DR

Langlois David DR

Semikoz Dmitri DR

Vennin Vincent CR /HDR Avril 2020

Volpe Cristina DR

University Paris 7

Huguet Eric MCF/ **HDR**

Mourad Jihad PR

Neronov Andrii PR

Nitti Francesco MCF/ **HDR**

Renaud Jacques PR

Serreau Julien MCF/ **HDR**

Steer Danièle PR

Emeritus

Deruelle Nathalie DR

Gazeau Jean-Pierre PR

Lachière-Rey Marc DR

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## Associated

K.Noui (Tour U.) D.Langlois 2-3 jours/semaine

F. Vernizzi (Saclay) D.Langlois 1 day/week

U.Reinosa (Polytechnique) J.Serrou 1 day/week

Julien Grain (IAS) V.Vennin 1 day/week

Brando Bellacini (Saclay)

Christos Charmousis (Orsay)

Blaise Gouteraux (Ecole Polytechnique)

Monica Guica (Saclay)

# Composition de l'Equipe

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- **1 post-doctorants present: [Prénom, Nom, indiquer projet, origine financement, date de début, date de fin]**

Hamada Yuta    ERC Advanced Grant, 9/2019-9/2020

- **Autre post-doctorants 2017-2019: [Prénom, Nom, indiquer projet, origine financement, date de début, date de fin]**

Abbar Sajad                      Neutrino Flavor Conversion in SN    IN2P3                      Oct 2017    Oct 2019

Witkowski Lukas                SM-GRAV                      ERC Advanced            Sept 2016    Sept 2019

Davide Forcella, SM-GRAV, ERC Advanced Grant, 10/2017-1/2019

Andrei Belokogne ,QFT espace temps courbes, Université de Corse, sept. 2017- sept. 2018

Marcela Cardenas, black hole thermodynamics, bourse chilienne, Avril 2017-Avril 2019

Nelson Merino, Conserved charges in gravity theories, bourse chilienne, Mai 2016-Mai 2018

Nicola Tamanini, Gravitational wave standard sirens, Labex P2IO and Eurotalent fellowship, 15/09/2015 - 14/09/2017

- **4 post-doctorants expected fall 2020: [Prénom, Nom, indiquer projet, origine financement, date de début, date de fin]**

- Panagiotis Betzios    ERC Advanced Grant,                      09/2020-09/2021

- Alberto Mangiagli                IN2P3                      10/2020-10/2022

- Alberto Roper Pol                ANR                      10/2020-10/2022

- Marius Ramsay                      ANR                      10/2020-10/2022

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# Composition de l'Equipe

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- **8 Doctorants: [Prénom, Nom, indiquer sujet, origine financement, directeur, codirection, cotutelle, date de début, date de fin]**

Auclair Pierre	Cosmology with Gravitational Waves	EPolytechnique	DanieleSteer/ Chiara Caprini	Oct 2018	Oct 2021
Bouyahiaoui Makarim	Models of multi-messenger sources of cosmic-rays, gamma-rays and neutrinos	Paris7	Dmitri Semikoz	Oct 2018	Oct 2021
Gatelet Yoann	Multimessenger astrophysics with Neutrinos	Paris 7	A.Neronov	Oct 2019	Oct 2022
Jani Kastikainen	Holography	cotutelle Helsinki	F.Nitti	Apr 2020	up to 2022
Korochkin Alexander	Gamma-ray astronomy	Vernadskii cotutelle Russie	Dmitri Semikoz G.Rubtsov	Oct 2018	Oct 2021
Moreau Gabriel	Champs quantiques en espace-temps courbe	Paris 7	Julien Serreau	Oct 2017	Oct 2020
Papanikolaou Theodoros	Constraining the early Universe with Primordial BH	Paris7	Vincent Vennin /D.Langlois	Oct 2018	Oct 2021
ROUSSILLE, Hugo	Modified gravity models	ENS Ulm	D.Langlois	Oct 2019	Oct 2022`

- **Expected/possible Doctorants Sept-Oct 2020: [Prénom, Nom, indiquer sujet, origine financement, directeur, codirection, cotutelle, date de début, date de fin]**

Edwan Préau (PhD Student, Kiritsis)	Sept 2020
Valentin Nourry (Phd Student, Nitti)	Sept 2020
??? (PhD student, Vennin), co-tutelle with Orsay.	Sept 2020

# Activités de l'Equipe

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## • **Coopérations/collaborations principales avec l'extérieur (avec équipes locales, nationales, internationales)**

- 1) Albert Einstein Institute Potsdam
- 2) Aquila University, Italy
- 3) ASU, FOENIX
- 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 Superieure
- 12) Geneva Observatory
- 13) GSSI, Italy
- 19) INR Moscow Russia
- 20) IFFI, Montevideo, Uruguay

# Activités de l'Equipe

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## • **Coopérations/collaborations principales avec l'extérieur (avec équipes locales, nationales, internationales)**

- 19) LPTMC, Sorbonne Université
- 20) Leiden Univ.
- 48) Laurentian University
- 49) Waseda University
- 51) 55) Osaka University
- 61) Stanford University
- 19) Simon Fraser, Vancouver
- 20) Institut d'Astrophysique de Paris
- 21) Institute d'Astrophysique Spatiale
- 22) ICTP Trieste
- 52) INFN Florence
- 53) INFN Milan and Milano University
- 54) IPMU Tokyo
- 32) RIKEN, Japon
- 13) Max Planck Institute fur Physik, Munich
- 17) l'Université Libre de Bruxelles, Belgique
- 19) L2C (Montpellier)
- 20) IPHC (Strasbourg)
- 21) Insistute of Cosmology and Gravitation, University of Portsmouth (Angleterre)
- 22) Perimeter Institute, Canada
- 23) UCL, Louvain La Neuve, Belgique
- 24) Warsaw University, Pologne
- 25) IPM Tehran, Iran
- 26) Trondheim U. Norway
- 27) University of Stavanger (Norway)

# Activités de l'Equipe

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## Coopérations/collaborations principales avec l'extérieur (avec équipes locales, nationales, internationales)

- 42) University of Trieste
- 44) University of Padova
- 45) University of Stavanger
- 46) University of Sussex
- 47) University of Nottingham
- 48) University of Helsinki
  
- 56) University of Heidelberg
- 57) University of Winskonsin
- 58) University of Vienna
- 59) University of Barcelona
- 60) University of Roma II, Tor Vergata
- ) University of Helsinki
- 1) Universte d'Orsay
- 4) University of Utrecht
- 5) University of Vienna
- 6) University of Roma II
- 7) UNiversity of Milano
- 8) University of Crete
- 9) University of Taiwan
- 11) University of McGill
- 16) Yukawa Institute for Theoretical Physics, Kyoto, Japon



# Activités de l'Equipe

## • Enseignement

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- E.Huguet Enseignement U. Paris Diderot: 192 heure/an ;
- J.Mourad Enseignement U. Paris Diderot: 192 heure/an ;
- A.Neronov Enseignement U. Paris Diderot: 192 heure/an ;
- F.Nitti Enseignement U. Paris Diderot: 192 heure/an ;
- J.Serreau Enseignement U. Paris Diderot: 192 heure/an ;
- D.Steer Enseignement U. Paris Diderot: 192 heure/an ; /invited lectures at a Portuguese university [ ``National Encounter of Physics Students" of Portugal, Lisbon, february 2019], cours pour l'ecole doctorale STEP UP (2018)"
- G-P. Gazeau Cours de 3 semaines à Tehran (Institute for Research in Fundamental Sciences) Septembre 2017, Tools for Signal Analysis and Quantum Physics // Cours de 3 semaines à ICTP Kigali, Master 1, Mars 2019, Special relativity for advanced electromagnetism // Cours de 2 semaines à université de Rabat, Juillet 2019, Coherent states in quantum optics
- Ch.Caprini "Gravitational waves", lectures for the Annual Retreat of the University of Mainz, Mainz (Germany), Sep 2017
- E.Kirisiris / 150 hours of university level courses
- M. Lachièze-Rey/ Enseignement au master LOPHIS (Univ Paris Diderot)
- D.Langlois Enseignement dans le M2 physique des hautes énergies à l'Ecole polytechnique
- D.Semikoz Cosmovia Inst. lectures Astroparticle Physics M2 /2016-2019 // Baikal summer school 2018
- V.Vennin 2018 and 2019: Lecturer in the Euclid collaboration summer school  
2020: Cosmology course of the Theoretical Physics master 2 at ENS Paris
- C.Volpe Cours à Ecole Polytechnique (depuis 2019-) et à IAP (2019), cours pour l'ecole doctorale STEP UP (2018).

# Activités de l'Equipe

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- **Participations à la communication 2017-2019**
- 24 talks/ Ch.Caprini
- 12 talks / N.Deruelle
- 17 talks/ G-P Gazeau
- 43 talks / E.Kirisiris
- 50 talks/ /M. Lachièze-Rey
- 25 talks/ D.Langlois
- 12 talks /A.Neronov
- 18 talks/ D.Semikoz
- 15 talks /J.Serreau
- 13 talks /D.Steer
- 29 talks/ V.Vennin
- 14 talks/M.C. Volpe

# Activités de l'Equipe

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## • Participations à la vulgarisation

- 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.Kirisiris 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 Savoir
- 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 méthode scientifique", France Culture  
2020: enseignement dans l'Université Ouverte de Paris Université  
2019: Radio show "La méthode 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 ?

# Activités de l'Equipe

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## Responsabilités hors projets (laboratoire, université, sites, comités, ..)

**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.Kiris** Membre Conseil du laboratoire APC, Before 2019 deputy chair of the European Physical 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 depuis 2015, comité de sélection de l'ED STEP-UP (pour les bourses doctorales)

**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

# Activités de l'Equipe

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- **Organisations d'écoles, de workshops, conférences, .. (2017-2019)**

- **APC**

- COSMO17 200 participants

- "infrared QCD", nov 8-10 2017, 20 participants

- The Universe as a Quantum Lab (September 2018, 75 participants)

- Assemblée Générale* of the GdR in APC October 2018 200 participants

- Galactic Cosmic Rays (December 2018) 70 participants

- S.low.SUGRA meeting (March 2019)

- Paris Primordial Cosmology Meetings (3 meetings per year)

- colloque Jean Marie Souriau, Univ. Paris Diderot, mai 2019

- APC -Perimeter-Brussels conference "Cosmological Frontiers in Fundamental Physics", APC, May 2020, \

- **Autre**

- 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 July 2017, Kolymbari, Crete.

- ``GRAVITY, COSMOLOGY & PHYSICS BEYOND THE STANDARD MODEL", 11-15 June 2018, Paris, France.

- Perimeter-Brussels-APC conference "Cosmological Frontiers in Fundamental Physics", Brussels, 14-16 May 2018, \

# Activités de l'Equipe

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- **Organisations d'écoles, de workshops, conférences, .. (2017-2019)**

- V.Vennin

  - from 201? 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-term workshop at the Institut Henri Poincaré (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), Universidad Autonoma 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", regular conferences 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

# Projet #1 String theory and Holography

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Responsable scientifique de labo du Projet : E.Kiris

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **2 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Elias Kiris 100% (responsable)
  - Francesco Nitti 50% (co-responsable)
- **2 post-doctorants [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Witkowski Lukas 100% research
  - Davide Forcella 100% research
- **2 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
  - Leandro Pimenta 100% research
  - Jewel Ghosh 100% research
- **Résultats scientifiques marquants de l'équipe (2016-2019)**
  - The comprehensive study of holographic RG flows and associated C-theorems
  - Development of a framework for the self-tuning of the cosmological constant, based on the holographic duality
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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 **JHEP 1902 (2019) 055** e-Print: [arXiv:1810.12318 \[hep-th\]](#)

10 papers in journals published + 2 preprints

## Projet #1 String theory and Holography

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

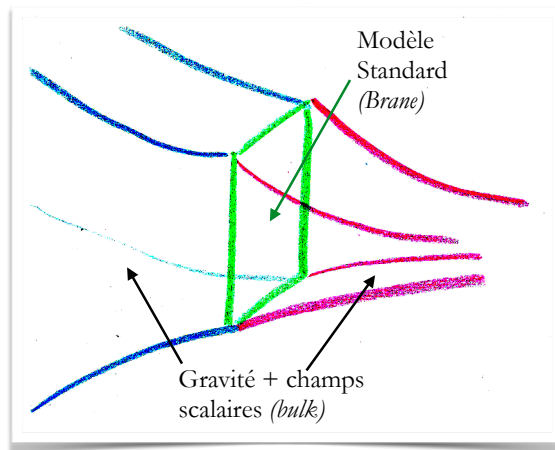
### Holographie, constante cosmologique et gravité modifié

#### 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) interagit 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

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## Liste des chercheurs de l'équipe impliqués dans le projet:

- **4 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

- J-P. Gaseau 100%
- E.Huguet 50%
- M.Lachieze-Rey 100%
- J.Mourad 50%

- **1 post-doctorants [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

- Andrei Belokogne 100% QFT espace temps courbes

- **Résultats scientifiques marquants de l'équipe (2016-2019)**

- Covariant integral quantization of various classical systems.
- Quantum field theory in de Sitter space-time, and cosmological implications
- Study of breaking of Supersymmetry
- Teleparallel Equivalent of General Relativity (TEGR) as a gauge theory of the translation group

- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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, 2018. 11 pp.

Published in **Phys.Rev.** D99 (2019) no.6, 064006

**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

# Projet #3 QFT and QCD

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**Responsable scientifique de labo du Projet : J.Serreau**

## Liste des chercheurs de l'équipe impliqués dans le projet:

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

- Julien Serreau 50% (responsable)

- **2 Doctorants: [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

- **Résultats scientifiques marquants de l'équipe (2016-2019)**

-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](https://arxiv.org/abs/1903.04184)

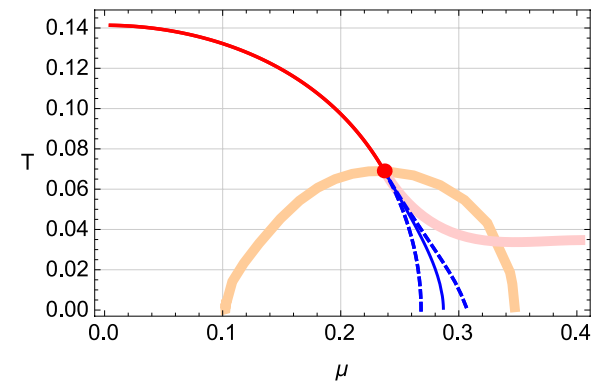
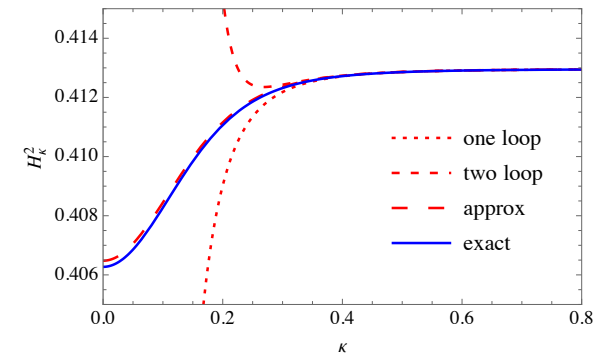
9 papers in journals published

**J.Serreau, J.Maelger , G.Moerau**

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

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**Responsable scientifique de labo du projet : D.Langlois**

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **2 permanents+1 accosie [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

- David Langlois 100% (responsable)
- Karim Noui 50%
- Daniel Steer 10%

- **Résultats scientifiques marquants de l'équipe (2016-2019)**

study of the most general class of scalar-tensor 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

- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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**

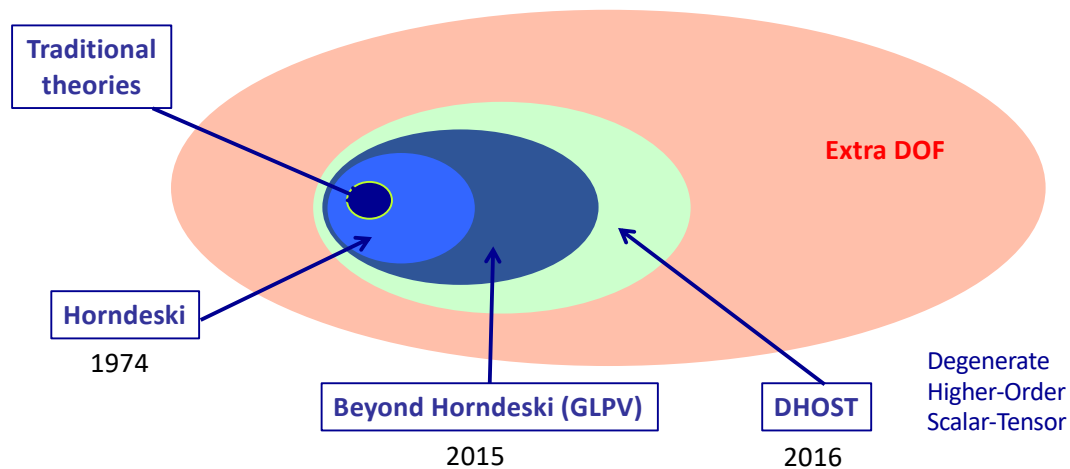
David Langlois (APC, Paris). Nov 15, 2018. 38 pp.

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

# Projet #5 Gravity theory and GW

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**Responsable scientifique de labo du Projet : N.Deruella**

## Liste des chercheurs de l'équipe impliqués dans le projet:

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

- Nathalie Deruelle 100% (responsable)

- **2 post-doctorants [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

Marcela Cardenas, 100% black hole thermodynamics

Nelson Merino, 100% conserved charges in gravity theories

- **1 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**

- Pierre Auclair, 100%

- **Résultats scientifiques marquants de l'équipe (2016-2019)**

- 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.

- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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**

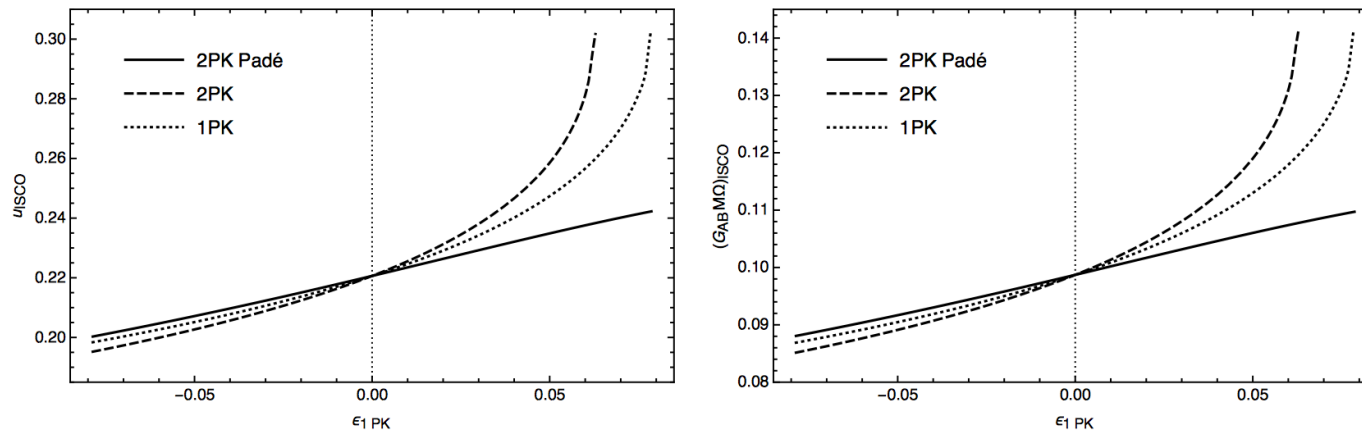
[Nathalie Deruelle, Jean-Philippe Uzan](#). 2018. 704 pp.

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  $\epsilon_{1PK}$  for  $\nu = 0.25$  and for  $\epsilon_{2PK}^0 + \nu \epsilon_{2PK}^\nu = \epsilon_{1PK}$ . General Relativity is recovered when  $\epsilon_{1PK} = 0$ . 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 ;  $x \equiv G_{ABM}\Omega_{ISCO}/(G_{ABM}\Omega_{ISCO})_{GR}$ .



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

# Projet #6 Cosmology and GW

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**Responsable scientifique de labo du Projet : Ch.Caprini/D.Steer**

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **2 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Chiara Caprini 80% (co-responsable)
  - Daniel Steer 40% (co-responsable)
- **1 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
- Pierre Auclair, 100% GWs from phase transitions and cosmic strings.
- **Résultats scientifiques marquants de l'équipe (2016-2019)**
- Stochastic GW background from cosmic strings
- SGWB in first order PT, compared with the estimated sensitivity curve of the interferometer LISA
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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 \[astro-ph.CO\]\]](#)

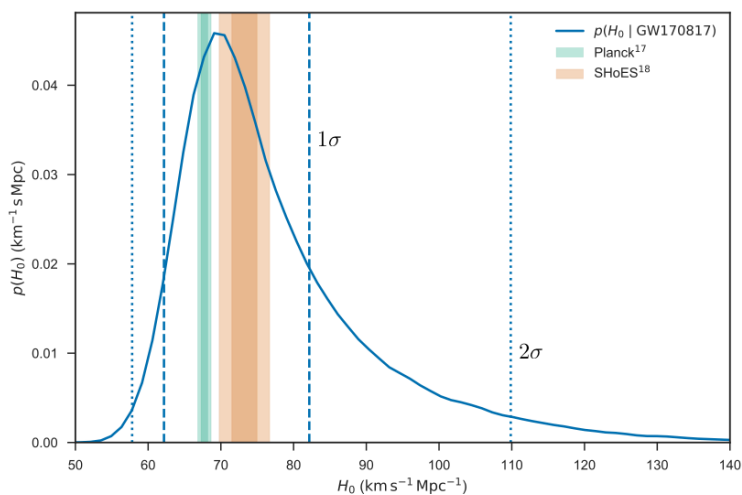


# Projet #6 Cosmology and GW

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*

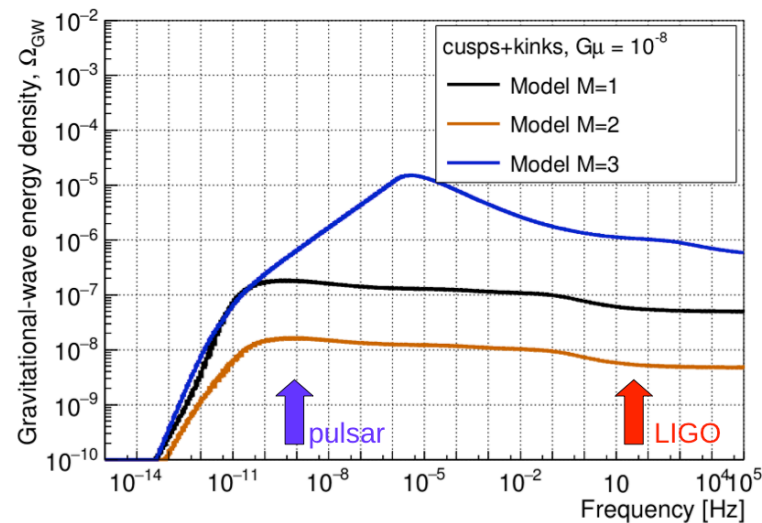
Nature 551 (2017) no.7678, 85-88.  
Marginalized posterior density for  $H_0$



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

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

Stochastic GW background from Cosmic Strings



+ 2 theoretical papers on cosmic strings

## Projet #6 Cosmology and GW

Ch.Caprini

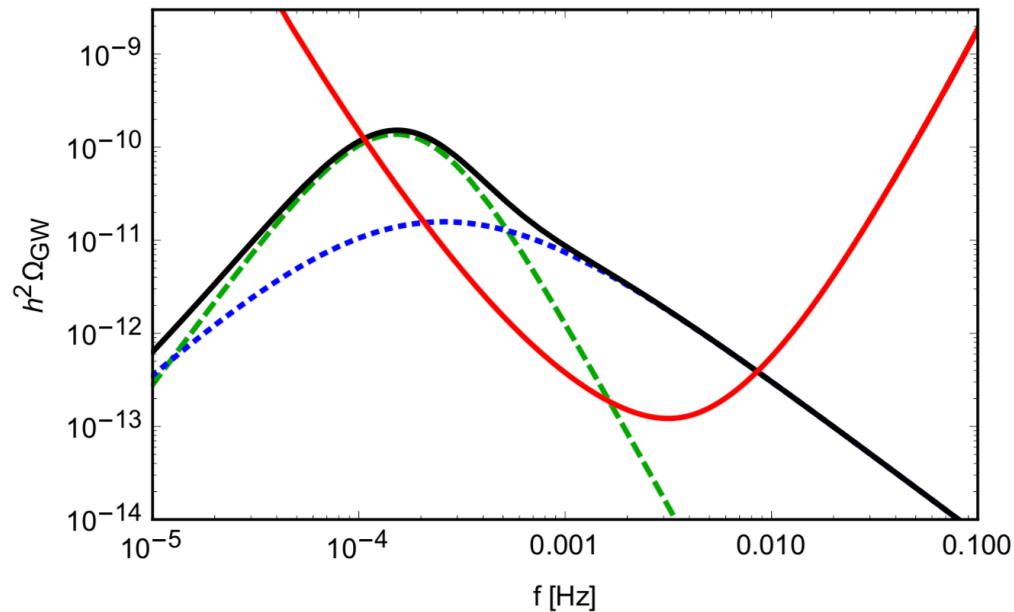
Gravitational waves can be used to perform cosmological tests:

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

5 papers on this subject in last 2 years + Primordial MF

$$T_* = 59.6 \text{ GeV}, \alpha = 0.17, \beta/H_* = 12.5$$



SGWB in first order PT,  
compared with the estimated  
sensitivity curve of the  
interferometer LISA from [arXiv:  
1801.04268](#)

# Projet #7 Inflation models

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**Responsable scientifique de labo du Projet : V.Vennin**

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **1 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Vincent Vennin 100% (responsable)
- **3 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
- Robert Hardwick, 100% Observational Constraints on Inflation, financement STFC (Angleterre), codirection avec David Wands, Sep 2014-Janvier 2019
- 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
- **Résultats scientifiques marquants de l'équipe (2016-2019)**
- Decoherence of cosmological perturbations during inflation
- Observational signatures of the quantum origin of cosmological perturbations
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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**

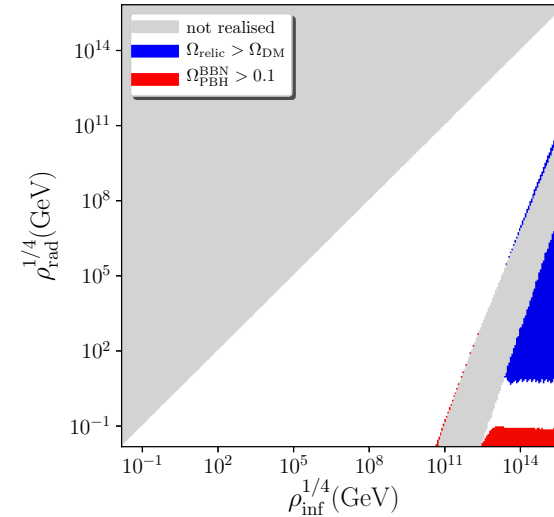
### **Observational constraints on quantum decoherence during inflation**

Jerome Martin (Paris, Inst. Astrophys.), Vincent Vennin (APC, Paris). Jan 30, 2018. 76 pp.

Published in **JCAP 1805 (2018) 063**

18 papers in journals published + 2 preprints

- **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

Responsable scientifique de labo du Projet : M.C.Volpe

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **1 permanent [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

- Maria Cristina Volpe 100% (responsable)

- **1 post-doctorant [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**

- Sajad Abbar 100% research

- **2 doctorants : [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**

- Andrea Gallo Rosso, 100% research "Observational aspects of supernova neutrinos", C.Volpe/ F. Vissani, Aquila U. et GSSI, 2016-2019 (financement GSSI). Postdoc à Laurentian University.
- Amelie Chatelain (2016-2018), 100% research "Neutrino flavour conversion in dense environments beyond the standard frameworks", Université de Paris 7. Bourse ENS.

M1 stage, Vladimir Savu, "Linearized neutrino evolution equations in supernovae and flavour instabilities", février 2017-juin 2017 (5 mois)

- **Résultats scientifiques marquants de l'équipe (2016-2019) :**

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

- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(3 max) :**

«Helicity coherence in binary neutron star mergers and non-linear feedback », Amélie Chatelain, Cristina Volpe, Phys.Rev. D95, (2017) 4, 043005

« 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

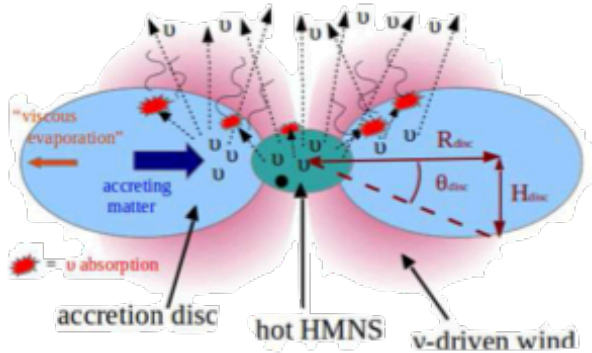
7 published papers in refereed journals, 1 submitted (arXiv), 2 to be submitted

# Projet #8 Neutrinos et Astrophysique des Neutrinos

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



Supernovae

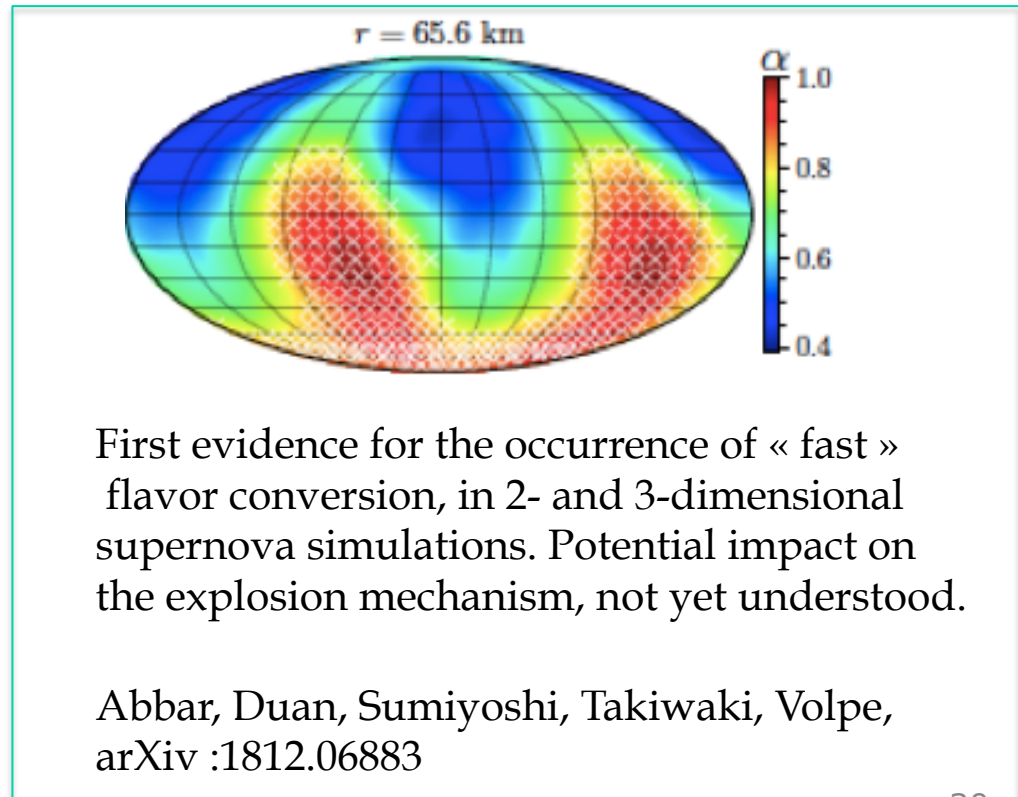
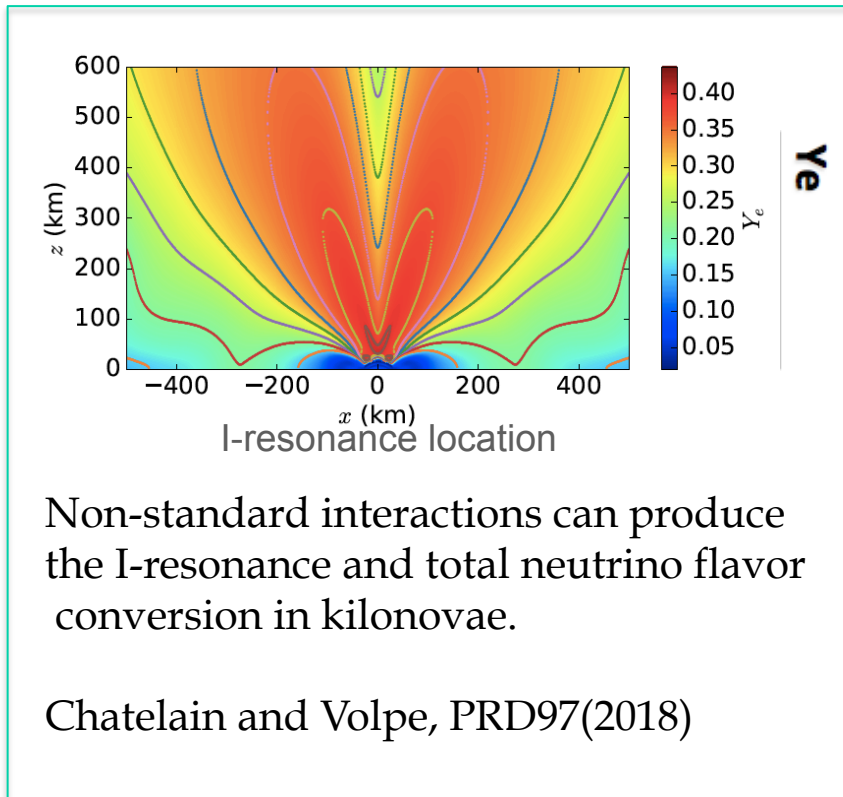


■ Neutrinos modify their flavor while travelling.

In dense environments new flavor mechanisms are being uncovered.

■ Flavor evolution can impact the neutron richness and nucleosynthesis of heavy elements - r-process - in core-collapse supernovae and binary neutron star merger remnants.

neutron star merger remnants



# Projet #9 Cosmic rays

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**Responsable scientifique de labo du Projet : D.Semikoz**

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **2 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Dmitri Semikoz 40% (responsable)
  - Andrei Neronov 15% (co-responsable)
- **1 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
  - M.Bouyahiaoui, 100% Cosmic ray models
- **Résultats scientifiques marquants de l'équipe (2016-2019)**
  - New anisotropic cosmic ray diffusion models was developed
  - Knee in cosmic rays was explained by anisotropic diffusion model
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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**

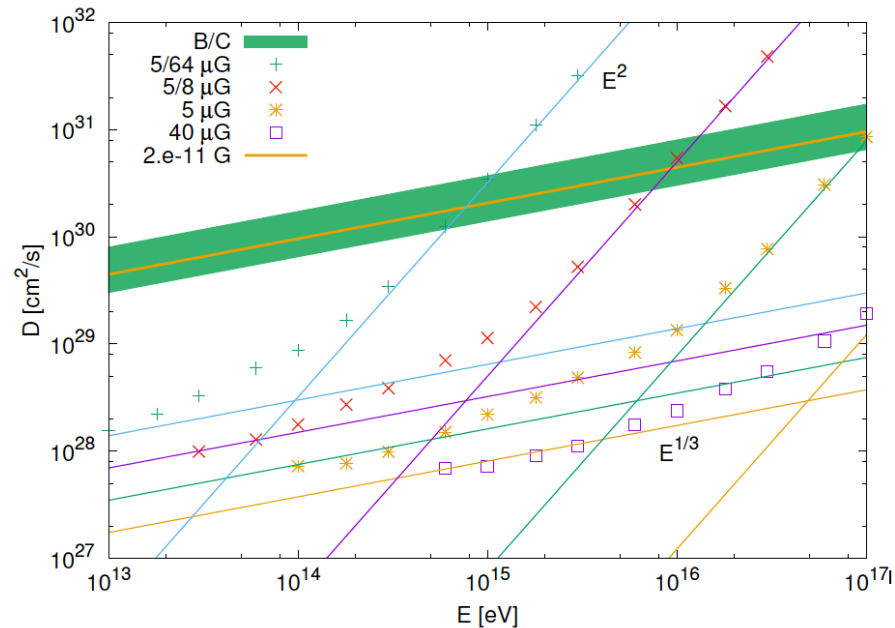
### **Vela as the Source of Galactic Cosmic Rays above 100 TeV**

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**

9 papers in journals + review on cosmic ray models

## Projet #9 Cosmic rays

D.Semikoz, A.Neronov, M.Bouvhiaoui



Old simplified isotropic 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).

New anisotropic theory of cosmic ray diffusion, which explain all observations was developed in our group.



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

**Responsable scientifique de labo du Projet : A.Neronov**

## Liste des chercheurs de l'équipe impliqués dans le projet:

- **2 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Andrei Neronov 35% (responsable)
  - Dmitri Semikoz 30% (co-responsable)
- **1 Doctorants: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
  - A.Korochkin, 100% gamma-ray astronomy
- **Résultats scientifiques marquants de l'équipe (2016-2019)**
  - New galactic component in diffuse gamma-rays at TeV energies was discovered in Fermi LAT data. This component is consistent with IceCube excess at multi-TeV energies
  - Global analysis of IceCube data was performed with both Galactic and extragalactic source contributions
  - New EBL model was constructed, consistency between optical observations and gamma-ray constraints was tested
- **Publications emblématiques de l'équipe dans revues à comité de lecture (2017-2019)(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**

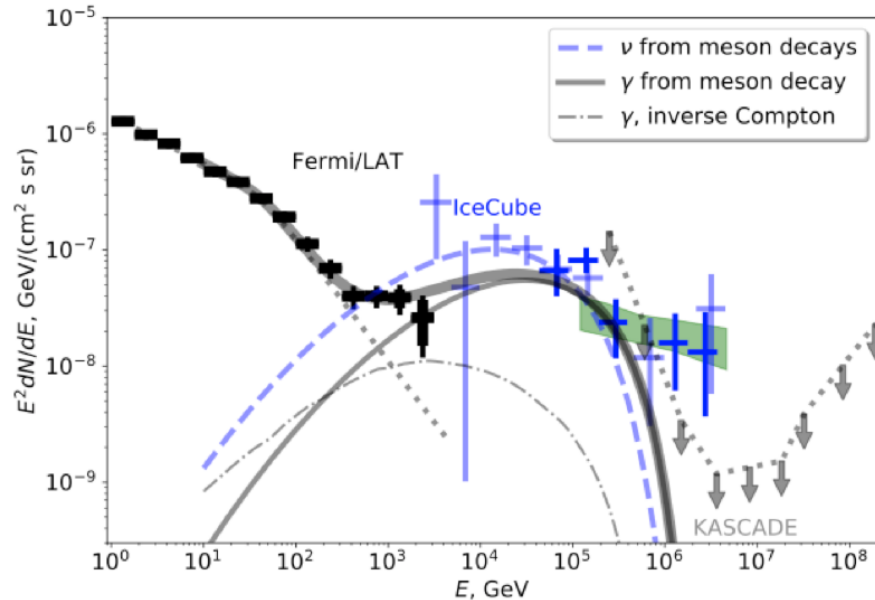
A. Neronov (APC, Paris & ISDC, Versoix), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Nov 15, 2018. 16 pp.

e-Print: [arXiv:1811.06356](https://arxiv.org/abs/1811.06356)

9 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 astrophysical sources

Indirect DM

New diffused gamma-ray component at TeV was discovered.

Heavy dark matter

Axion-like particles

Sterile neutrinos

Global analysis of astrophysical 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

# Production scientifique

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- **Thèses récentes soutenues dans l'équipe (2017-2019) :**

- **Prénom, Nom, Sujet, Directeur de thèse, financement, dates début/fin, position actuelle**
- ...

Chatelain Amélie	Novel neutrino flavour conversion phenomena in media	ENS	Cristina Volpe	Sept 2016 Sept 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
Andrea Gallo Rosso	"Supernova neutrinos and observations »	GSSI	Cristina Volpe + F. Vissani	Sept 2016 Avr 2019

## **New Projet #1** ANR with Russia Multimessenger Universe Avril 2020- March 2023

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- **3 permanents [Prénom, Nom, %ETPT dans le projet, (responsabilité)]**
  - Dmitri Semikoz 40% (responsible)
  - Andrei Neronov 15%
  - Ch.Caprini 20%
- **2 Postdocs: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**
  - Alberto Roper Pol, 100% production of GW and magnetic fields in cosmological models of phase transitions
  - Marius Ramsoy 100% 3-dimentional constraint similations of magnetic field in local Universe

APC and IAP from France, INR, Moscow and Novosibirsk U. from Russia  
APC is 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 Nucleosynthesis) 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.

## **New Projet #2 New IN2P3 project Cosmology with LISA**

Oct 2020- Oct 2022

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- **Chiara Caprini** with Stas Babak and Antoine Petiteau (Gravity),

Title:

Cosmology with LISA

Description:

To work on the potential of LISA to probe cosmology, both on the characterisation and detection of the stochastic gravitational wave background from the early universe, and on forecasting the constraints on the cosmological parameters using LISA standard sirens

POSTDOC: Alberto Mangiagli

# Evolution anticipée de l'Equipe (3-5 ans)

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## • Evolution de la composition de l'équipe (départs/arrivées permanents, docs, post-docs...)

### départs permanents

- **Pierre Binetruy** Prof décédé le 1 avril 2017
- Deruelle Nathalie DR emeritus 2018
- Gazeau Jean-Pierre Prof emeritus 2017
- Lachièze-Rey Marc DR emeritus 2017

### arrivées permanents

Andrei Neronov Prof 2018

Vincent Vennin CR 2017

previous recrutement CNRS 2007

doctorants 2-4 /an

post-docs 2-6