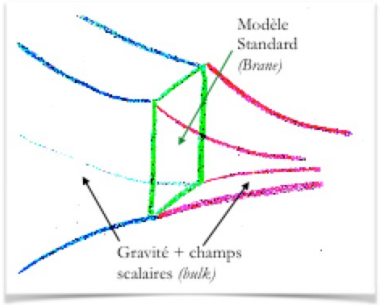
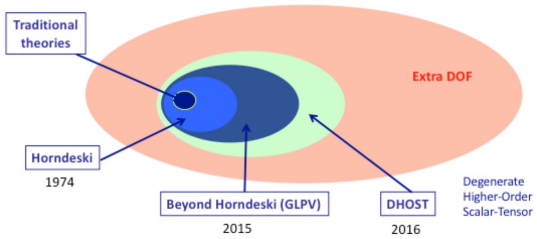
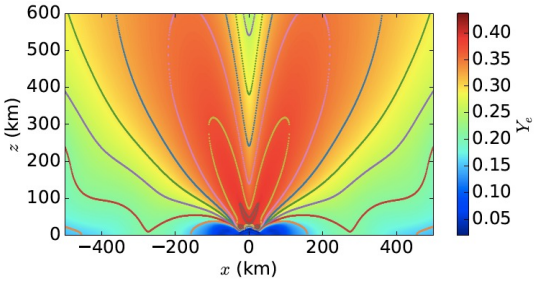
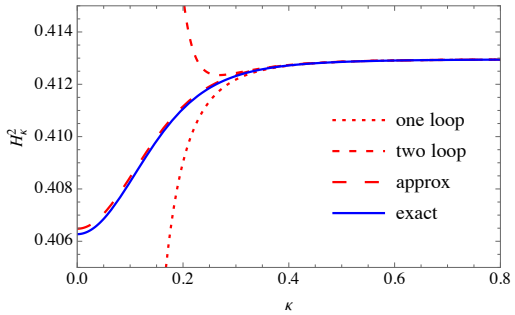
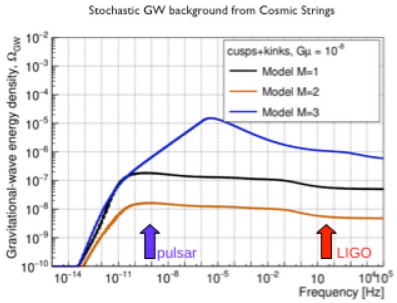


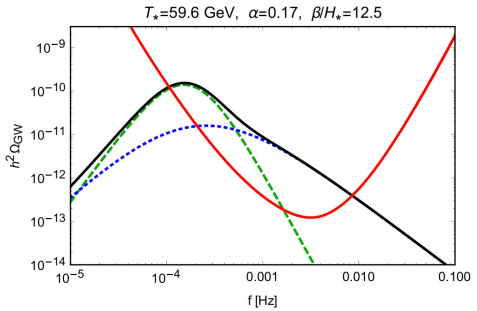




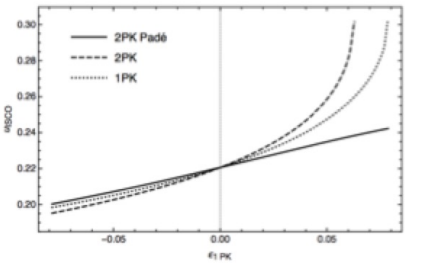
APC Theory Group

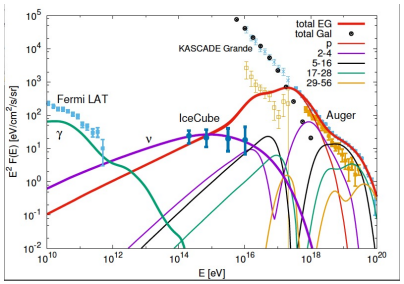


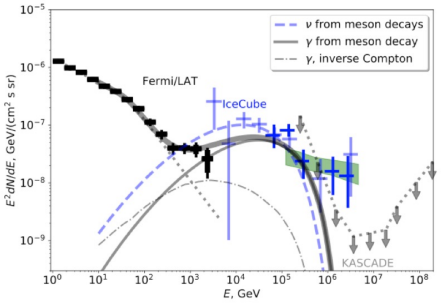




Dmitri Semikoz







Composition de l'équipe de recherche

- Responsable scientifique de l'équipe :
- Head of group Dmitri Semikoz, vice-head Eric Huguet

Liste des chercheurs de l'équipe :

- **11+4 permanents [Name, Status (Emeritus, PR, DR, MCF, CR, IR-Chercheur), (HDR)**
- **CNRS**
- 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
- Serreau Julien MCF/ ***HDR***
- Steer Danièle PR

- **Emeritus**
- Deruelle Nathalie DR
- Gazeau Jean-Piere PR
- Lachièze-Rey Marc. DR
- Renaud Jacques PR

Before Sept 2021

Caprini Chiara DR

Composition de l'équipe de recherche

- 3 post-doctorants [prénom, nom, indiquer projet, origine financement, date de début, date de fin]
- Alberto Mangiagli IN2P3 1/2021-1/2023
- Alberto Roper Pol ANR 10/2020-10/2022
- Marius Ramsoy ANR 11/2020-11/2022

- 7 doctorants [prénom, nom, indiquer sujet, origine financement, directeur, codirection, cotutelle, date de début, date de fin]

• Korochkin Alexander	Gamma-ray astronomy	Vernadskii	D. Semikoz	Oct 2018 Sept 2022
•				
• ROUSSILLE, Hugo	Modified gravity models	ENS Ulm	D.Langlois	Oct 2019 Oct 2022
• Jani Kastikainen	Holography	otutelle 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

Activités de l'équipe de recherche

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

- Associated scientists:

- K.Noui (Orsay) 2 days/week
- F. Vernizzi (Saclay) 1 day/week
- U.Reinosa (Polytechnique) 1 day/week
- Julien Grain (IAS) 1 day/week
- Brando Bellacini (Saclay)
- Christos Charmousis (Orsay)
- Blaise Gouteraux (Ecole Polytechnique)
- Monica Guica (Saclay)
- Herve Bergeron (Orsay)
- Chiara Caprini (Geneva) 1 week/month

Activités de l'équipe de recherche

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

- Visiteurs de longue durée (>3 mois) depuis 3 ans (sabbatiques, cofinancés, ...)

- M.Takook 1 year +1 year PAUSE

- Before covid we had 3-6 1-3 months visitors and 30+ short term visitors per year

M.Kachelriess (Trondheim U) Nov-Dec 2021

Activités de l'équipe de recherche

- Coopérations/collaborations principales avec l'extérieur (avec équipes locales, nationales, internationales)
  - **Collaboration with following institutes:**

1) Albert Einstein Institute Potsdam
2) Aquila University, Italy
3) ASU, Phoenix, Arizona, USA
4) Brookhaven 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 and physics department
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

Activités de l'équipe de recherche

- Coopérations/collaborations principales avec l'extérieur (avec équipes locales, nationales, internationales)
  - **Collaboration with following institutes:**

- Stockholm 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) Universte d'Orsay

Activités de l'équipe de recherche

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

- **PhD defended in period (2017-2021)**
- **Name, PhD subject, financial source, PhD advisor, starting date, final date…**

Chatelain Amélie	Novel neutrino flavour conversion phenomena in media	ENS	Cristina Volpe	Sept 2016 Sept 2018
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
Moreau Gabriel	Champs quantiques en espace-temps courbe	Paris 7	Julien Serreau	Oct 2017 Oct 2020
Auclair Pierre	Cosmology with Gravitational Waves	EPolytechnique	D.Steer/ Ch. Caprini	Oct 2018 Jul 2021
Bouyahiaoui Makarim	Models of multi-messenger sources of cosmic-rays, gamma-rays and neutrinos	Paris7	D. Semikoz	Oct 2018 Dec 2021
Papanikolaou Theodoros	Constraining the early Universe with Primordial BH	Paris7	V. Vennin	Oct 2018 Oct 2021

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 Betzioa 100% research

•Yuta Hamada 100% research

• **3 PhD students: [Name, %ETPT in projet, (status)]**

• Valentin Nourry 50% research

• Edwan Préau 100% research

•Jani Kastikainen 100% research

•**Important scientific results in project (2020-2021)**

•Non-perturbative study of holographic field theories on de Sitter spacetime

•Models with the self-tuning of the cosmological constant and holographic relaxion mechanism

•Holographic RG flows on products of spheres

•Study of AdS vacuum decay by Coleman-de Luccia instantons

•Study of holographic F-theorems in flavored ABJM model

•Baryons in phenomenological holographic models for QCD (in progress)

•Computation of weak processes in dense strongly coupled media (like neutron stars) using semi-holography (in progress)

•**Important publications (2020-2021)(3 max) :**

•Revisiting Coleman-de Luccia transitions in the AdS regime using holography, J.K. Ghosh (ICTS, Bangaloreand Independent U., Dhaka), E. Kiritsis (APC), F. Nitti (APC) L. Witkowski (IAP), Feb 23, 2021, ***JHEP*09 (2021) 065**

•Back-reaction in massless de Sitter QFTs: holography, gravitational DBI action and f(R) gravity J.K. GhoshICTS, Bangalore and Independent U., Dhaka), E. Kiritsis (APC), F. Nitti (APC) L. Witkowski (IAP), May 18, 2020, ***JCAP* 07 (2020) 040**

•The Self-Tuning of the Cosmological Constant and the Holographic Relaxion Y. Hamada (APC), E. Kiritsis(APC), F. Nitti (APC) L. Witkowski (IAP), Jan 15, 2020 , ***Fortsch.Phys.* 69 (2021) 2, 2000098**

•

5 papers in journals published

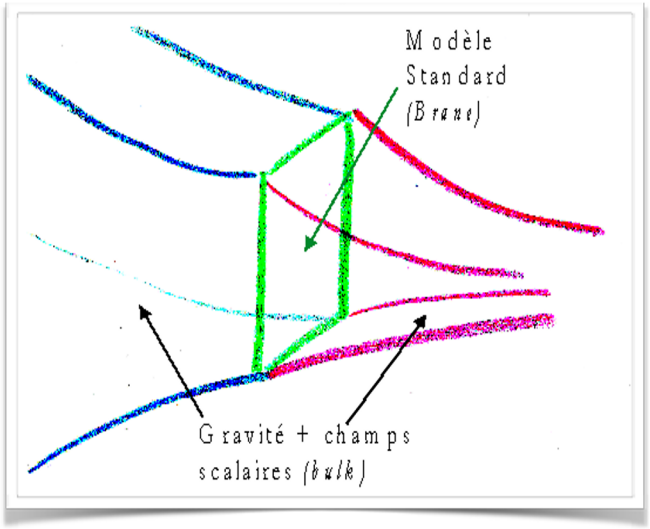
Projet #1 String theory and Holography

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

LList of researchers in the project:

•**5 permanents [Name, %ETPT in projet, (status)]**
•E.Huguet 50%
•J.Mourad 50%
•J-P. Gaseau 100%
• J. Renaud 100%
•M.Lachieze-Rey 100%

•**Important scientific results in project (2020-2021)**
•Covariant integral quantization of various classical systems.
•Restriction of “massless” to “massive” scalars from Conformal to Sitter space
•Study of breaking of Supersymmetry: New vacua with broken supersymmetry with (p+1) dimensionnal space-timePoincar\'esymmetry are found with supersymmetric and tachyon-free non-supersymmetric 10D string theories.

•**Important publications (2020-2021)(3 max) :**

Massive scalar field on (A)dS space from a massless conformal field in R6,
E. Huguet, J. Queva and J. Renaud, J.~Math.~Phys. 61, 053506 (2020).

On boundaries, charges and Fermi fields
Mourad, J. and Sagnotti, A., hep-th 2002.05372, **Phys. Lett. B 804 (2020) 135368.**

String (In)Stability Issues with Broken Supersymmetry
Mourad, J. and Sagnotti, A., hep-th 2107.04064", JHEP 2021 (2021)

Projet #3 QFT in curved spacetime 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)

•**1 PhD student: [Prénom, Nom, sujet, %ETPT dans le projet, (responsabilité)]**

Moreau Gabriel Champs quantiques en espace-temps courbe %100

•**Important scientific results in project (2020-2021)**

-nonperturbative QFT techniques to compute the effect of gravitationally enhanced quantum fluctuations during inflation.

-modified perturbative approach for the infrared regime of QCD. Calculation of the phase diagram of the quark-gluon plasma. Semi-analytical computation of dynamical breaking of chiral symmetry.

•**Publications emblématiques de l'équipe dans revues à comité de lecture (2020-2021)(3 max) :**

A novel background field approach to the confinement-deconfinement transition D. M. van Egmond, U. Reinosa (Ecole Polytechnique, CPHT), J. Serreau (APC, Paris), M. Tissier (Sorbonne Univ. LPTMC). SciPost (2021), to appear

The 1/N expansion for stochastic fields in de Sitter spacetime G. Moreau, J. Serreau (APC, Paris). PhysicalReview D 102 (2020) 125015

A window on infrared QCD with small parameters M. Pelaez (Republica Univ. Montevideo), U. Reinosa (Ecole Polytechnique, CPHT), J. Serreau (APC, Paris), M. Tissier (Sorbonne Univ. LPTMC). Reports on Progress in Physics(2021)

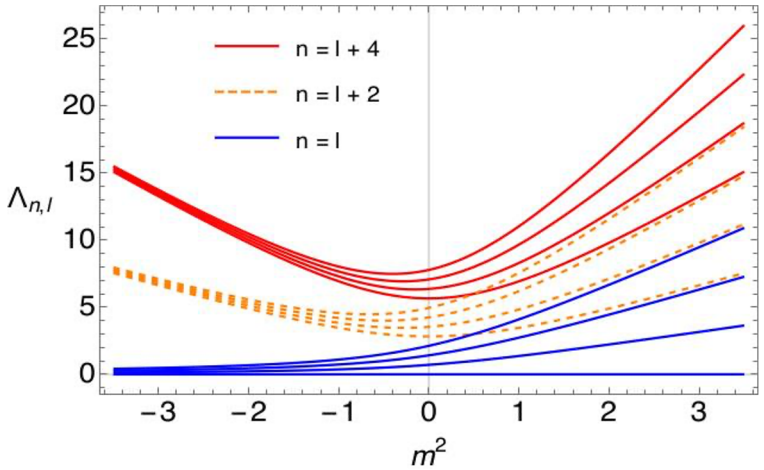
7 papers in journals published + 1 conference proceedings

QFT in curved spacetime and QCD

J. Serreau, G. Moreau

Quantum field theory in curved spacetime

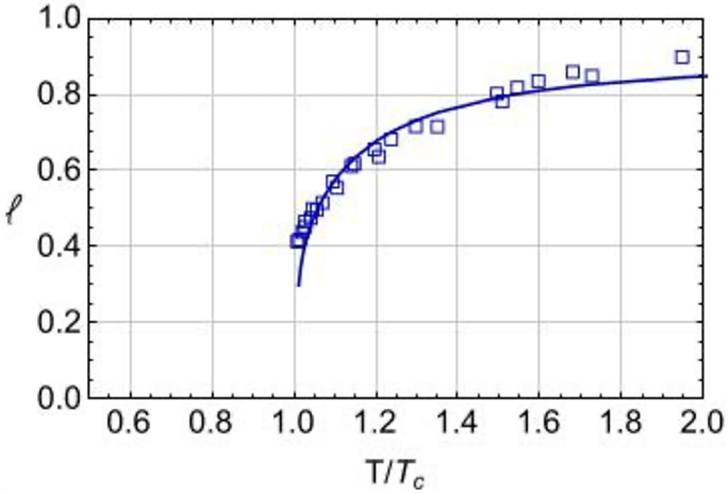
- development of nonperturbative QFT techniques to compute the effect of gravitationally enhanced quantum fluctuations during inflation
- analytical expressions of correlation lengths/times relevant for inflationary physics



Exact eigenvalues of the Fokker-Planck operator in the large-N limit as a function of the self coupling [PRD 102 (2020) 125015]

Infrared regime of Quantum Chromodynamics

- analytical computation of the phase diagram of QCD with modified perturbative approach (massive extension of Landau gauge = Curci-Ferrari model)
- semi-analytical computation of dynamical breaking of chiral symmetry with the CF model



The order parameter of the confinement-deconfinemen transition in SU(3) Yang-Mills theory as a function of temperature (one-loop calculation vs. lattice results) [SciPost (2021), to appear]

Projet #4 Modified Gravity

Scientist responsible for project : D.Langlois

List of researchers in the project:

- **2 permanents+1 associé [Name, %ETPT in projet, (status)]**
- David Langlois 100% (responsable)
- Karim Noui 50%
- Danièle Steer 10%

- **1 Doctorant: [Name, %ETPT in projet, (status)]**
- Hugo Roussille 100%

- **Important scientific results in project (2020-2021)**
  - geometric reformulation of quadratic DHOST (Degenerate Higher-Order Scalar-Tensor) theories
  - perturbations and quasi-normal modes of black holes in DHOST theories
  - tests of different modified gravity theories with GWs

- **Important publications (2020-2021)(3 max) :**

Quadratic degenerate higher-order scalar-tensor theories revisited David Langlois(APC, Paris), Karim Noui(IDP, Tours and APC, Paris), Hugo Roussille(APC, Paris and IDP, Tours), Published in: *Phys.Rev.D* 103 (2021) 8, 084022

Asymptotics of linear differential systems and application to quasi-normal modes of nonrotating black holes David Langlois(APC, Paris), Karim Noui(IDP, Tours and APC, Paris), Hugo Roussille(APC, Paris and IDP, Tours), To appear in: *Phys.Rev.D*

Probing modified gravity theories and cosmology using gravitational-waves and associated electromagnetic counterparts S. Mastrogiovanni D. Steer, M. Barsuglia, *Phys.Rev.D* 102 (2020) 4, 044009

Projet #5 Equivalent formulations of General Relativity

E. Huguet

Scientist responsible for project : E. Huguet

List of researchers in the project:

- **1 permanents [Name, %ETPT in projet, (status)]**
  - E. Huguet 50% (responsible)

- **Important scientific results in project (20-2021)**
  - Critical analysis of the Teleparallel Equivalent of General Relativity (TEGR) as a gauge theory of the translation group
  - Reformulation of the Teleparallel Equivalent of General Relativity (TEGR) using a Cartan connection.
- **Important publications (2020-2021)(3 max):**
- **``Teleparallel gravity as a gauge theory: coupling to matter with Cartan connection.''**
  E.~Huguet, M.~Le~Delliou, M.~Fontanini and Z.- C.~Lin,, Phys. Rev. D {\bf 103}, 044061 (2021).

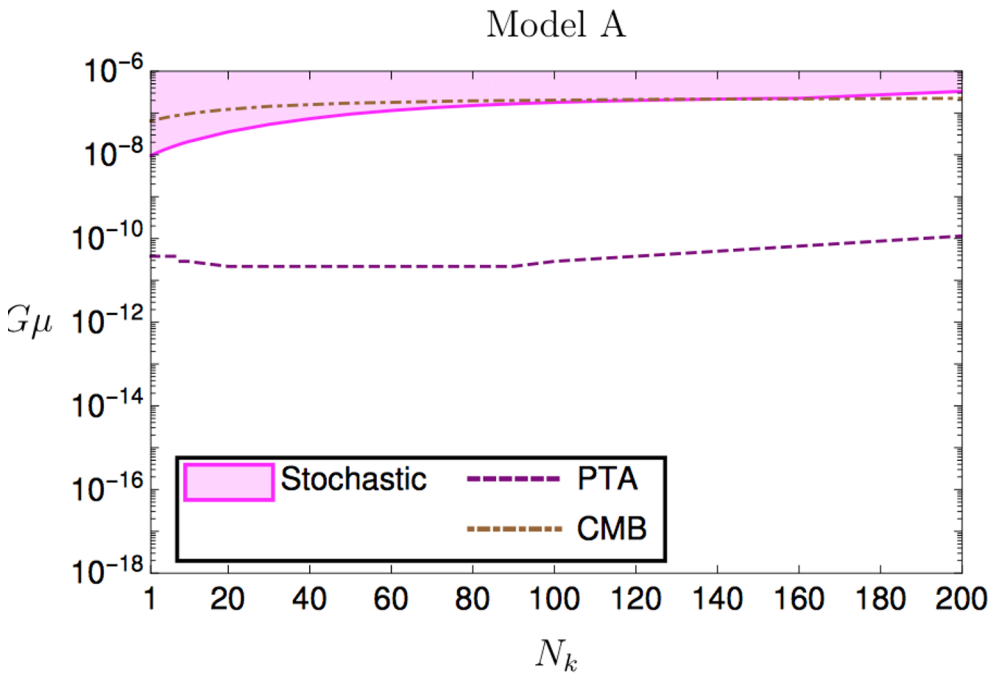
- **``Cartan approach to Teleparallel Equivalent to General Relativity: a review.'',**
  E.~Huguet, M.~Le~Delliou and M.~Fontanini, Int. Jou. Geom. Meth. Math. Phys., 18 supp01, 21400041 (2021).

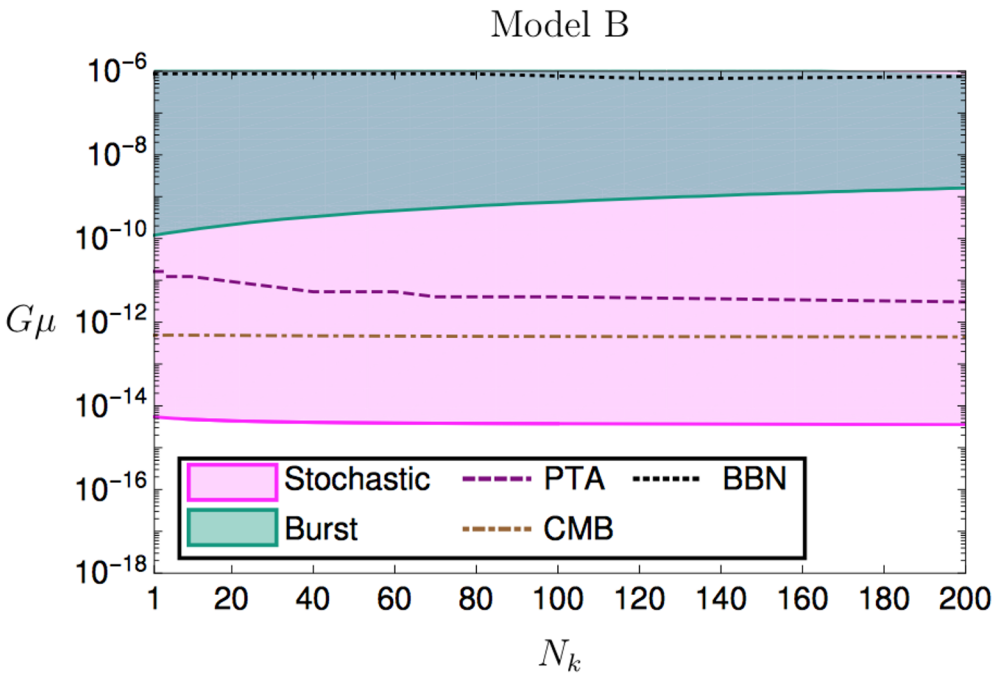
- **``Teleparallel theory as a gauge theory of translations: Remarks and issues.'',**
  M.~Le~Delliou, E.~Huguet and M.~Fontanini, Phys. Rev. D 101, 024059 (2020).

3 papers in journals published

Projet #6 Cosmology and GW

- **D.Steer**
- **K.Leide (PhD)**
- **Constraints on cosmic strings using LIGO-Virgo O3 data.**





Exclusion plots for 2 models of cosmic strings. y-axis = string tension Gmu; x-axis = number of kinks of strings

Phys.Rev.Lett. 126 (2021) 24, 241102

Projet #7 Early-Universe Cosmology

Scientist responsible for project: V.Vennin

List of researchers in the project:

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

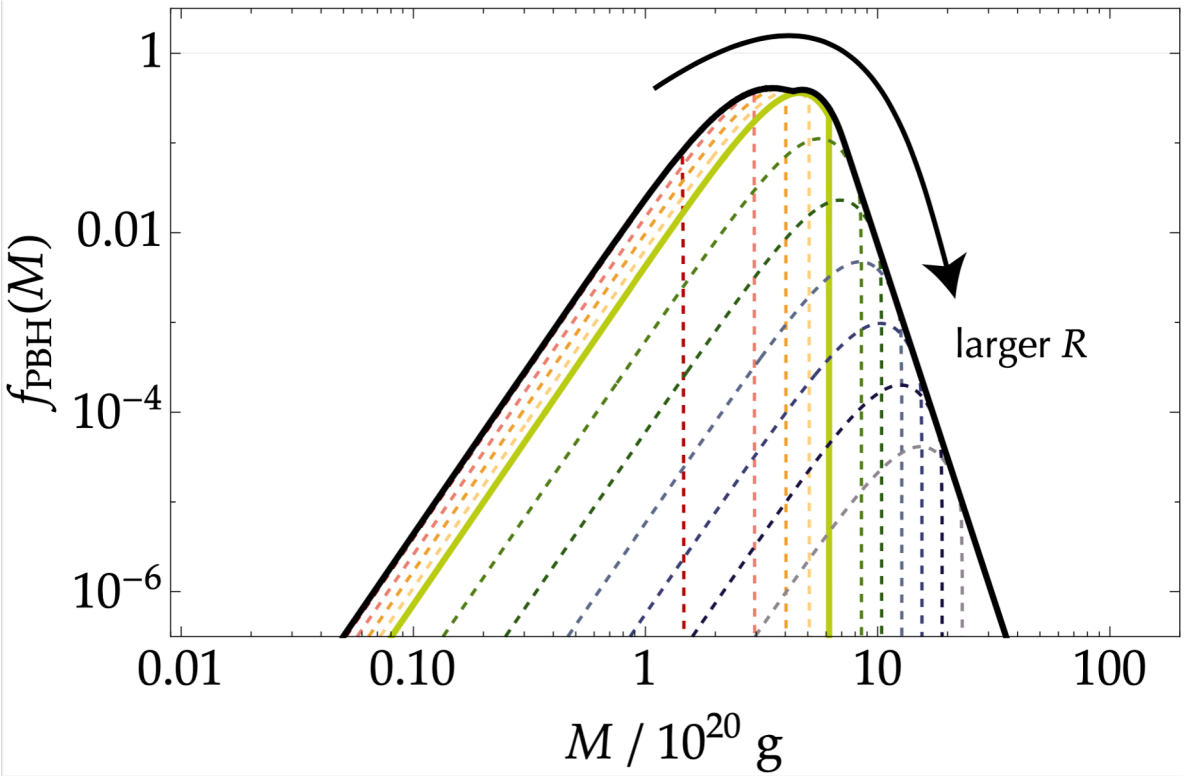
- **2 Doctorants: [Name, %ETPT in projet, (status)]**
  - Theodoros Papanikolaou 100%, *Primordial Black Holes*, ED STEPPUP, Septembre 2018→ Septembre 2021
  - Thomas Colas 100%, *Quantum aspects of primordial fluctuations*, ED PIF, co-tutelle avec Julien Grain (IAS), depuis Septembre 2020

- **Important scientific results in project (2020-2021)**
  - Quantum backreaction in stochastic inflation: statistics of cosmological fields and consequences for primordial black holes
  - Primordial black holes from metric preheating
  - Induced gravitational waves from a primordial-black-hole dominated era
  - Observational signatures of the quantum origin of cosmological perturbations: real-space quantum discord, generalised Bell inequalities
  - Dynamical collapse models of the wavefunction in cosmology

- **Important publications (2020-2021)(3 max) :**
  - Gravitational waves from a universe filled with primordial black holes (Theodoros Papanikolaou, Vincent Vennin, David Langlois), JCAP 03 (2021) 053
  - Ultra slow roll with quantum diffusion (Chris Pattison, Vincent Vennin, Hooshyar Assadullahi, David Wands), JCAP 04 (2021) 080
  - Bipartite temporal Bell inequalities for two-mode squeezed states (Kenta Ando, Vincent Vennin), Phys. Rev. A 102 (2020) 5, 052213

2020-2021: 11 papers in journals published + 4 preprints + 1 HDR

- **Highlight 1: mass fraction of primordial black holes in the presence of quantum diffusion**



Statistics of coarse-grained cosmological fields in stochastic inflation, Yuichiro Tada, Vincent Vennin (2021)

Quantum kicks in the stochastic motion of the inflation yield large cosmological fluctuations that may later collapse into primordial black holes. The figure shows the mass distribution of such black holes, in a model where the inflaton's potential features an exactly flat region

Projet #8 Neutrino physics et Astrophysics

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 (2019), now at MPI Münich

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

- Andrea Gallo Rosso, (2019) 100% research "Observational aspects of supernova neutrinos", supervisors : M.C.Volpe/ F. Vissani, Aquila U. et GSSI,(financement GSSI). Postdoc à Laurentian, Stockholm U.

•Julien Froustey (en 2020), 100% research, (IAP), co-encadrement avec C. Pitrou.

•

Pilar Hernandez-Pallesteros, Master 2-PHE and ETH Zürich, "The diffuse supernova neutrino background and its potential¨, 2022 (4 mois)

•

Important scientific results in project (2019-2022)

•Effets de décohérence dans la propagation des neutrinos, dues à la gravitation, près d'objets compacts

•Première mise en évidence de modes "fast" (modes de très courte échelle) dans les simulations multi-dimensionnelles des supernovae

•Premier calcul des nombre des degrés de liberté effectif des neutrinos à l'époque de la nucléosynthèse primordial incluant le terme complet de collision des neutrinos

•

Important publications (2019-2022)(3 max):

« Neutrino decoherence in presence of strong gravitational fields », Chatelain and Volpe, *Phys. Lett. B 801 (2020) 135150.*

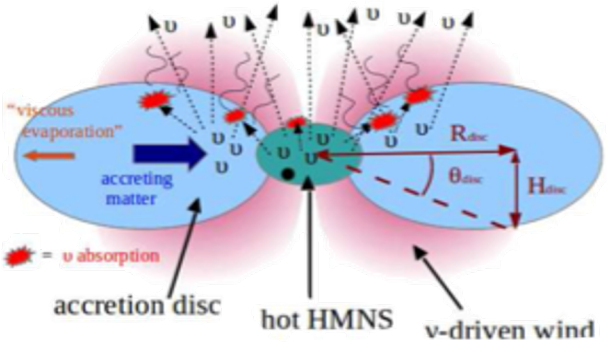
« Neutrino decoupling including flavor oscillations and primordial nucleosynthesis », Froustey, Pitrou, Volpe, *JCAP* 12 (2020) 015.

« On fast neutrino flavor conversion modes in the non linear regime », Abbar, Volpe, 790 (2019) 545.

5 published papers in refereed journals, 3 proceedings + 1 preparation, 1 invited review (in preparation), 11 articles (JUNO)

Neutrino physics and astrophysics

M.C.Volpe, A. Abbar, A.Chatelain, J. Froustey, A. Gallo Rosso

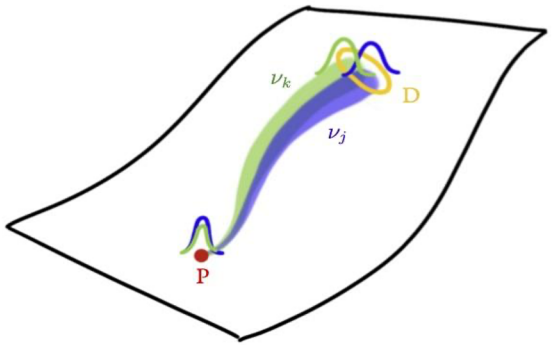


neutron star mergers

- 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.

Supernovae

Core-collapse supernova neutrinos



Decoherence of the neutrino wave packets during propagation, due to the presence of strong gravitational fields nearby compact objects.

Chatelain, Volpe,Phys.Lett. B 801(2020)135150.

Cosmological neutrinos

Precise calculation of the effective number of degrees of freedom at the epoch of Big-bang nucleosynthesis,
including for the first time the full neutrino collision term, giving
Neff = 3.0440 .

Froustey, Pitrou,Volpe,JCAP 12 (2020) 015.

> Predictions for future observations of supernova neutrinos in neutrino detectors such as Super-Kamiokande, Hyper-K, JUNO, DUNE, …

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 30% (responsible)
    - Andrei Neronov 15% (co-responsible)
- **1 Doctorants[Name, %ETPT in projet, (status)]**
    - M.Bouvahiaoui, 100% Cosmic ray models

- **Important scientific results in project (2020-2021)**
- Detailed model on cosmic ray propagation in local 1 kpc was constructed
- Cosmic ray spectrum in outer galaxy was studied with Tibet data
- New secondary production model in A-A collisions AAfrag was developed

- **Important publications (2020-2021)(3 max) :**

Pion decay model of the Tibet ASgamma PeV gamma-ray signal
S. Koldobsky (Moscow Phys. Eng. Inst.), A.Neronov (APC, Paris), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). . Published in **Phys Rev D 104 (2021) 4, 043010**

Energy spectra of secondaries in proton-proton interactions
S. Koldobsky (Moscow Phys. Eng. Inst.), M. Kachelriess (Norwegian U. Sci. Tech.), A. Lskavyan (Moscow Phys. Eng. Inst.), A.Neronov (APC, Paris), S.Ostapchenko (Hamburg U. and SINP, Moscow), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.)., 2110.00496 [astro-ph.HE], accepted PRD

High-energy neutrinos from cosmic ray interactions in the Local Bubble
M. Bouyahiaoui (APC, Paris), M. Kachelriess (Norwegian U. Sci. Tech.), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). Jun 22, 2020. 10 pp.
Published in **Phys ReV D 101 (2020)** 12, 123023

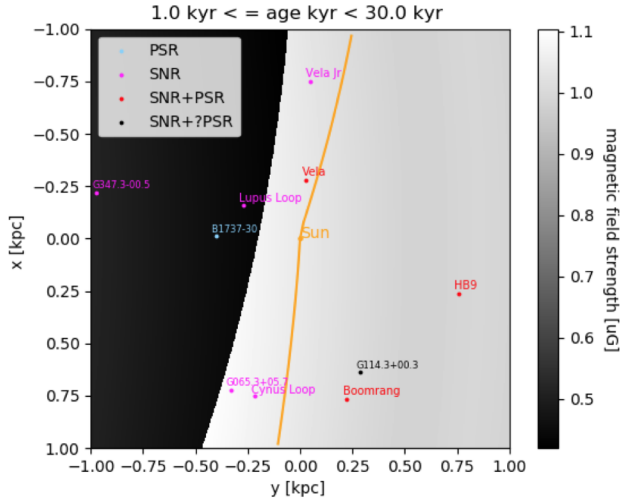
3 papers in journals + 2 archive preprints under consideration + JEM-EUSO

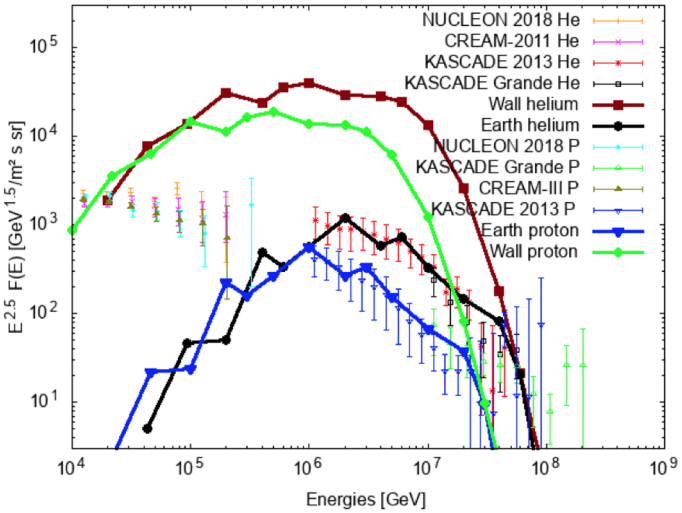
Cosmic rays

Knee is sharp feature in CR known from 1957. Nature is unknown. We explore possibility it is dominated by nearby SN Vela in framework of anisotropic diffusion scenario, taking into account Local Bubble and other local matter detected by Gaia. This Model explain knee in cosmic rays, IceCube neutrino excess in 1-100 TeV energies.

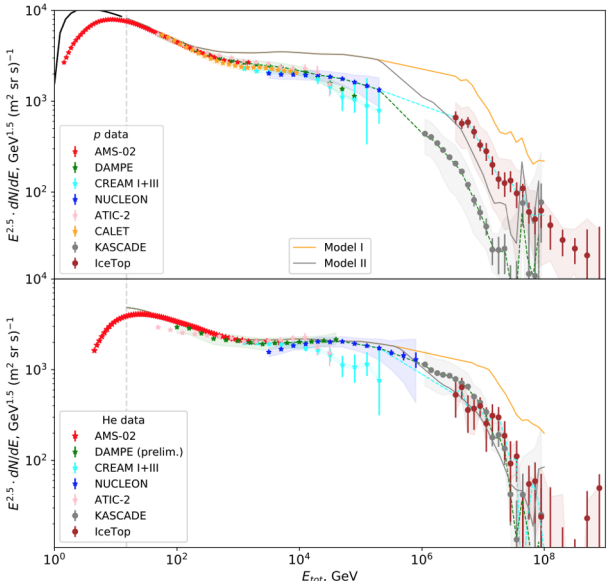
PhD Thesis of M.Bouvahiaoui 3 papers in journals + 2 conference proceedings

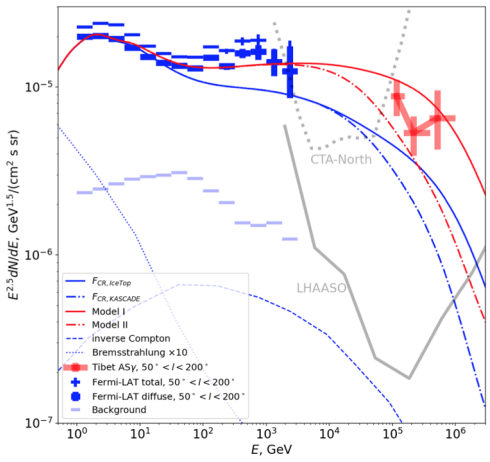
We are organizing writing new code for anisotropic cosmic ray diffusion at CR knee with 10 scientists from 5 countries





Phys ReV D 101 (2020) 12, 123023





Phys Rev D 104 (2021) 4, 043010

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, 50% gamma-ray astronomy

- **Important scientific results in project (2020-2021)**
- Tibet high galactic latitude data allowed to establish new limit on PeV gamma-rays which is order of magnitude better compared to old KASCADE limit and close to predictions of several models, restrict heavy DM
- We predicted neutrino flux for Galactic sources which have high 100 TeV flux
- Icecube data coincide with active radio loud blazars (like famous TXS), we constructed model which explain radio-neutrino connection
- LHAASO sensitivity to diffuse galactic gamma-rays was studied
- **Important publications (2020-2021)(3 max):**

New limit on high Galactic latitude PeV γ-ray flux from Tibet ASγ
A. Neronov (APC, Paris),D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.), Ye.Vovk (Tokyo U.) . Jul 14, 2021 10 pp. Published in ***Astron.Astrophys.* 653 (2021) L4**

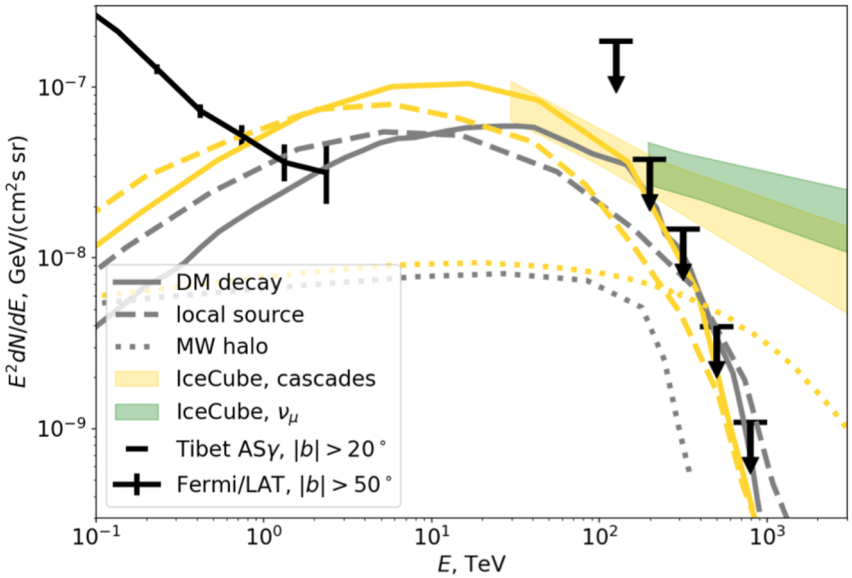
Neutrinos from the gamma-ray source eHWC J1825-134: Predictions for Km3 detectors
V. Niro(APC, Paris), L. Fusco(APC, Paris), A.Neronov (APC, Paris) S. Gabici(APC, Paris), D. Semikoz(APC, Paris)
Published in: *Phys.Rev.D* 104 (2021) 2, 023017

LHAASO telescope sensitivity to diffuse gamma-ray signals from the Galaxy
A. Neronov (APC, Paris & ISDC, Versoix), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). *Phys.Rev.D* 102 (2020) 4, 043025

4 papers in journals + 1 preprint + several experimental papers ANTARES,FACT,CTA

Multimessenger physics with high energy gamma-rays and neutrinos

A.Neronov, D.Semikoz



Tibet **ASγ** gamma-ray limit at high galactic latitude confirm extragalactic nature of high energy neutrinos above 300 TeV. It constrain parameter space heavy DM model and Local Bubble models

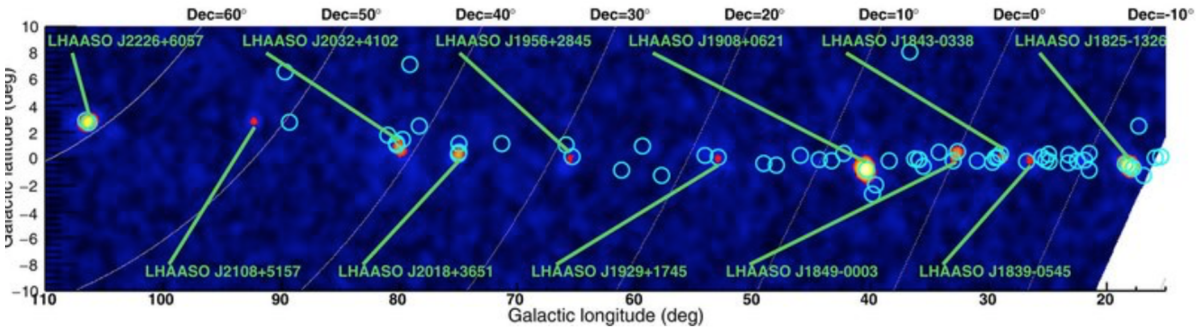
New limit on high Galactic latitude PeV γ-ray flux from Tibet ASγ

A. Neronov (APC, Paris),D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.), Ye.Vovk (Tokyo U.) . Jul 14, 2021

10 pp. Published in ***Astron.Astrophys.* 653 (2021) L4**

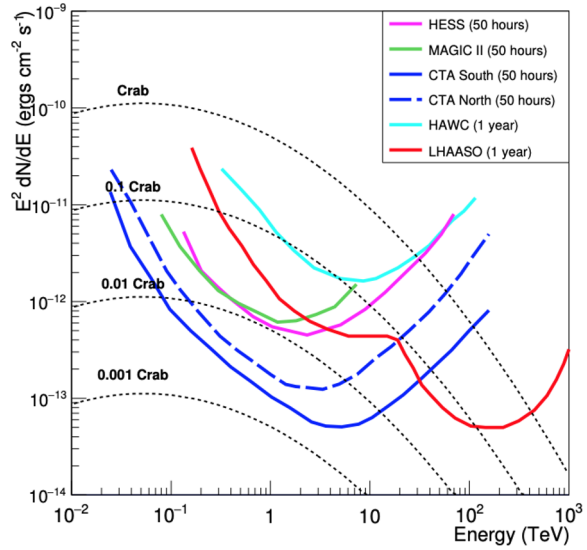
Multimessenger physics with high energy gamma-rays and neutrinos

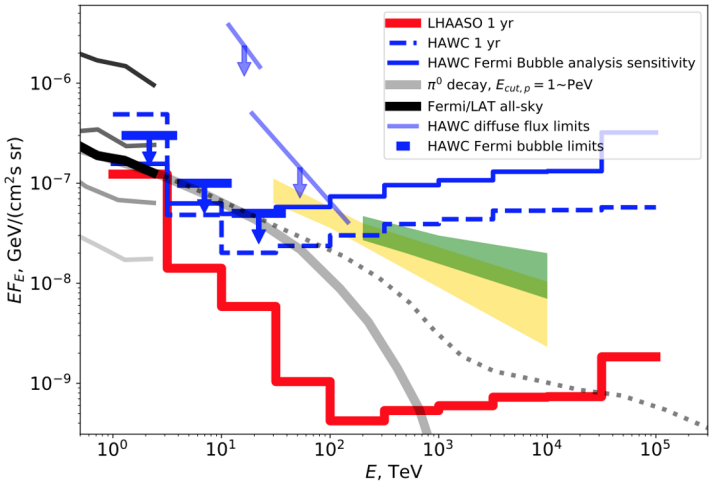
LHAASO - best to date cosmic ray / gamma-ray experiment in E=100TeV energy range



LHAASO Nature, May 2021

A.Neronov and D.Semikoz associated members of LHAASO since Nov 2021 for diffuse gamma-rays from Galaxy analysis





A.Neronov and D.Semikoz
Phys. Rev. D 102, 043025 (2020)

Projet ANR New windows in Early Universe with multimessenger astrophysics (ANR 2020-2023)

cosmology, gravitational waves and gamma-ray astronomy

Scientist responsible for project : D.Semikoz PI, include APC and IAP, Paris

List of researchers in the project:

- **2 permanents [Name, %ETPT in projet, (status)]**
  - Chiara Caprini 20% (co-responsible)
  - Andrei Neronov 20% (co-responsible)
  - Dmitri Semikoz 40% (responsible)
- **2 Postdocs[Name, %ETPT in projet, (status)]**
  - 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
- **1 Doctorants [Name, %ETPT in projet, (status)]**
  - A.Korochkin, 100% gamma-ray astronomy
- **Important scientific results in project (2020-2021)**
- NANOGrav signal explained by production from primordial MF. Same field needed or H0.
- New way to detect inflation MF by set of blazars in nearby Universe similar to set of pulsars in GW
- CTA can test strong MF
- **Important publications (2020-2021)(3 max):**

NANOGrav signal from magnetohydrodynamic turbulence at the QCD phase transition in the early Universe
A. Neronov (APC, Paris), Ch. Caprini (APC, Paris), A. Roper Pol (APC, Paris), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). **(Sep 29, 2020) *Phys.Rev.D* 103 (2021) 4, 041302**

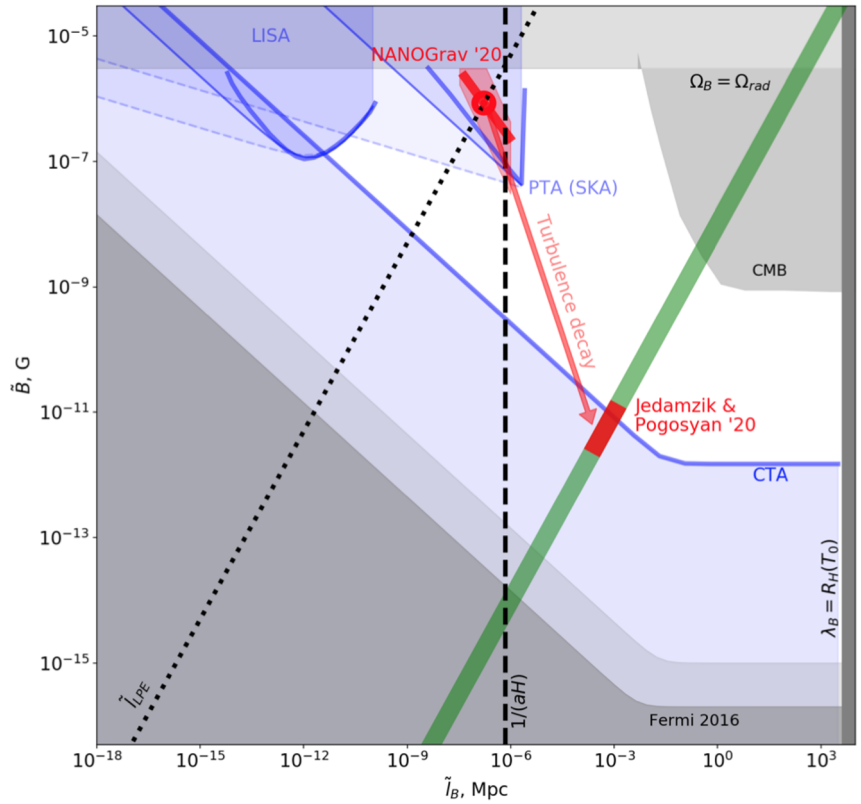
Detectability of large correlation length inflationary magnetic field with Cherenkov telesopes
Alexander Korochkin (APC, Paris and Moscow, INR), Andrii Neronov(APC, Paris and Ecole Polytechnique, Lausanne), Guilhem Lavaux (Paris, Inst. Astrophys. Marius Ramsoy (APC, Paris and Paris, Inst. Astrophys). Dmitri Semikoz (APC, Paris and Moscow Phys. Eng. Inst.) (Nov 19, 2021) 2111.10311 [astro-ph.HE] accepted JETP

Sensitivity reach of gamma-ray measurements for strong cosmological magnetic fields
Alexander Korochkin (APC, Paris and Moscow, INR), Andrii Neronov(APC, Paris and Ecole Polytechnique, Lausanne) Dmitri Semikoz (APC, Paris and Moscow Phys. Eng. Inst.) (Jul 28, 2020) Published in: *Astrophys.J.* 906 (2021) 2, 116

5 papers in journals + 2 preprints

ANR New windows in Early Universe

Ch.Caprini, .A.Neronov, D.Semikoz



Primordial MF can help to solve H0 problem, can be responsible for NANOGrav, can be detected by CTA in future.

Baryonic feedback from AGN is important for observations of large IGMF, connection to LSS studies

NANOGrav signal from magnetohydrodynamic turbulence at the QCD phase transition in the early Universe

A. Neronov (APC, Paris), Ch. Caprini (APC, Paris), A. Roper Pol (APC, Paris), D.V. Semikoz (APC, Paris & Moscow Phys. Eng. Inst.). **(Sep 29, 2020) *Phys.Rev.D* 103 (2021) 4, 041302**

Now we use local LSS data up to 200 Mpc. Next step we use LSS from SDSS in known directions, in future Euclid and LSST