# Rencontres de Physique des Particules 2017

Monday 24 April 2017 - Wednesday 26 April 2017

Centre de Physique des Particules de Marseille


# Recueil des résumés

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# A Minimal Model of Gravitino Dark Matter

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Motivated by the absence of signals of new physics in both searches for new particles at LHC and for a Weakly Interacting Massive Particle (WIMP) dark matter candidate, we consider a scenario where supersymmetry is broken at a scale above the reheating temperature. The low energy particle content consists then only in Standard Model states and a gravitino. We investigate the possibility that the latter provides the main component of dark matter through a freeze in mechanism from annihilation of thermalized Standard Model particles. We focus on the case where its production through scattering in the thermal plasma is well approximated by the non-linear supersymmetric effective Lagrangian of the associated goldstino and identify the parameter space allowed by the cosmological constraints, allowing the possibility of large reheating temperature compatible with leptogenesis scenarios, alleviating the so called "gravitino problem". We considered the framework of high scale supersymmetry, where the scale of super-partners MSUSY lies above the reheating temperature whereas the gravitino mass m3/2 stays below. In this case, there still exist processes which produce thermally gravitinos through scattering of the Standard Model particles at the earliest time of reheating. This scale pattern m3/2 ≪ TRH ≪ MSUSY is common in some string models with high-scale supersymmetry breaking and opens new possibilities in model building.

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# Bs to tau tau prospects

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# Cosmology update

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# Dark Matter

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# Dark matter constraints and uncertainties in the pMSSM

glenn robbins[1]

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We explore the parameter space of the phenomenological MSSM in light of the constraints from dark matter density measurements, indirect and direct detection experiments, and the LHC. We emphasise in particular the impact of the astrophysical uncertainties and quantify their effects, and highlight the complementarity between the different constraints

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## Data analysis with theoretical uncertainties

I present a a new model for handling theoretical uncertainties that often complicate the extraction of fundamental parameters from experimental data. The idea is to define a theoretical uncertainty as a fixed but unknow bias, that is let to vary in a given range. The choice of this range as well as its shape in the multidimensional case is discussed with the associated frequentist properties. I illustrate this method with a few examples from indirect tests of the Standard Model.

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## Determining the strong coupling

Alberto Ramos[1]

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We review the ALPHA collaboration strategy for obtaining the QCD coupling at the electroweak scale via Lattice QCD simulations. In the three-flavor effective theory we compute non-perturbatively the running of the strong coupling from hadronic scales to the electroweak scale. The result for the Lambda parameter in the three-flavor effective theory is used to obtain an accurate value of the strong coupling by means of (high order) perturbative relations between the effective theory couplings at the charm and beauty quark "thresholds".

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## Electric dipole moment of light nuclei

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The nuclear electric dipole moment (EDM) is a very sensitive probe of CP violation beyond the standard model.
The EDM of light nuclei can be evaluated in few-body calculations assuming the one-meson exchange model for the P, CP-odd nuclear force.
In this talk, we present our recent results on the calculation of the EDM of several light nuclei and the mechanism of the enhancement of CP violation.

We also give future prospects for the discovery of new physics beyond standard model such as the supersymmetry.

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## First results about elliptic flow with a unified approach at RHIC energies

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The parton model, proposed by Richard Feynman in 1969, can describe the structure of hadrons (like as protons and neutrons) and model hadrons at high energy. We use the parton model in the Standard Model (SM) to explain hadrons by the way of Quantum Chromodynamics . Hadrons are described as bound states of partons (quarks and gluons). We cannot observe directly partons because they are confined in hadrons. We call the phenomena where partons become hadrons : the hadronization. For the moment we have no explications about how partons become hadrons. SM predict one state where partons are deconfined, this state is called Quarks-Gluons-Plasma (QGP).
To study the QGP, we make particles collisions at very high energy in the Large Hadron Collider (LHC) or in the Relativistic Heavy Ions Collider (RHIC). As the QGP life-time (10e−21 s) and size (10e−15 m) are really small in these experiments, we cannot study directly the QGP. Therefore, proving the existence and describing the properties of the QGP is a challenge. Experimentally, we only know the initial and final conditions. To have access between these two states, we must have some models and theoritical concepts to explain how we can make particles.
One approch to explain experimental data is the Parton-Based-Gribov-Regge Theory, this Theory combining the model parton with Gribov-Regge Theory. In a collision (nucleus-nucleus by example), we assume that each interaction can be replaced by a Pomeron. An individual scattering can be referred to as Pomeron, identified with a parton ladder, eventually showing up as flux tubes (or strings). Each string follows the Lund Model where we can split strings with a pair of quarks-antiquarks (the antiparticle of quark) by the Schwinger Mechanism. Between two nuclei, we possed a lot of strings, we make a separation core-corona to make QGP or hadronization of particles.
At very high collision energy, EPOS has proved its efficacity for a large number of observables. I want to test EPOS now at less high energy. I will show first results in elliptic flow with EPOS at p
sNN = 19.6 or 39 GeV.

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## Flavour Physics Overview

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**Formal Aspects / 26**

## Hadronic Vacuum Polarization contribution to g-2

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**Formal Aspects / 5**

## Hadronic Vacuum Polarization in QCD and its Evaluation in the Euclidean

Eduartdo de Rafael[1]

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I shall discuss a new technique to evaluate integrals of QCD Green's functions in the Euclidean based on their Mellin-Barnes representation. I shall talk about an application to the lowest order Hadronic Vacuum Polarization (HVP) contribution to the anomalous magnetic moment of the muon. It is shown that with a precise determination of the slope and curvature of the HVP function at the origin from lattice QCD, one can already obtain a result which may serve as a test of the determinations based on experimental measurements.

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## Hadronic vacuum polarization contribution to the anomalous magnetic moments of all leptons from first principles

Kohtaroh Miura[1]

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We present the latest lattice QCD results for
the leading-order contributions of the hadron vacuum polarization (LO-HVP)
to the muon's anomalous magnetic moment. Calculations are carried out
with the u, d, s and c quarks at the physical quark masses
in volumes of linear extent larger than 6 fm,
and at six values of the lattice spacing,
allowing for a fully controlled continuum extrapolation.
All connected and disconnected contributions are calculated.
Furthermore, we provides the LO-HVP contributions to the electron's and
tau-lepton's anomalous magnetic moments.
We discuss possible uncertainties which may come from finite-volume
and isospin-breaking effects, and compare the results of the full HVP
with phenomenological estimates.

**Astroparticles and Cosmology / 0**

## Helicity coherence in binary neutron star mergers and nonlinear feedback

Amélie Chatelain[1] ; Cristina VOLPE[1]

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In astrophysical environments such as core-collapse supernovae or binary neutron star mergers, the physical conditions are so extreme that neutrino propagation can have a significant role in the dynamics of the system, the nucleosynthesis, and modify the signals that might be detected from

such events. Since the discovery of neutrino oscillations in 1998 and the assessment of the Mikheev-Smirnov-Wolfenstein (MSW) effect, steady progress had been made in understanding neutrino flavor conversions. Neutrino self-interactions have proven to complicate the problem, making the evolution equations intrinsically nonlinear, and have triggered a decade of theoretical investigations. A variety of flavor instabilities has been uncovered, depending on the physical conditions and the geometry of the environment considered. In anisotropic media, the most general mean-field equations include corrections to the relativistic limit, due to the nonzero neutrino mass. This contribution creates a coupling between neutrino and antineutrino referred as *helicity* or *spin coherence*.

In this talk, we summarize the progress made in neutrino flavor evolution, from solar neutrinos to binary neutron star mergers neutrinos, and we discuss the effects of helicity coherence on propagation in the context of these mergers [1].

[1] A. Chatelain and C. Volpe, "Helicity coherence in binary neutron star mergers and nonlinear feedback", Phys.Rev. D95 (2017) no.4, 043005, arXiv:1611.01862 [hep-ph].

**Higgs and BSM** / **20**

## Higgs and BSM

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**Higgs and BSM** / **8**

## Higgs production at NLO in the Standard Model Effective Theory

Nicolas Deutschmann[1]

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The Effective Field Theory approach is a fruitful way of putting model independent constraints on heavy new physics. As the Higgs sector is one of the most popular candidates for deviations from the Standard Model prediction, it is particularly important that the constraints extracted from the experimental data on the Higgs boson be as meaningful as possible, which entails making accurate and precise theoretical predictions.

In this presentation, I discuss a two-loop calculation performed to improve the existing Leading Order result for the Higgs gluon-fusion cross section in the Standard Model Effective Field Theory. I will review the modern multi-loop calculation techniques employed to obtain this amplitude and I will present the first result for a two-loop form factor with an insertion of a chromomagnetic operator in the Standard Model EFT.

**Flavour** / **10**

## K->pipi and neutral kaon mixing

Nicolas Garron[1]

[1] *University of Liverpool*

I report on the theoretical computation of epsilon'/epsilon in the Standard Model. I will focus on the hadronic matrix elements wich have been computed by the RBC-UKQCD collaboration. I will also talk on neutral kaon mixing beyond the standard model and propose an explanation for the discrepancy observed between the different determinations.

**SM / 13**

## Matrix elements for dark matter

Laurent Lellouch[1]

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We calculate the matrix elements for the quark content of the nucleon relevant for the direct detection of dark matter.

**Astroparticles and Cosmology / 18**

## Multidimensional Simulations of Pair Instability Supernovae Explosions

Nina Smirnova[1]

[1] *LAPTh*

Multidimensional Simulations of Pair Instability Supernovae Explosions

**Higgs and BSM / 16**

## Non-perturbative analysis of the spectrum of meson resonances in an ultraviolet-complete composite Higgs model

Nicolas Bizot[1]

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In this talk, I will consider a vector-like gauge theory of fermions that confines at the multi-TeV scale and that realizes the Higgs particle as a composite Goldstone boson.
Among other things, I will present the non-perturbative computation of the mass spectrum of the composite mesons in the approximation where the strong dynamics is described by
four-fermion operators.

**Higgs and BSM / 7**

## Optimisation of MET searches at the LHC. Complementarity with DM-related constraints.

**Auteur(s):** Bryan Zaldivar[1]

**Co-auteur(s)** ANDREAS GOUDELIS [2] ; Benjamin Fuks [3] ; Daniele Barducci [4] ; Genevieve Belanger [5] ; Shankha Banerjee [1]

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In the context of a simplified dark matter model with a pseudo-scalar mediator, we study how the present missing energy searches could be optimised for future LHC runs.
We then complete the analysis with complementary constraints coming relic abundance and indirect detection searches. We find that LHC high luminosity prospects strongly constrain the thermal relic hypothesis in large part of the parameter space of the model.

**Formal Aspects / 24**

## Resurgence

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## Scalar contributions to the hadronic light-by-light

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**Higgs and BSM / 3**

## Simplified dark matter models with a spin-2 mediator at the LHC

**Auteur(s):** Ursula Laa[1]

**Co-auteur(s)** Kentarou Mawatari [1] ; Kimiko Yamashita [2] ; Sabine Kraml [1]

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Following the LHC DM working group proposal, a simplified Dark Matter model approach has been widely adopted for the interpretation of LHC Run-II searches. In particular models with s-channel spin-1 and spin-0 mediators have been studied in detail. In this talk I will discuss the LHC phenomenology of the less explored spin-2 mediator scenario, presenting constraints on the model parameter space from the current 13 TeV LHC data. I will show the complementarity among different

searches, in particular monojet and multijet plus missing energy searches and resonance searches. For universal couplings of the mediator to standard model particles, dilepton (and diphoton) resonance searches provide the strongest constraints for mediator masses above 200 (500) GeV. Missing energy searches are competitive only in the low-mass region. They can, however, be more important in non-universal coupling scenarios and/or when the coupling of the mediator to dark matter is much larger than its couplings to SM particles.

**Higgs and BSM / 12**

# Solving the Goldstone boson catastrophe in generic theories and two-loop Higgs masses in non-supersymmetric models

Johannes Braathen[1] ; Mark Goodsell[1]

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After the Higgs discovery, calculating its properties with high precision has become of great importance in the study of extensions of the Standard Model. The state-of-the-art calculation of Higgs masses is now at two-loop order for generic theories, performed in the Landau gauge. However, these calculations are plagued by infrared divergences due to tachyonic running Goldstone masses – the so-called Goldstone boson catastrophe (GBC). I will present the recent solution to this problem for general renormalisable field theories [1609.06977] and the study of two-loop corrections to Higgs masses in non-supersymmetric models, made possible by the implementation of the solution to the GBC in SARAH.

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# Testing naturalness through precision measurements

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Symmetry-based solutions of the hierarchy problem generically predict new states that cancel the Standard Model one-loop quadratic divergence of the Higgs mass. Phenomenological investigations are generally focused on the top-partners, expected to be at the TeV scale by naturalness arguments, their quantum numbers are model-dependent. While direct LHC searches have so far turned empty-handed regarding the presence of such new particles, loop-induced observables provide complementary probes and may prove essential to fully characterize their properties.

In this work, we evaluate the contributions of a selection of top-partners representations to quantities such as the Peskin-Teukachi parameters and the loop-induced Higgs couplings. In particular, we investigate whether such observables can provide a test of the required relation between the top Yukawa and top-partner couplings needed to insure the loop cancellation.

**SM / 1**

# Transverse-momentum dependence of gluon distributions at small-x

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I present a recent calculation of the transverse-momentum dependence of gluon distributions, in the small-x limit. This is done by solving the so-called JIMWLK non-linear QCD evolution equation, a functional RG equation that resums the leading logarithms in 1/x.

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# Update from the LHC

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**Astroparticles and Cosmology / 4**

# Well-tempered n-plet dark matter

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The WIMP-paradigm tells us that a neutral particle with an EW cross-section and an electroweak-scale
mass roughly explains the observed relic abundance. However, a closer look reveals that this correspondance
is quantitatively not very precise since multi-TeV dark matter masses are reached for the simplest models, which is 1-2 orders of magnitude larger than the electroweak scale. But with an extended dark sector,
it is possible to maintain the DM particle mass close to the electroweak scale and to keep the observed relic density.
I will talk about simple effective models of fermionic WIMP dark matter, where the dark matter candidate is a mixture of a Standard Model
singlet and an n-plet of $SU(2) \times U(1)$. The dark matter is assumed to be around the electroweak scale, and the mixing is generated
by higher-dimensional operators. I will focus on the observed relic density and direct detection constraints for n = 3, 4 and 5.

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# When unification freezes dark matter

Maíra Dutra[1]

[1] *Laboratoire de Physique Théorique d'Orsay*

Motivated by the absence of WIMP signal in the recent direct and indirect
detection searches, we consider a
scenario where the breaking of an abelian symmetry generates the
annihilation of hypercharge bosons into the

Nambu-Goldstone of the theory, the dark matter candidate.
The couplings are generated by loops of heavy fermions which masses are also determined
by the scale of the $U(1)$ breaking. In other words, all the parameters of the model are dynamically generated and naturally leads
to the right amount of dark matter for a breaking scale of the order of unification scale and a very light Nambu-Goldstone boson
at the keV range.