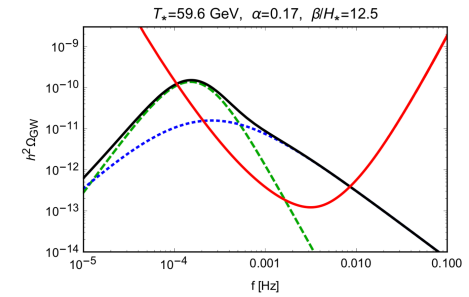
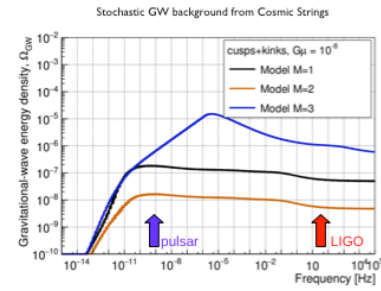
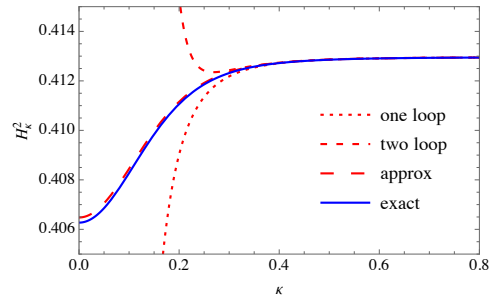
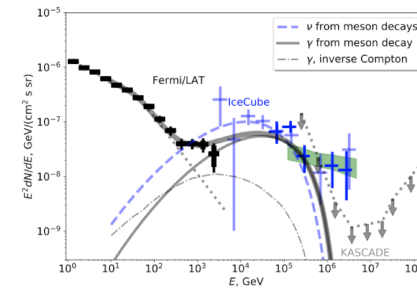
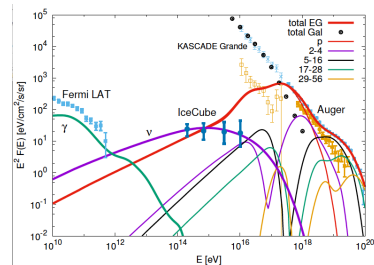
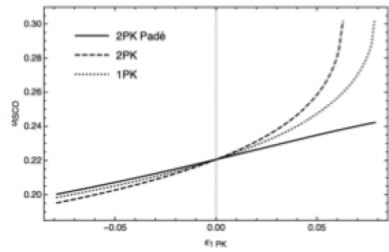


# APC Theory Group



# Dmitri Semikoz



# Theory group list 28 persons

- Abbar Sajad 416A [sajad.abbar@apc.in2p3.fr](mailto:sajad.abbar@apc.in2p3.fr) 01.57.27.69.38 Théorie
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- Caprini Chiara 414 A [caprini@apc.in2p3.fr](mailto:caprini@apc.in2p3.fr) 0157276046 Théorie
- Chatelain Amélie 424 A [amelie.chatelain@apc.in2p3.fr](mailto:amelie.chatelain@apc.in2p3.fr) 0157276920 Théorie
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- Witkowski Lukas 416 A [lukas.witkowski@apc.univ-paris7.fr](mailto:lukas.witkowski@apc.univ-paris7.fr) 0157276049 Théorie

# Theory group list 13+4 permanent

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- Steer Danièle 420 A [steer@apc.univ-paris7.fr](mailto:steer@apc.univ-paris7.fr) 0157276044 Théorie
  
- Up to 09.2019
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- Emeritus
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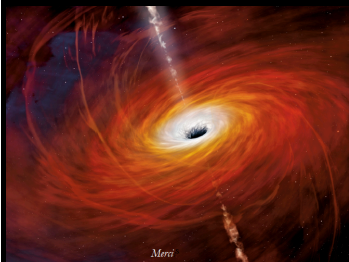
# Theory group 2 postdocs and 9 PhD

- Postdocs
- Abbar Sajad 416A [sajad.abbar@apc.in2p3.fr](mailto:sajad.abbar@apc.in2p3.fr) 01.57.27.69.38 Théorie
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- PhD students
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- Papanikolaou Theodoros 424A [papaniko@apc.in2p3.fr](mailto:papaniko@apc.in2p3.fr) 0157276920 Théorie

In last 2 years 2-6 postdocs and 8-9 PhD

# Scientific life

- Weekly theory seminar Tuesday 14:00 // Responsible K.Noui from Jan 1, 2019 (J.Serreau for last 5 years )
- Journal club every second Friday 12:30 // Responsible: postdocs with N.Deruelle
- APC colloquium Friday, 11:00// V. Vennin coorganize it from theory side
- Every year we organize 2-4 workshops in APC



# Theory group research

- ❑ **Astroparticle physics and neutrino:** A.Neronov, D.Semikoz, C.Volpe, S.Abbar, M.Bouyahiaoui, A. Chatalain, A.Korochkin
- ❑ **Cosmology:** Ch.Caprini, D.Langlois, D.Steer, V.Vennin, K.Noui, A.Neronov, Th. Papanikolaou
- ❑ **Gravity:** Ch.Caprini, N.Deruelle, K.Noui, D.Langlois, J.Mourad, D.Steer, P.Auclair
- ❑ **String Theory and Holography :** E.Kirisiris, F.Nitti, J.K. Ghosh, L.Witkowski
  - Duality, Holography
- ❑ **Quantum Field Theory (QFT) :**E.Huguet, J.Renaud, J.Mourad, J.Serreau, J.Maelger , G.Moerau, M.Lachieze-Rey, J-P. Gaseau

-

# Quantum field theory

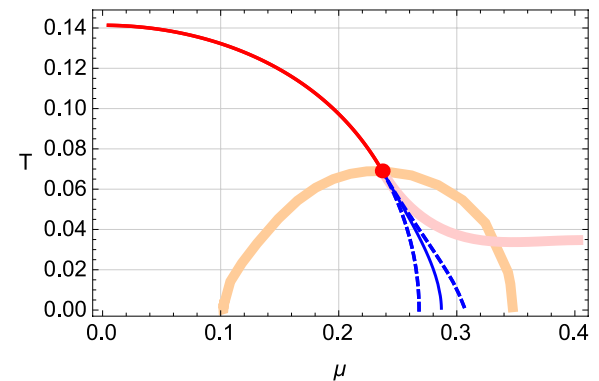
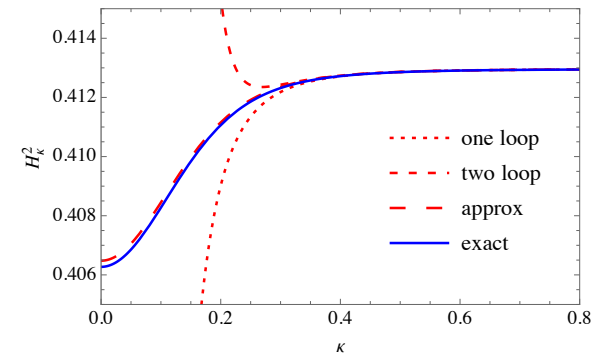
**E.Huguet, J.Renaud, J.Mourad, J.Serreau,  
J.Maelger , G.Moeraud, M.Lachieze-Rey, J-P.  
Gazeau**

- Integral quantization **J-P.Gazeau**
  - Covariant integral quantization of various classical systems.
  - Quantum field theory in de Sitter space-time, and cosmological implications.
  - Integral quantization of cosmological models.
  - Foundations of quantum physics
  - 11 papers in journals
- brane supersymmetry breaking **J.Mourad**
  - Study of breaking of Supersymmetry in the tachyon-free  $USp(32)$   $U(32)$  orientifold models
  - 2 papers in journals
- Teleparallel Equivalent of General Relativity (TEGR) as a gauge theory of the translation group **E.Huguet**
  - 2 papers in journals

# QFT and QCD

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
- 9 papers in journals



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

# String theory and Holography

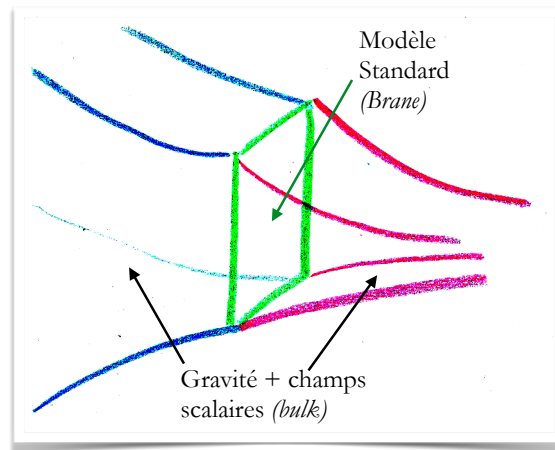
E.Kirisis, F.Nitti, J.K. Ghosh, D.Forcella,  
L.Witkowski

## 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*)

# String theory and Holography

**E.Kirisiris, F.Nitti, J.K. Ghosh, D.Forcella,  
L.Witkowski**

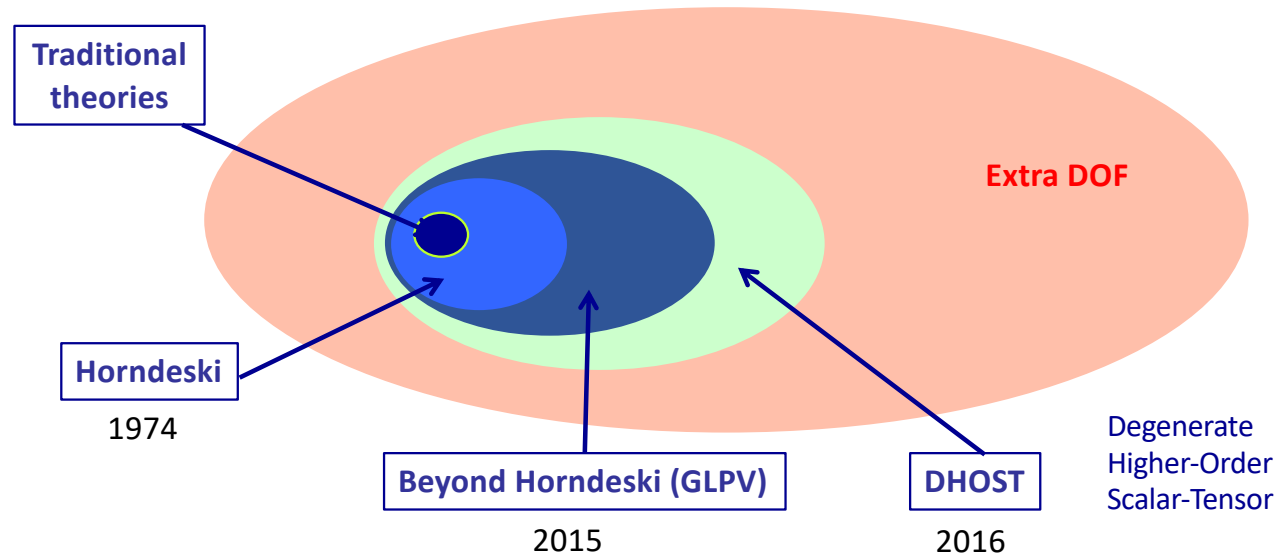
## ERC advanced grant of E.Kirisiris

- Proposed a self-tuning mechanism for the cosmological constant in the context of brane-world/holographic setup. In this context the SM cosmological constant can be dynamically "hidden" as there are solutions where the observed metric is flat although the cosmological constant is non-zero.
- The comprehensive study of holographic RG flows and associated C-theorems
- The holographic emergence of gravity and axions from a hidden theory with a large number of degrees of freedom was studied. It was shown that we can obtain new regions in parameter space in this context.
- possibility of de Sitter/inflating solutions in string-theory/supergravity connected with AdS spaces does not work (no go theorem)
- 10 papers in journals published + 2 preprints

# Modified gravity & Dark Energy

## D.Langlois, K.Noui, D.Steer

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



# Modified Gravity & Dark Energy

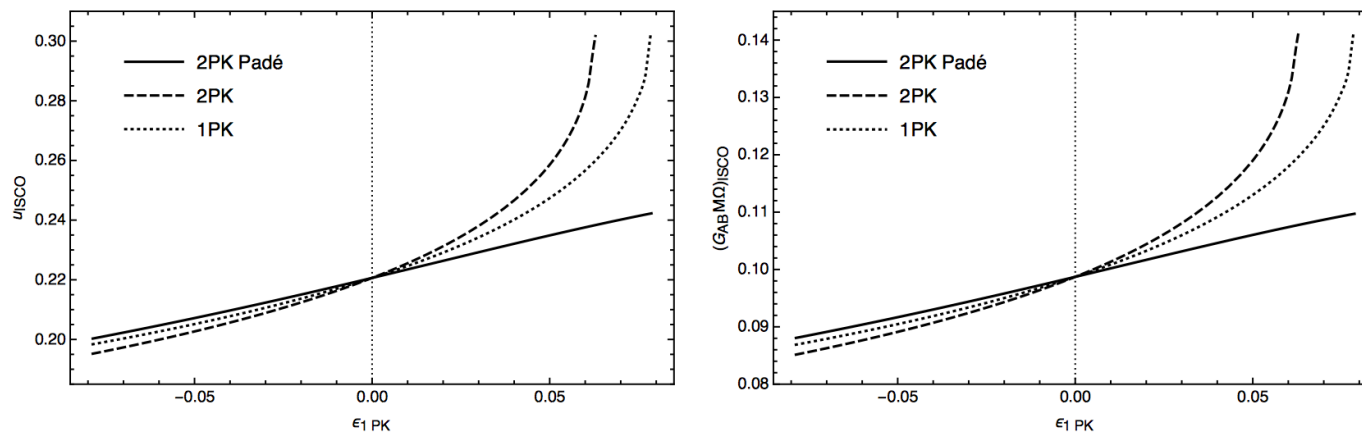
## D.Langlois, K.Noui and D.Steer

- **Largest family of scalar-tensor theories: DHOST**
  - Main motivation: dark energy
  - study of a new class of theories: DHOST (Degenerate Higher-Order Scalar-Tensor) theories obtained in 2015 (Langlois & Noui). Cf review DL, 1811.06271
  - strongly constrained by **GW170817** and  $c_g = c$  [Langlois, Saito, Yamauchi & Noui 18]
  - cosmological evolution: background + perturbations [Crisostomi, Koyama, Langlois, Noui & Steer 18]
- Other extensions: mimetic gravity, U-DHOST, higher-derivative metric theories
- 9 papers published

# 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**

1) Book **Relativity in Modern Physics**

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

2) + 3 papers on Gravity theory

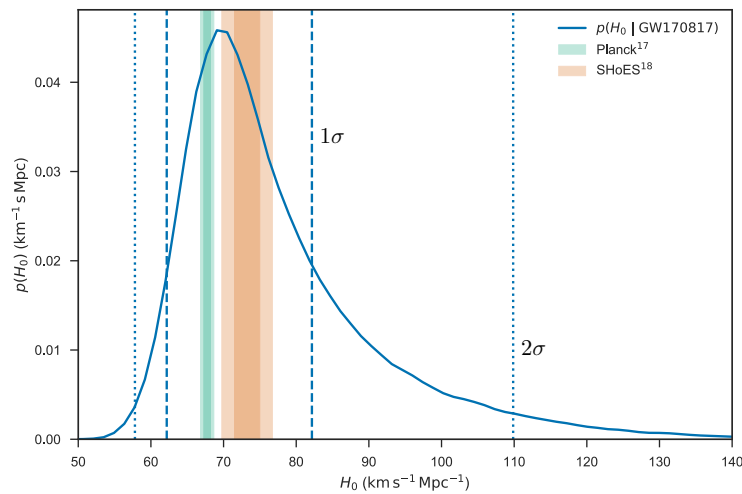
# Cosmology with GW

## D.Steer, P.Auclair

- 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.

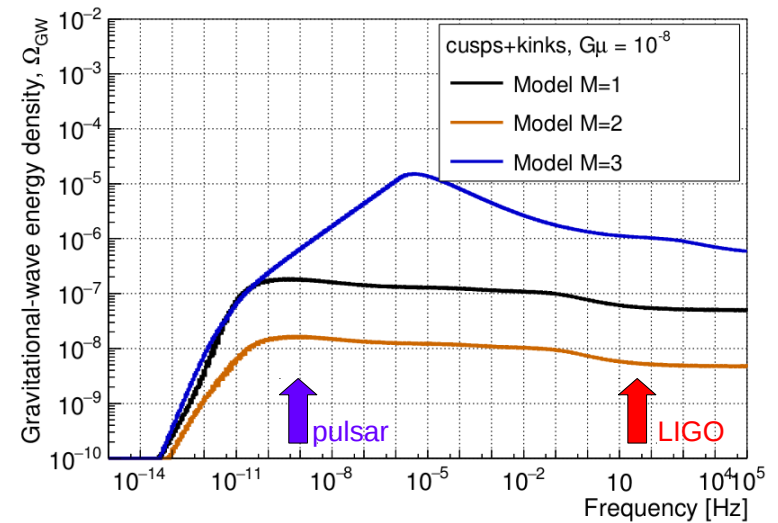
Marginalized posterior density for  $H_0$



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

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

Stochastic GW background from Cosmic Strings

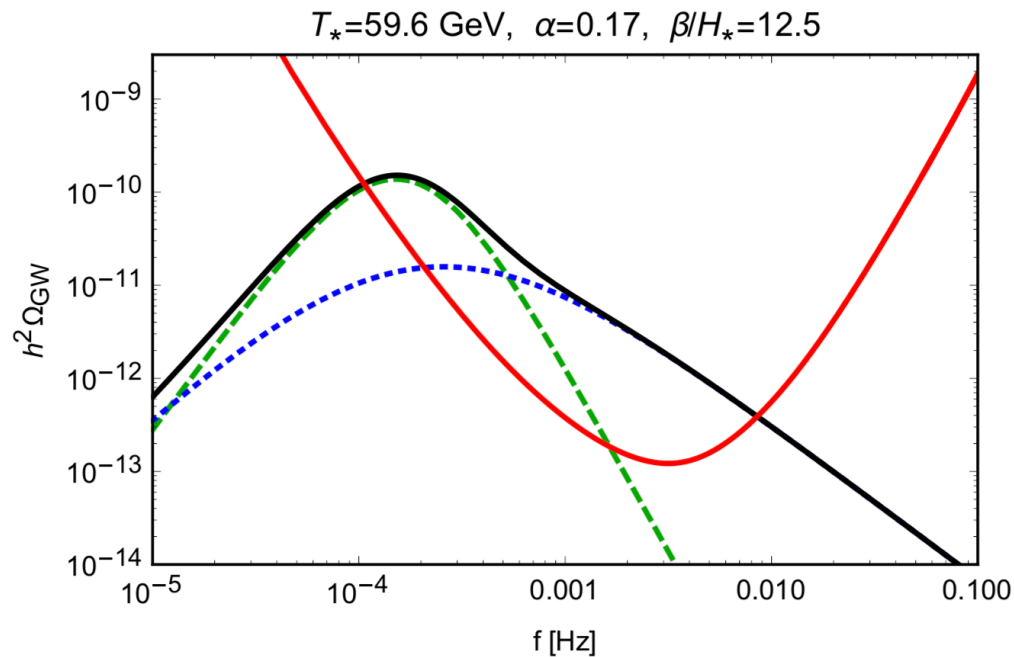


+ 2 theoretical papers on cosmic strings

# Cosmological GW

## C.Caprini

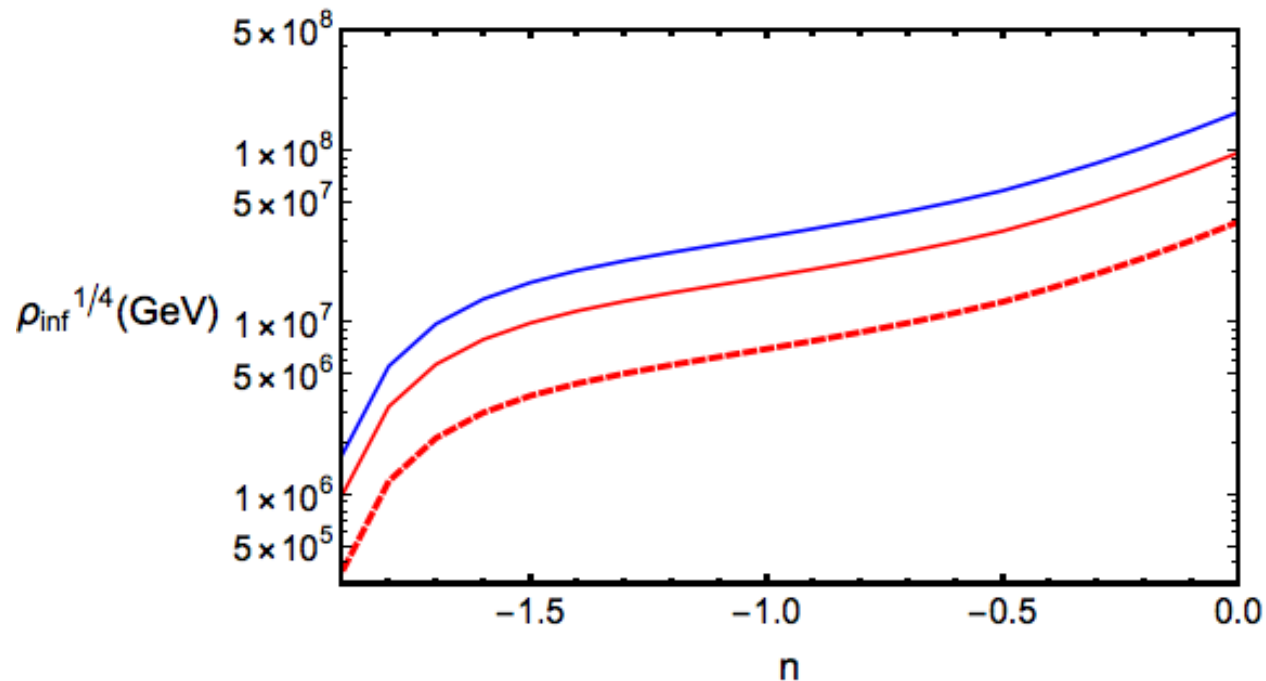
Gravitational waves can be used to perform cosmological tests:  
they can bring us direct information on the status of the universe at very early times  
they can be used to test the accelerated expansion of the universe at late times  
5 papers on this subject in last 2 years



SGWB in first order PT,  
compared with the estimated  
sensitivity curve of the interferometer  
LISA from [arXiv:1801.04268](https://arxiv.org/abs/1801.04268)

# Primordial Magnetic Fields

## C.Caprini



A model that could account for the minimal magnetic field amplitude derived from blazars observations. The MF is generated during inflation, but for the MF amplitude to be high enough the inflationary scale should be low enough. The x axis is the MF spectral index and the curves are for different e-folds of the rolling of the field that is coupled to the gauge field

# Inflation models

## V.Vennin

- **Inflation**

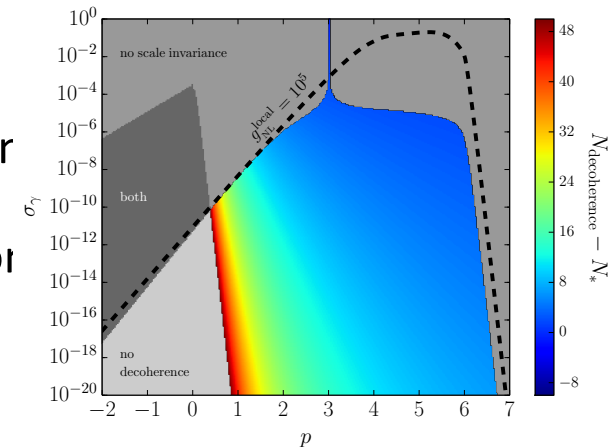
- Stochastic Inflation
- Observational signatures of the quantum origin of cosmological perturbations
- Dynamical collapse models of the wavefunction in cosmology
- Quantum decoherence of cosmological perturbations
- Inflation model building in supergravity

- **PBH**

- Primordial Black Holes from reheating instabilities with **Th.Papanikolaou**

- **14 papers in last 2 years**

- **Plus 10 CORE collaboration papers (Cosmology group)**



From 1805.05609. Decoherence of cosmological perturbations during inflation

$P=3$  standard cosmology case.

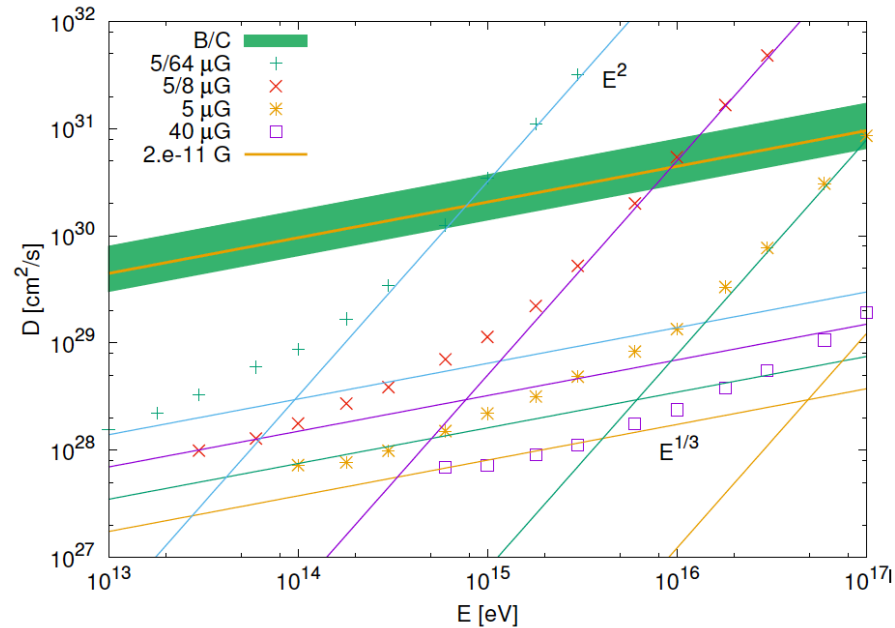
Dashed line non-Gaussianity limit.

$P$ - grows index of interaction with cosmological evolution ,

$\sigma_\gamma$  - interaction strength between cosmological fluctuations and environment

# Cosmic Rays

D.Semikoz, A.Neronov, M.Bouvhahiaoui



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).

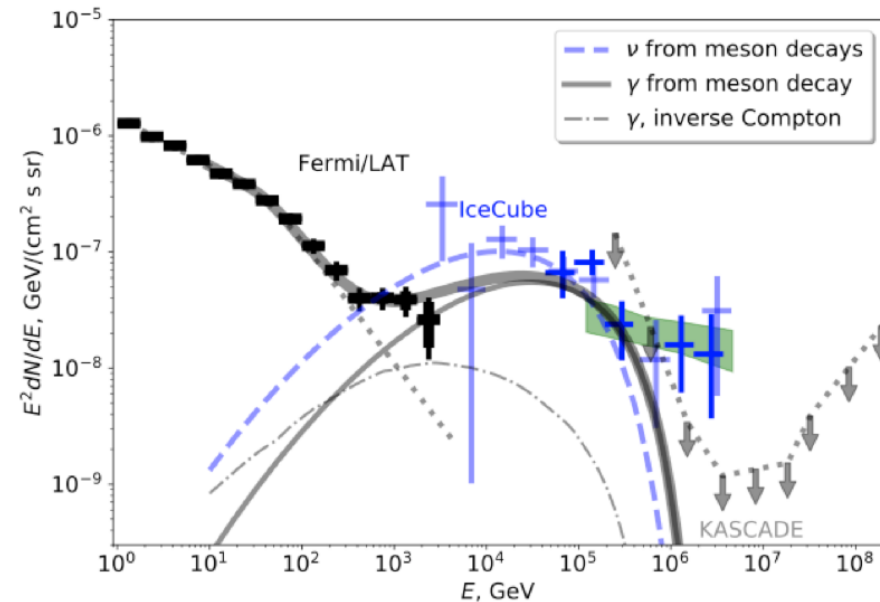
New anisotropic theory of cosmic ray diffusion, which explain all observations was developed.

8 papers + review on 'Cosmic ray models'

New project to use EUSO-team experience to build new fluorescence telescope on ground

# Gamma-rays

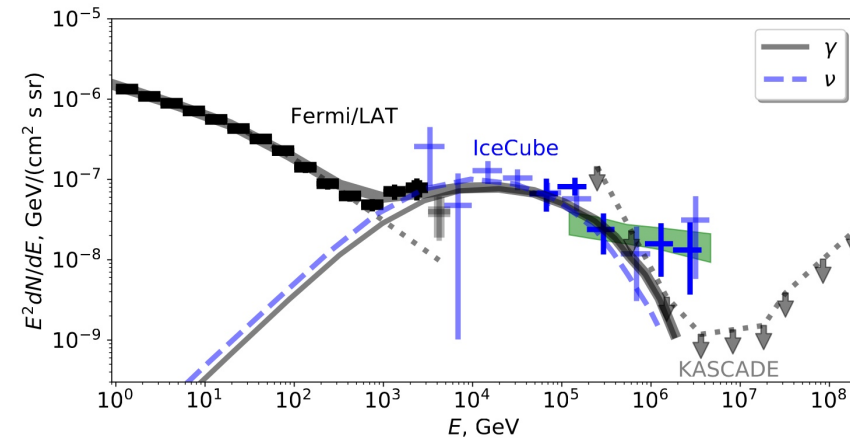
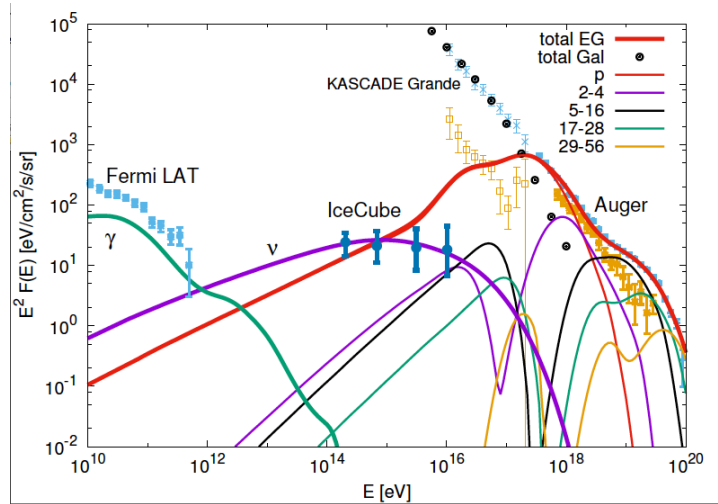
A.Neronov, D.Semikoz, A.Korochkin



- Indirect DM
  - New diffused gamma-ray component at TeV was discovered.
  - Heavy dark matter
  - Axion-like particles
  - Sterile neutrinos
- IACT
  - New EBL model // A.Korochkin
  - Application to EBL/intergalactic magnetic fields // CTA
  - FACT // A.Neronov

# High energy astrophysical neutrinos

A.Neronov, D.Semikoz



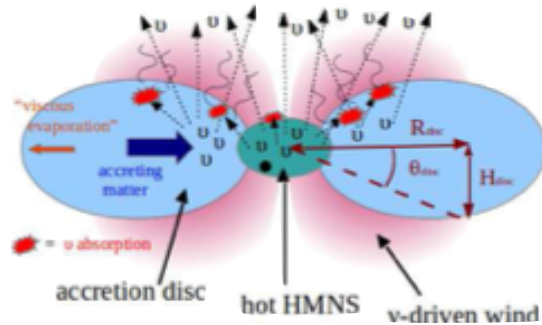
- Global analysis of neutrino data
- Minimal model of UHECR and neutrinos
- Source population studies
- Neutrinos from cosmic rays interacting with Local Bubble
- Neutrino from heavy dark matter
- 5 papers
- In contact with Antares/km3

# Neutrinos from SN

C.Volpe, S.Abbar, A.Chatelain

Neutrino flavor evolution in dense environments

neutron star mergers remnant



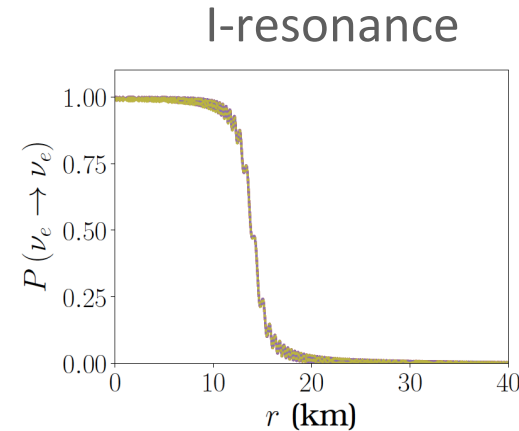
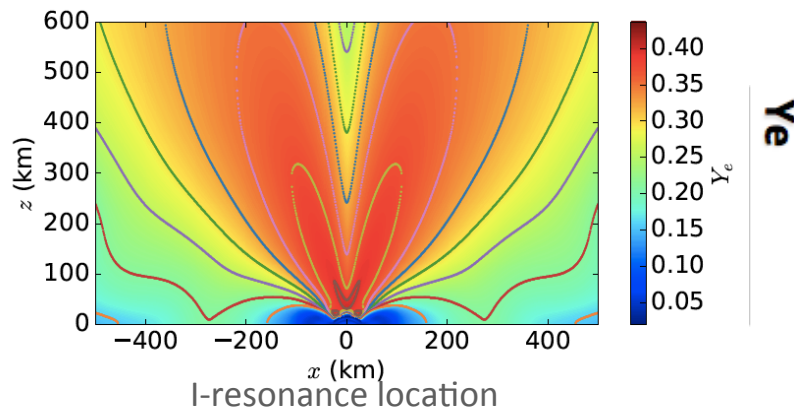
Neutrinos modify their flavor while travelling.

In dense environments new flavor mechanisms are being uncovered.

Neutrinos influence the neutron richness of the material in core-collapse supernovae and binary neutron star merger remnants.

Flavor evolution impacts the electron fraction ( $Y_e$ ) and the nucleosynthesis of heavy elements - r-process.

Non-standard interactions can produce the I resonance and total flavor conversion in kilonovae



Chatelain, Volpe,  
PRD97 (2018)2

Fast neutrino conversion in non-linear regime

SN Neutrino signal

6 papers and 2 proceedings

*GdR “Ondes Gravitationnelles”  
initiated by P.Binetruy*

- Ch.Caprini, Director
- D.Steer and V.Vennin Cosmology group coordinators
- 200 members,
- one yearly meeting, several topical workshops/ meetings per year

# Conferences and workshops organized by theory group

- 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)

# Associated people

- K.Noui (again from 09.19) D.Langlois 2-3 jours/ semaine
- F. Vernizzi (Saclay) 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)

# 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
- Franceosco Vissani (Aquila U.) - one month 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)

# Visitors 1 week-1 month, 1-23

- Kazufumi Takahashi (RESCUE, Tokyo)
- Shinji Mukohyama (Yukawa Institute, Kyoto)
- Michele Oliosi (Yukawa Institute, Kyoto)
- Hayato Motohashi (Yukawa Institute, Kyoto)
- Tomo Takahashi
- Jose Maria Ezquiaga (University of Madrid, May 2019)
- Christopher Pattison (University of Portsmouth, January 2019)
- Juan Garcia Bellido (University of Madrid, December 2018)
- Robert Hardwick (University of Portsmouth, October 2018)
- Hector Ramirez (University of Valencia, October 2018)
  
- Caner Unal (University of Prague, September 2018)
- Suratna Das (IIT Kanpur, September 2018)
- Gabriel Leon (UNLP La Plata, September 2018)
- Tommi Tenkannen (Queen Mary University of London, September 2017)
- Robert Hardwick (University of Portsmouth, September 2017)
- G.Sigl (Hamburg U., March 2019)
- Germano Nardini (University of Stavanger, Norway)
- Inyong Cho (Seoul National University of Science and Technology), June 23-july 6th 2019
- T. Prokopec (ITP, Utrecht): June 2018
- G. Rigopoulos (Newcastle University), May 2018
  
- Carlo Giunti (Torino U. and INFN)
- Gail McLaughlin (North Carolina State University)
- Mike Uwe Frensel (Basel U.)

# Visitors 24-54

- Yago Bea (U. Barcelona) - Dec. 9-11 2018
- Timm Wrase (T.U. Wien) - Dec. 5-7 2018
- Niko Jokela (U. Helsinki) - Sept 24-27 2018
- Umut Gursoy (U. Utrecht) - Sept 18 2018
- Sergei Dubovsky (NYU) 9-12 Jan 2018
- Giuseppe Dibitto (U. Uppsala) 13-15 Dec 2017
- Miguel Montero (U. Utrecht) 7-11 Nov 2017
- Niko Jokela 18-20 Oct 2017
- David Tong (U. Cambridge) May 31 - June 1 2017
- Mike Blake (MIT) May 27 - June 7 2017
  
- Carlos Hoyos (U. Oviedo) 14-17 June 2017
- Thomas Hertog (U. Leuven) 15 June 2017
- Blaise Goutéraux (Nordita) 23-26 Jan 2017
- Erik Verlinde (U. Amsterdam) 1-3 Feb 2017
- Andrei Parnachev (Trinity College, Dublin), June 2019
- David Mateos (U of Barcelona) June 2019
- Dieter Lust (LMU, Munich) June 2019
- Saso Grozdanov (MIT) December 2018
- Razvan Gurau (Durham) January 2018
- Alfonso Ballona (U. of Sao Paolo) Nov 2018
  
- Deog Ki Hong (University of Pusan), Sept 2017
- Petr Horava (UC Berkeley) Jan 2017
- Gary Gibbons (Cambridge U.) May 2017
- Alessandro Strumia (CERN and Pisa) Jan 2017
- Dimitri Skliros (LMU, Munich), Jan 2017
- Giovanni Villadoro (ICTP Trieste), Nov 2017
- Thomas Hertog (KU Leuven) Jun 2017
- E. Akhmedov (ITEP, Moscow), Dec. 2017
- M. Peláez (IFFI, Montevideo, Uruguay), Nov 2017
- N. Wschebor (IFFI, Montevideo, Uruguay), Sep. 2017
- A. Cuchieri (Brésil), June 2017

# Office space

- 414 window does not work
- 402 back to Theory group as soon as possible for associated people, retired members of group and visitors
- In past we had help with PCCP offices for our visitors

# Help of APC administration

- We need administrative help of lab for visitors and workshops
- In 2019 1 workshop was cancelled and some visitors had refinding problems due to lack of administrative support.

# Permanent positions

- Prof. 46.3 promotion MdC theoretical physics  
Univ. Paris 7 // 3 members of group
- CNRS young researcher on thematiques of  
group.

# Conclusions

- Theory group perform excellent research in all scientific directions, in which other APC groups are working plus do other fundamental physics research.
- We have significant interaction and collaboration with other groups of APC
- We need help from lab with:
  - Prof. Positions for MdC
  - Administrative support of visitors and conferences/workshops
  - office space