# Cosmology meets Particle Physics: Ideas & Measurements

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# Book of Abstracts

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## Polytropic and Chaplygin f(T)-gravity models

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We reconstruct the
different f(T)-gravity models corresponding to a set of dark
energy scenarios containing the polytropic, the standard Chaplygin,
the generalized Chaplygin and the modified Chaplygin gas models. We
also derive the equation of state parameter of the selected
f(T)-gravity models and obtain the necessary conditions for
crossing the phantom-divide line.

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## f(T) modified teleparallel gravity as an alternative for original and entropy-corrected versions of the holographic and new agegraphic dark energy models

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In the present work, we reconstruct the different f(T)-gravity
models corresponding to the original and entropy-corrected versions
of the holographic and new agegraphic dark energy models. We also
obtain the equation of state parameters of the corresponding
f(T)-gravity models. We conclude that the holographic and new
agegraphic f(T)-gravity models behave like phantom or quintessence
model. Whereas for the entropy-corrected models, the equation of
state parameter can justify the transition from the quintessence
state to the phantom regime as indicated by the recent observations.

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## Diffuse Galactic Gamma Rays at intermediate and high Latitudes, Constraints on ISM properties and DM

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The measurements with unprecedented accuracy by Fermi of the diffuse gamma ray emission in the Galaxy at energies between 100 MeV and 100 GeV are a very powerful tool to probe and constrain the properties of sources and propagation of cosmic rays (CRs) in the Galaxy, as well as interstellar medium (ISM). In particular, high latitude data (|b|>10) depend mainly on properties of the local enviroment, i.e. the same regime being probed by the measurements of the local CR fluxes. Starting from a wide set of models compatible with local secondary to primary ratios, the local fluxes of protons, Helium nuclei and leptons, we discuss the additional information obtained comparing against the high latitude diffuse emission, the strongest implications being on the ISM gas distribution and the scale height of the diffusion region.
Understanding better the contribution of conventional astrophysical sources to diffuse gamma rays may have implications on indirect dark matter (DM) searches. By including DM as a possible source of antiprotons, leptons and gamma rays, we have performed a combined analysis to derive constraints on the DM annihilation rate. We have studied a garden variety of DM candidates including supersymmetric, leptophilic as well as light WIMP models suggested by direct detection searches.

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# Cosmic ray - dark matter scattering

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We consider the process of scattering of Galactic cosmic-ray electrons and protons off of dark matter with the radiation of a final-state photon. This process provides a novel way to search for Galactic dark matter with gamma rays. We argue that for a generic weakly interacting massive particle, barring effects such as co-annihilation or a velocity-dependent cross section, the gamma-ray emission from cosmic-ray scattering off of dark matter is typically smaller than that from dark matter pair-annihilation. However, if dark matter particles cannot pair-annihilate, as is the case for example in asymmetric dark matter scenarios, cosmic-ray scattering with final state photon emission provides a unique window to detect a signal from dark matter with gamma rays. We estimate the expected flux level and its spectral features for a generic supersymmetric setup, and we also discuss dipolar and luminous dark matter. We show that in some cases the gamma-ray emission might be large enough to be detectable with the Fermi Large Area Telescope.

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# Quartic couplings in Inert Doublet Model and Dark Matter data

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We analyse the thermal evolution of the Universe in the Inert Doublet Model for known three regions of Dark Matter masses: low mass (4 - 8) GeV, medium mass (30 - 80) GeV and high mass (500 - 1000)

GeV. We argue that those three regions of DM mass exhibit different behaviour, both in the possible types of evolution and in the energy relic density values. We use use the masses of the scalar particles as the input parameters to constrain the two self-couplings between neutral scalars. We argue, that the astrophysical data along with the positivity constraints should be used to simultaneously constrain both triple and quartic self-couplings.

Based on arXiv:1009.4593 - I. F. Ginzburg, K.A. Kanishev, M. Krawczyk, D. Sokolowska, arXiv:1104.3326, arXiv:1107.1991 - D. Sokolowska

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## Cosmological decoherence in the framework of stochastic inflation

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In this work we propose a classical phase space formulation of the Starobinsky stochastic inflation, which may be suitable for a quantitative study of decoherence of cosmological perturbations in a self-interacting inflationary theory. The precise knowledge of how much cosmological perturbations have decohered is essential to the understanding of acoustic oscillations of CMB photons.
In our approach to decoherence, neglecting observationally inaccessible, non-Gaussian correlators will give rise to an increase in phase space area and Gaussian entropy of the state. The original Starobinsky approach recovers the correct late time behavior of the field correlators at each order in perturbation theory. Likewise, the classical phase space formulation may provide the correct late time growth of the phase space area and Gaussian entropy, which in turn may have an observational effect on the acoustic peaks in the CMB.

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## The problematic backreaction of SUSY-breaking branes

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We investigate whether vacuum solutions in flux compactifications that are obtained with smeared sources (orientifolds or D-branes) still survive when the sources are localised. This seems to rely on whether the solutions are BPS or not. We then use a specific setup with SUSY-breaking branes to further investigate this issue and show, for a wide class of boundary conditions, that there is no flux vacuum when the branes are described by a genuine delta-function. Even more, we find that the smeared solution is the unique solution with a regular brane profile. Our setup consists of a non-BPS AdS7 solution in massive IIA supergravity with smeared anti-D6-branes and fluxes T-dual to ISD fluxes in IIB supergravity. This casts doubts on the stringy consistency of non-BPS solutions that are obtained in the limit of smeared sources.

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## Massive Abelian Gauge Symmetries and Fluxes in F-theory

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F-theory compactified on a Calabi-Yau fourfold naturally describes non-Abelian gauge symmetries through the singularity structure of the elliptic fibration. In contrast Abelian symmetries are more difficult to study because of their inherently global nature. We argue that in general F-theory compactifications there are massive Abelian symmetries, such as the uplift of the Abelian part of the U(N) gauge group on D7-branes, that arise from non-Kahler resolutions of the dual M-theory setup. The four-dimensional F-theory vacuum with vanishing expectation values for the gauge fields corresponds to the Calabi-Yau limit. We propose that fluxes that are turned on along these U(1)s are uplifted to non-harmonic four-form fluxes. We derive the effective four-dimensional gauged supergravity resulting from F-theory compactifications in the presence of the Abelian gauge factors including the effects of possible fluxes on the gauging, tadpoles and matter spectrum.

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## Three-loop anomalous dimensions for squarks in SUSY QCD

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In this talk the calculation of the three-loop DRbar renormalization constants for the squark wave function and mass are discussed in the framework of supersymmetric QCD.
We introduce the general framework and describe in detail the reconstruction of the exact mass-dependence of the dimension-two scalar correlators.
From the renormalization constants the results for the corresponding anomalous dimensions are extracted. The calculation was done with non-zero epsilon scalar mass. As far as the renormalization of the epsilon scalar mass is concerned we have evaluated our results for three different schemes: DRbar, DRbarPrime and on-shell.

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## SO(10)-inspired Leptogenesis

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Leptogenesis is a broad class of models in which the observed Baryon Asymmetry of the Universe arises from a first lepton asymmetry. Furthermore, being Leptogenesis a cogent embedding for the seesaw mechanism, in these models neutrinos are provided a mass that matches the mass scale suggested by oscillation experiments in a natural way. In our work we consider a specific Leptogenesis model, obtained by imposing SO(10)-inspired conditions on the seesaw parameter space. The result is an N2-dominated scenario which merges two previously disconnected phenomenologies, related to the neutrino oscillations and the Baryon Asymmetry of the Universe, in a new and predictive framework. As a consequence, adopting the SO(10)-inspired Leptogenesis model, we can predict the same seesaw low energy parameters that the neutrino experiments aim to measure. In particular we calculate the probability distribution functions for the neutrino masses and mixing parameters, given the informations from neutrino oscillation experiments and the 7 year WMAP analyses.
In this way, beside confirming the presence of a lower bound on m_1 and m_ee, our analyses pointed to values of theta_13 which are in agreement with the latest results obtained by T2K.

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# Gravitino LSP and long-lived staus at the LHC

**Authors:** Jan Heisig[1]; Jörn Kersten[1]

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We present the phenomenology of the gravitino dark matter scenario at the large hadron collider (LHC) experiment. We consider the case that the next-to-lightest supersymmetric particle (NLSP) is the lighter stau. For a wide range of gravitino masses the lighter stau is stable on the scale of a detector. Such a particle will give rise to a prominent signature as a 'slow muon'. The dominant production channel of staus depends strongly on the hierarchy of the mass spectrum. However, the direct production (via the Drell-Yan process) is always present and independent of the remaining spectrum and thus sets a lower bound on the discovery potential of this scenario. In a careful analysis we show that this scenario will be found in the long-term LHC run for almost all reasonable assumptions for the mass spectrum including very high mass spectra as motivated from big bang nucleosynthesis (BBN) constraints.

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# A common framework for Minimal Length and Doubly Special Relativity

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Considering the possibility that at high energies a minimal resolvable length is directly related to one version of doubly special relativity we study an explicit common framework to embed both concepts. This allows us to analyze their compatibility and experimental consequences. As a result of this particular approach we conclude that both concepts are compatible only for momenta sufficiently smaller than the inverse of the minimal length. In this regime we can relate dissimilar experimental observables, for example modified atomic energy levels from minimal length effects with cosmological signals considering doubly special relativity. This correlation also should be the main tool to falsify this particular approach.

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## Simultaneous decoupling of bottom and charm quarks

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The framework of simultaneous decoupling of two heavy quarks in QCD is discussed. In particular we compute the decoupling constant for $\alpha_s$ with massive charm and bottom quarks to three-loop accuracy taking into account the exact dependence on $m_c/m_b$. The application of a low-energy theorem on this quantity allows for the extraction of the three-loop effective Higgs-gluon coupling valid for extensions of the Standard Model with additional heavy quarks.

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## Inflation and gravitino dark matter embedded in gauge-maediated SUSY-breaking mechanism

**Author:** Kohei Kamada[1]

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Cosmic inflation in the primordial universe is now considered as a part of the "standard"cosmology because it can solve the horizon and flatness problems and account for the origin of the primordial perturbation. However, we still cannot tell what is the real model of inflation that our universe has experienced.
On the other hand, supersymmetry is one of the most promising candidate of the physics beyond the standard model of particle physics and expected to be proved by LHC and other experiments. The realistic sypersymmetry model must be broken at a low energy scale and we require "hidden SUSY-breaking sector". Here we constructed a inflation model embedded in a SUSY-breaking sector and succeeded in finding a parameter set that does not have any critical cosmological problems.
In this talk, I introduce this model and explain how we avoid cosmological problems.
I also discuss the implication to the particle physics model.

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## Radio data and synchrotron emission in consistent cosmic ray models

**Author:** Torsten Bringmann[1]

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It is well established that even rather simple phenomenological two-zone diffusion models of the galactic halo can reproduce cosmic-ray nuclear data, and the observed antiproton flux, surprisingly well. Here, we consider lepton propagation in such models and compute the expected galactic population of electrons, as well as the diffuse synchrotron emission that results from their interaction with galactic magnetic fields. We find models that are consistent not only with cosmic ray data but also with radio surveys at essentially all frequencies. Requiring such a globally consistent description of seemingly unrelated galactic phenomena strongly disfavors both very large (L > 15 kpc) and small (L<= 1 kpc) values for the effective size of the diffusive halo. This has important implications for, e.g., indirect dark matter searches.

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## Inflation and non-minimal scalar-curvature coupling in gravity and supergravity

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Inflationary (slow-roll) dynamics in the gravity theory with a non-minimal scalar-curvature coupling can be equivalent to that in the certain f(R) gravity theory. We briefly review that correspondence and extend it to N=1 supergravity. The nonminimal coupling in supergravity is rewritten in terms of the standard (minimal) N=1 matter-coupled supergravity, by using their manifestly supersymmetric formulations in curved superspace. The equivalence relation between the supergravity with the nonminimal scalar-curvature coupling and the F(R) supergravity (ie. the N=1 locally supersymmetric extension of f(R) gravity) during the slow-roll inflation is established in the manifestly supersymmetric way (via curved superspace).

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## The overshoot problem in inflation after tunneling

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Within the context of the string theory landscape, inflation may happen after tunneling from a false vacuum onto a (possibly steep) slope. The field will be generically slowed down by the curvature dominated friction term. It has been argued from toy models of linear potentials that this may be insufficient to provide for a slow roll regime lest the potential is sufficiently flat for a large field range. This overshoot problem seems to exclude small field inflation models after tunneling events.

We extent the analysis to monomial potentials of arbitrary integer order. For orders 2 and 3 we give estimates of amount of overshoot. In contrary to this, for monomial potentials of order 4 and higher, the terminal velocity at the bottom of the potential is zero, allowing for small field inflation after tunneling.

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## Thermal decoupling in dark matter models with Sommerfeld-enhanced annihilation rates

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The expansion of the Universe causes DM annihilations to cease at chemical decoupling, but the DM is still kept in thermal equilibrium until kinetic decoupling. The temperature $T_{\rm kd}$ at which this happens translates directly into a small-scale cutoff for the matter density fluctuations. After kinetic decoupling the WIMP temperature decreases more quickly than the heat bath temperature, which causes the DM to reenter an era of annihilation if the cross-section is enhanced by the Sommerfeld effect. This can influence the final relic abundance of the DM signifcantly. Important for this discussion is the velocity distribution of the WIMPs, which can be kept Maxwellian by DM self-scatterings, and the temperature at which the annihilations finally cease, either by matter domination or the saturation of the Sommerfeld factor. The temperatures at which these effects take place, and the total effect on the final relic density are estimated for a leptophilic model and an estimate for the cutoff mass $M_{\rm cutoff}$ for the first protohalos will be given in this talk.

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## A sufficient condition for de Sitter vacua in type IIB string theory

**Authors:** Alexander Westphal[1]; Markus Rummel[2]

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We derive a sufficient condition for realizing meta-stable de Sitter vacua with small positive cosmological constant within type IIB string theory flux compactifications with spontaneously broken supersymmetry. There are a number of lamp post' constructions of de Sitter vacua in type IIB string theory and supergravity. We show that one of them – the method ofK\"ahler uplifting' by F-terms from an interplay between non-perturbative effects and the leading $\alpha'$-correction – allows for a more general parametric understanding of the existence of de Sitter vacua. The result is a condition on the values of the flux induced superpotential and the topological data of the Calabi-Yau compactification, which guarantees the existence of a meta-stable de Sitter vacuum if met. Our analysis explicitly includes the stabilization of all moduli, i.e. the K\"ahler, dilaton and complex structure moduli, by the interplay of the leading perturbative and non-perturbative effects at parametrically large volume.

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## The massless string spectrum on AdS_3 x S^3 from the supergroup

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A detailed description of the space of states underlying the hybrid formulation of string theory on AdS_3 x S^3 with pure NS-NS flux is given. The cohomology characterising the massless string states is computed, and the result is shown to agree with the expected supergravity answer.

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## Direct stau production at hadron colliders in cosmologically motivated scenarios

**Author:** Jonas Lindert[1]

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We calculate dominant cross section contributions for stau pair production at hadron colliders within the MSSM, taking into account left-right mixing of the stau eigenstates. We find that b-quark annihilation and gluon fusion can enhance the cross sections by more than one order of magnitude with respect to the Drell-Yan predictions. These additional production channels are not yet included in the common Monte Carlo analysis programs and have been neglected in experimental analyses so far. For long-lived staus, we investigate differential distributions and prospects for their stopping in the collider detectors. New possible strategies are outlined to determine the mass and width of the heavy CP-even Higgs boson H0. Scans of the relevant regions in the CMSSM are performed and predictions are given for the current experiments at the LHC. The obtained insights allow us to propose collider tests of cosmologically motivated scenarios with long-lived staus that have an exceptionally small thermal relic abundance.

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## The fine-tuning and phenomenology of the generalised NMSSM

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We determine the degree of fine-tuning needed in a generalised version of the NMSSM that follows from an underlying Z4 or Z8 R-symmetry. We find that it is significantly less than is found in the MSSM or NMSSM and remarkably the minimal fine-tuning is achieved for Higgs masses of 130 GeV - 140 GeV.

**29**

## How sensitive is the CMB to a single lens?

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While weak lensing (WL) of the CMB by LCDM large scale structure is well understood, the case of WL by a single, anomalously large, statistical isotropy breaking structure, is substantially different. We address the issue of the detectability of such a lens by means of its WL signal on the CMB, thus mending some previous results. Next we show that non-Gaussianities induced by LCDM WL play a key role in constraining this detectability. Finally, we consider the WMAP cold spot as an example and find that the hypothesis that it is caused by a void (or a texture) can barely (cannot) be tested via WL of the CMB.

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## Production of the Exotic 1−− Hadrons ϕ(2170), X(4260) and Yb(10890) at the LHC and Tevatron via the Drell-Yan Mechanism

**Authors:** Ahmed Ali[1]; Wei Wang[1]

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We calculate the Drell-Yan production cross sections and differential distributions in the transverse momentum and rapidity of the $J^{PC} = 1^{--}$ exotic hadrons $\phi(2170)$, X(4260) and $Y_b(10890)$ at the hadron colliders LHC and the Tevatron. These hadrons are tetraquark (four-quark) candidates, with a hidden $s\bar{s}$, $c\bar{c}$ and $b\bar{b}$ quark pair, respectively. In deriving the distributions and cross sections, we include the order $\alpha_s$ QCD corrections, resum the large logarithms in the small transverse momentum region in the impact-parameter formalism, and use the state of the art parton distribution functions. Taking into account the data on the production and decays of these vector hadrons from the $e^+e^-$ experiments, we present the production rates for the processes $pp(\bar{p}) \to \phi(2170)(\to \phi(1020)\pi^+\pi^- \to K^+K^-\pi^+\pi^-) + ...$, $pp(\bar{p}) \to X(4260)(\to J/\psi\pi^+\pi^- \to \mu^+\mu^-\pi^+\pi^-) + ...$, and $pp(\bar{p}) \to Y_b(10890)(\to (\Upsilon(1S), \Upsilon(2S), \Upsilon(3S))\pi^+\pi^- \to \mu^+\mu^-\pi^+\pi^-) + ....$ Their measurements at the hadron colliders will provide new experimental avenues to explore the underlying dynamics of these hadrons.

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## Bayesian analysis of current direct detection experiments

**Author:** Chiara Arina[1]

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Recently there has been a huge activity in the dark matter direct detection field, with the report of an excess from CoGeNT
and Cresst, the two events in the CDMS-II along with the annual modulated signal of DAMA/Libra and the strong exclusion bound
from Xenon100. We analyse these results within the framework of bayesian inference. Indeed bayesian methods are well suited for marginalizing over the experimental systematics and the background. We present the results for
spin-independent interaction on nucleus with particular attention to the low dark matter mass region and the compatibility between experiments. In the same vein we also investigate the impact of astrophysical uncertainties on the WIMP preferred parameter space within the class of isotropic dark matter velocity distributions.

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# Experimental tests of multimetric gravity - gravitational waves and the cosmos

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We consider a class of gravity theories containing N copies of the standard model and a corresponding number of metric tensors. Theories of this type exhibit repulsive gravitational forces between the different standard model copies in the Newtonian limit, and provide a potential explanation for the small late-time acceleration of the universe. In this talk we present some new results on possible tests of such theories. We focus on the physics of gravitational waves and briefly discuss potential cosmological tests.

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# Reheating, Matter, Dark Matter –All you need is Neutrino Decays

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The decays of heavy Majorana neutrinos and their superpartners shortly after inflation simultaneously give rise to three crucial ingredients for the hot early universe: (1) the entropy inherent to the thermal radiation that dominates the overall energy density, (2) the matter-antimatter asymmetry and (3) dark matter. For characteristic neutrino parameters baryogenesis can be accomplished by means of nonthermal leptogenesis. At the same time the reheating temperature is controlled by the neutrino lifetime in such a way that thermal production of the gravitino, which we assume to be the lightest superparticle, automatically yields the observed amount of dark matter. This connection between the neutrino sector and supergravity results in constraints on superparticle masses in terms of neutrino masses and vice versa. In order to generate a sufficient neutrino abundance after inflation we consider, as an example, neutrino production in the course of tachyonic preheating associated with spontaneous B - L breaking. Our scenario is sensitive to the light neutrino masses and the supergravity mass spectrum and can hence be tested by colliders and in cosmological observations.

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# CP-mirror Extension of Standard Model in SU(3)$\times$SU(2)$_L\times$SU(2)$_R\times$U(1)$_I$

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We propose an extension of standard model based on SU(3)$\times$SU(2)$_L\times$SU(2)$_R$ $\times$U(1)$_I$ gauge group, where for each standard model (SM) fermion (plus the right handed neutrino) there is a CP-mirror counterpart with the same lepton or color quantum number. Thus for left handed lepton and quark doublets $\begin{pmatrix} \nu^0 \\ e^- \end{pmatrix}_L$, $\begin{pmatrix} u^{2/3} \\ d^{-1/3} \end{pmatrix}_L$ (respectively (1,\textbf{2},1,-1) and (3,\textbf{2},1,1/3)) we have right

handed lepton and quark doublets with reverse hypercharges, i.e. $\begin{pmatrix} E^+ \\ N^0 \end{pmatrix}_R$, $\begin{pmatrix} D^{1/3} \\ U^{-2/3} \end{pmatrix}_R$ (respectively (1,1,\textbf{2},1) and (\textbf{3},1,\textbf{2},-1/3)). While for right handed lepton and quarks singlets, $e_R^-, \nu_R^0, u_R^{2/3}, d_R^{-1/3}$ (respectively (1,1,1,-2), (1,1,1,0), (\textbf{3},1,1,4/3), (\textbf{3},1,1,-2/3)), we have a left handed lepton and quark singlet with reverse hypercharges, $E_L^+, N_L^0, U_L^{-2/3}, D_L^{1/3}$ (respectively (1,1,1,2), (1,1,1,0), (\textbf{3},1,1,-4/3), (\textbf{3},1,1,2/3)). We also impose a global lepton number conservation, thereby there is no majorana neutrino in this model. In the Higgs sector we have left and right Higgs doublets, but no bidoublet (thus no FCNC and no mixing between the $W_L$ and $W_R$). Additionally we have two lepto-quark singlet ((**3**$^*$,1,1,-2/3) and (**3**$^*$,1,1,2/3)) and one singlet scalars (1,1,1,0). This model by construction is anomaly free.

After spontaneous symmetry breaking, the left and right Higgs doublets will acquire vacuum expectation values (vev) with $v_R > v_L$, breaking the parity spontaneuously. The two set of fermions will have different masses with the standard model particles have their usual masses through the usual mechanism, while the CP-mirror counterpart will have very heavy masses due to its Yukawa coupling with the right handed Higgs doublet. As an exception is the neutrino, since both the the singlet right handed neutrino and its CP-mirror counterpart have $I = 0$, we can have a mixing between them with arbitrary heavy bare mass. This mixing will lead to a type-I Dirac seesaw-like mechanism which, in the mass basis, gives one neutrino with a very small mass and the other one with very large mass. The lepto-quark scalars will facilitate the decay of the very heavy CP-mirror leptons into the SM quarks and the very heavy CP-mirror quarks into the SM leptons. Several other consequence will also be explored.

Keywords: extended standard model, left-right symmetry, seesaw mechanism

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# Form Factors and Strong Couplings of Heavy Baryons from QCD Light-Cone Sum Rules

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We derive QCD light-cone sum rules for the hadronic matrix elements of the heavy baryon transitions to nucleon. In the correlation functions the $\Lambda_c, \Sigma_c$ and $\Lambda_b$ -baryons are interpolated by three-quark currents and the nucleon distribution amplitudes are used. To eliminate the contributions of negative parity heavy baryons, we combine the sum rules obtained from different kinematical structures. The results are then less sensitive to the choice of the interpolating current. We predict the $\Lambda_b \to p$ form factor and calculate the widths of the $\Lambda_b \to p\ell\nu_l$ and $\Lambda_b \to p\pi$ decays.
Furthermore, we consider double dispersion relations for the same correlation functions and derive the light-cone sum rules for the $\Lambda_c ND^{(*)}$ and $\Sigma_c ND^{(*)}$ strong couplings. Their predicted values can be used in the models of charm production in $p\bar{p}$ collisions.

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# Non-diagonal current correlators with two different masses up to three-loop order

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Current correlators provide an important tool to relate theoretical calculations and experimental measurements. In this talk non-diagonal correlators of scalar, pseudoscalar, vector and axialvector currents are considered coupling to fermions with two different masses m_1 and m_2. We evaluate moments up to three-loop order considering the hierarchies m_1 » m_2 and m_1 = m2. It is shown that the combination of the two expansions leads to an excellent approximation of the exact result.

**38**

## Heavy flavor 3-loop corrections to Deep Inelastic Scattering

**Authors:** Carsten Schneider[1]; Fabian Wissbrock[2]; Isabella Bierenbaum[3]; Jakob Ablinger[1]; Johannes Bluemlein[2]; Sebastian Klein[3]

[1] *RISC Linz*

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Heavy flavor contributions are of key relevance for DIS precision analyses of HERA and world hard scattering data. We present recent results on the $O(as^3T_F^2)$ contributions to the massive operator matrix elements (OMEs) describing the Heavy Flavor Wilson Coefficients in the limit $Q^2 \gg m^2$ for general values of the Mellin variable $N$. We thereby consider contributions stemming from diagrams with two fermionic lines of identical or different masses. For two heavy flavor Wilson coefficients, $L_q^{\mathsf{PS}}(N)$ and $L_g^{\mathsf{S}}$, the complete 3-loop results for general vales of $N$ has been obtained. Along with the computation for the OMEs a first independent recomputation of the corresponding contributions to the 3–loop anomalous dimensions $\gamma_{qg}(N)$, $\gamma_{qq}^{\mathsf{PS}}(N)$, and $\gamma_{qq}^{\mathsf{NS},(\mathsf{TR})}(N)$ has been performed. All our results could be expressed by nested harmonic sums only, while in intermediary results more general structures emerged.

**39**

## Higgs boson production in gluon fusion to NNLO in the MSSM

**Authors:** Alexey Pak[1]; Matthias Steinhauser[1]; Nikolai Zerf[1]

[1] *Institut fuer Theoretische Teilchenphysik, Karlsruhe Institute of Technology (KIT)*

We present our calculation of the NNLO production cross section of the Higgs-boson via gluon fusion within the framework of an effective theory.
This includes the determination of the matching coefficient $C_1$, which contains all hard effects of the heavy SUSY particles, up to three loops in SUSY-QCD.
We will point out the correct treatment of the used supersymmetric regulator (DRED) during the matching procedure.
Finaly numerical results for the cross section are discussed for typical supersymmetric scenarios.

**40**

## Status of the AMS-02 detector on the International Space Station

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On May 19th 2011 the Alpha Magnetic Spectrometer 02 (AMS-02) was mounted on the International Space Station (ISS). Since then the detector is measuring the spectrum of cosmic rays (CRs) and gamma rays with unpreceded accuracy at an unpreceded rate. AMS-02 is able to measure charged CRs up to Iron and up to TeV energies. The first task of analysis is the calibration of the detector in space. This talk focuses on approaches of the calibration for the transition radiation detector (TRD), which was mainly build in Germany (RWTH Aachen, KIT Karlsruhe).

**41**

## Implications of CoGeNT's New Results For Dark Matter

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This talk will present on an independent analysis of the recent release of the first 15 months of CoGeNT's data. The analysis will focus on the properties of a dark matter particle that are consistent with the spectrum and modulation of the low energy excess of events in the detector. I will also examine the data in light of the new CRESST results and present prospects of detecting such a dark matter particle at other experiments.

**42**

## Local CP-violation in quark gluon plasma: a holographic study.

**Author:** Tigran Kalaydzhyan[1]

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We study the local CP-violation in a sQGP-like plasma due to the presence of strong magnetic fields and/or due to the spatial rotation of the medium. We consider the STU model as a gravity dual of the plasma with multiple anomalous U(1) currents. In the bulk we add additional background gauge fields to include the effects of external electric and magnetic fields on the plasma. Reducing the number of chemical potentials in the STU model to two and interpreting them as quark and chiral chemical potential, we obtain a holographic description of the chiral magnetic and chiral vortical effects (CME and CVE) in relativistic heavy ion collisions. These effects formally appear as first-order transport coefficients in the electromagnetic current. We compute these coefficients from our model using fluid-gravity duality. We also find analogous effects in the axial current. Finally, I'll briefly discuss a variant of our model, in which the CME/CVE is realized in the late-time dynamics of an expanding plasma.

**43**

## Local CP-violation in quark gluon plasma: a lattice study.

**Author:** Tigran Kalaydzhyan[1]

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**Corresponding Author:** tigran.kalaydzhyan@desy.de

We study local CP-odd properties of the non-Abelian vacuum induced by strong external magnetic fields. These properties can be probed by local chirality and electric currents of the light fermions in the gluonic background. We perform calculations in the quenched SU(3) lattice gauge theory with tadpole-improved Luscher-Weisz action and overlap fermions. The main results of the study are the following: (1) There are finite local fluctuations of the chirality growing with strength of the magnetic field. (2) We observe a spatial inhomogeneous distribution of the chirality –it is mostly localized on low dimensional defects (with d=2-3), exactly as fermionic zero-modes. (3) There are also fluctuations of the electromagnetic current of quarks along the field. Combining this with a finite conductivity of the vacuum (also measured during the study) we arrive to some lattice evidences of the Chiral Magnetic Effect (CME).
Finally, I'll describe a field-theoretic interpretation of our results using a two-component superfluid model, where the axial current is carried by an axion-like excitation of the superfluid condensate.

**44**

## A Conformal Bi-metric Model for the Inflationary Phase

**Author:** Giandomenico Palumbo[1]

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We consider a pure geometric action that characterizes a bi-metric gravity model, where the two metric tensors are conformally related to each other through a conformal factor physically represented by a scalar field.
We show how this scalar field can be seen as the field that drives the Inflationary expansion. The only two parameters of the action are respectively the Planck energy scale and the energy scale of Inflation, while the inflationary potential has the shape of the Landau-Ginzburg potential. For this potential, that is well known in the inflationary scenario, the theoretical prediction of the spectral index is in good agreement with the recent experimental
data.
Moreover the metric of the MTZ (Martinez-Troncoso-Zanelli) Black Holes is a solution of this model and in the cosmological context, we can regard these Black Holes as (unstable) Primordial Black Holes.
As a final remark, we show that in two dimensions our model is related to Liouville gravity.

**45**

## The Primordial Lithium Problem : Can We Avoid New Physics ?

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The primordial abundances of light elements form an important evidence of the Big Bang Model of the universe. With precise measurements of the baryon-to-photon ratio, \eta from WMAP, these final abundances, which are functions of \eta alone in general, are fixed and must be consistent. As a result, any discrepancy between the theoretical and observational abundances of these elements, as exists for lithium, may be due to inadequacies in the Big Bang Nucleosynthesis (BBN) Model which is based on the Standard Model of particle physics and cosmology. In fact, the theoretical Li-7 abundance is 3-4 times more than the observational value inferred from \eta_{WMAP} ; this is known as the "Lithium Problem". This could potentially point to new physics beyond the Standard Model. However, one must first exhaust standard alternatives / solutions before resorting to new physics. Here we examine solutions within standard nuclear physics that lead to additional destruction of A=7 isotopes due to new nuclear reaction channels or upward corrections to existing channels, as the production channels are more constrained. This could be achieved within the Standard Model via missed resonant nuclear reactions, which is the possibility explored here. We find some potential candidate resonances that can solve the lithium problem and specify required resonance energies and widths. For all of these states, a large channel radius (a > 10 fm) is needed to give sufficiently large widths. These resonance properties need experimental verification. If experiment rules them out, then we may be compelled to invoke new physics to solve the lithium problem and potentially constrain new physics models.

**46**

## Dilaton gravity at the brane with general matter-dilaton coupling

**Author:** Dominika Konikowska[1]

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In the ongoing search for a unified description of gravity and the gauge interactions of the Standard Model, string theories are usually regarded as the most promising proposal. At the leading order the low-energy effective action in string theories, restricted to gravity and the dilaton, yields precisely the standard Einstein gravity coupled to the dilaton field. Regarding that the very formulation of string theories requires additional spatial dimensions, I will address such dilaton gravity in a 5-dimensional brane scenario. I will derive in the covariant approach the effective Einstein-like brane equation for a general non-minimal coupling of the dilaton to the brane matter Lagrangian in the Einstein frame - thus accounting for the lack of a clear consensus as to which of the conformally-related frames is the natural physical frame. The bulk's influence on the brane gravity will be clearly identified. Subsequently, I will show that the inhomogeneities in the perfect fluid on the brane (describing the matter content of the universe) are highly constrained in this scenario for the common assumption of the anti de Sitter type bulk.

**47**

## Dark goo: Bulk viscosity as an alternative to dark energy

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We present a simple (microscopic) model in which bulk viscosity plays a role in explaining the present acceleration of the universe. The effect of bulk viscosity on the Friedmann equations is to turn the pressure into an "effective" pressure containing the bulk viscosity. For a sufficiently large bulk viscosity, the effective pressure becomes negative and could mimic a dark energy equation of state. Our microscopic model includes self-interacting spin-zero particles (for which the bulk viscosity is known) that are added to the usual energy content of the universe. We study both background equations and linear perturbations in this model. We show that a dark energy behavior is obtained for reasonable values of the two parameters of the model (i.e. the mass and coupling of the spin-zero particles) and that linear perturbations are well-behaved. There is no apparent fine tuning involved. We also discuss the conditions under which hydrodynamics holds, in particular that the spin-zero particles must be in local equilibrium today for viscous effects to be important.

**48**

## Numerical evaluation of QCD one-loop amplitudes

**Author:** Benedikt Biedermann[1]

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We present the publicly available program NGLUON allowing the numerical evaluation of colour-ordered amplitudes at one-loop order in massless QCD. The current version for an arbitrary number of external gluons is extended to an arbitrary number of quark flavours. Besides numerical stability and performance issues, we discuss the reconstruction of the full QCD amplitudes from color-ordered building blocks for up to six partons. First phenomenological issues with regard to the LHC are discussed.

**49**

## Semi-Classical Charged Black Holes

**Authors:** Friðrik Freyr Gautason[1]; Larus Thorlacius[2]

[1] *Leibniz Universität Hannover*

[2] *Nordita*

I present numerical simulations of formation and evaporation of two dimensional charged black holes. I will start by introducing the model we use and explain the challenges we meet when we try to study the internal structure of black holes. I will then summarize the algorithm used and present results. In the classical case we observe the equivalent of the so-called mass inflation scenario for four dimensional charged black holes but then we study how quantum effects modify the global geometry of charged black holes.

**50**

## Ultra-High Energy Neutrinos and the Glashow Resonance

**Author:** Atsushi Watanabe[1]

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We study the signatures of the Glashow resonance process $\bar{\nu}_e e \to W$ in the high-energy astrophysical neutrino observatory IceCube.
We note that in addition to the standard hadronic and electromagnetic showers produced by an incoming neutrino at the resonance energy of $E_\nu \approx 6.3$ PeV, there are two clear signals of the process: the pure muon" from $\bar{\nu}_e e \to \bar{\nu}_\mu \mu$ and thecontained lollipop" from $\bar{\nu}_e e \to \bar{\nu}_\tau \tau$.
The event rate and the signal-to-background ratio (the ratio of the resonant to concurrent non-resonant processes) are calculated for each type of interaction, based on current flux limits on the diffuse neutrino flux.
Because of the low background in the neighborhood of the resonance, the observation of only one pure muon or contained lollipop event essentially signals discovery of the resonance, even if the expected event numbers are small.
We also evaluate the total event rates of the Glashow resonance from the extra-galactic diffuse neutrino flux and emphasize its utility as a discovery tool to enable first observations of such a flux.
We find that one can expect 3.6 (0.65) events per year for a pure $pp$ ($p\gamma$) source, along with an added contribution of 0.51 (0.21) from non-resonant events.
We also give results as a function of the ratio of $pp$ vs $p\gamma$ sources.

**51**

# Flavour issues for a heavy scalar spectra with a low gluino mass: the G2-MSSM case

**Authors:** Gordon Kane[1]; Joern Kersten[2]; Kenji Kadota[3]; Liliana Velasco-Sevilla[4]

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In recent years it has been learned that scalar superpartner masses and trilinear couplings are generically larger than about 20 TeV at the short distance string scale if our world is described by a compactified string or M-theory with supersymmetry breaking and stabilized moduli. Here we study implications of this, for a particular realization (compactification of M-theory on a G2 manifold) where there is a good knowledge of the superpotential, the gauge kinetic function, and a light gluino.
Flavour violation stems from off-diagonal and non-universal diagonal elements of scalar mass matrices and trilinear couplings, and from renormalization group running. We also examine stability bounds on the scalar potential. While heavy scalars alone do not guarantee the absence of flavour problems because results depend on the Yukawa and trilinear couplings, our studies show that models with heavy scalars and light gluinos can be free from flavour problems.

**52**

# A fitting formula for the effects of massive neutrinos in the non-linear regime

**Author:** Daniel Boriero[1]

**Co-author:** Yvonne Wong [2]

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The distribution of matter in small scales, subject to nonlinear effects, will be much better known in the next few years through upcoming surveys. To accomplish the measurement of parameters such as the neutrino mass the theoretical preciseness must evolve accordingly. We present some improvements in theoretical prediction for the matter power spectrum taking in account the effect of massive neutrinos in the nonlinear regime. The method used was a modified version of Halofit calibrated over N-Body simulations with massive neutrinos.

**53**

## Electroweak constraints on non-minimal UED and split UED and implication for the KK mass spectrum

**Author:** Thomas Flacke[1]

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Models with Universal Extra Dimensions provide one of the simplest extra dimensional extensions of the Standard Model which incorporates a dark matter candidate and can provide a rich LHC phenomenology which strongly resembles SUSY signals. The minimal UED Kaluza Klein Spectrum can be modified in two ways: by operators which are localized at the orbifold fixed points (non-minimal UED) or by five-dimensional fermion mass terms (split UED). We show that and how both these options strongly modify the electroweak precision constraints on UED and discuss implications for the Kaluza Klein mass spectrum.

**54**

## UV-protected (Natural) Inflation: Primordial Fluctuations and non-Gaussian Features

**Author:** Yuki Watanabe[1]

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We consider the UV-protected inflation, where the inflaton potential is obtained by quantum (one-loop) breaking of a global symmetry into a discrete symmetry. In this model, all coupling scales are sub-Planckian. This is achieved by coupling the inflaton kinetic term to the Einstein tensor such that the friction is enhanced gravitationally at high energies. In this respect, this new interaction makes virtually any potential adequate for inflation while keeping the system perturbative unitary. We show that even if the gravitationally enhanced friction intrinsically contains new nonlinearities, the UV-protected inflation (and any similar models) behaves as a single field scenario with red tilted spectrum and potentially detectable gravitational waves. Interestingly enough, we find that non-Gaussianity of the curvature perturbations in the local form are completely dominated by the nonlinear gauge transformation from the spatially flat to uniform-field gauge and/or by parity violating interactions of the inflaton and gauge bosons. In particular, the parity violating interactions may produce detectable non-Gaussianity.

**55**

## Knotted strings and leptonic flavor structure

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Tight knots and links arising in the infrared limit of string theories may provide an interesting alternative to flavor symmetries for explaining the observed flavor patterns in the leptonic sector. As an example we consider a type I seesaw model where the Majorana mass structure is based on the discrete length spectrum of tight knots and links. It is shown that such a model is able to provide an excellent fit to current neutrino data and that it predicts a normal neutrino mass hierarchy as well as a small mixing angle $\theta_{13}$.

**56**

## Light NMSSM Higgs bosons in SUSY cascades

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The next-to-minimal supersymmetric SM (NMSSM) admits light Higgs bosons (MH < MZ) without being in conflict with current experimental bounds. Due to a large singlet component, their direct production in standard channels at the Large Hadron Collider (LHC) is suppressed. We demonstrate that there are good prospects for observing such a light Higgs boson in decays of heavy neutralinos and charginos. We consider an example scenario with 20 GeV < MH < MZ. Performing a Monte Carlo analysis at the level of fast detector simulation, it is demonstrated how the Higgs signal can be separated from the main backgrounds. The resulting b ̄b mass spectrum could provide an opportunity for light Higgs boson discovery already with 5 fb−1 of LHC data at 7 TeV.

**57**

## Primordial decays and non-Gaussianities

**Author:** Angela Lepidi[1]

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Cosmological perturbations and their possible non-Gaussian features are key observables to understand the evolution of the primordial universe and the involved high energy physics.
After a basic review on the subject, I will present a general formalism that provides a systematic computation of the linear and non-linear perturbations for an arbitrary number of cosmological fluids in the early Universe going through various transitions, in particular the decay of some species. The mixed inflaton-curvaton scenario is presented as an application. More generally, the presented formalism can be used as a toolbox to study systematically the cosmological constraints, arising from linear perturbations and from non-Gaussianities, for particle physics models in the early Universe.

**58**

## Goldstone bosons in Higgs inflation

**Author:** Sander Mooij[1]

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Higgs inflation uses the gauge variant Higgs field as the inflaton. During inflation the Higgs field is displaced from its minimum, which results in associated Goldstone bosons that are apparently massive. Working in a minimally coupled U(1) toy model, we use the closed-time-path formalism to show that these Goldstone bosons do contribute to the one-loop effective action. Therefore the computation in unitary gauge gives incorrect results. Our expression for the effective action is gauge invariant upon using the background equations of motion.

**59**

## The matter bispectrum in the Lagrangian framework

**Author:** Cornelius Rampf[1]

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In this talk we calculate the one-loop correction to the matter bispectrum using Lagrangian Perturbation Theory (LPT). To achieve this we first compute the fastest growing mode of the fourth order solution in LPT, which is as yet missing in the literature. Then, we construct a general expression for the bispectrum in the LPT framework and perform a loop expansion. Resummation techniques are then applied. Finally, we compare our results to those from N-body simulations, for both Gaussian and non-Gaussian initial conditions.

**60**

## Quasi-stable neutralinos at the LHC

**Author:** Jan Hajer[1]

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In this talk I will present our work on phenomenology of supergravity models with R-parity breaking, in which the gravitino is the lightest superparticle and a bino-like neutralino is the next-to-lightest superparticle. Based on Fermi-LAT constraints on gravitino decays we estimated a lower bound on the neutralino decay length of $c\tau_{\chi_1^0}$
$gtrsim 30$ cm. We performed a detailed study on the sensitivity of LHC experiments to R-parity breaking. We found that the LHC can probe a parameter range which is one to two orders of magnitude smaller than the present upper bound obtained from astrophysics and cosmology.

**61**

## Subleading-N improved Parton Showers

**Authors:** Malin Sjödahl[1]; Simon Plätzer[2]

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Parton shower simulations are typically formulated in the large-N limit, neglecting color correlations suppressed by inverse powers of N. We outline an algorithm to improve parton shower algorithms by subleading-N color correlations. Preliminary numerical results from an implementation building on recent extensions to the Herwig++ event generator are presented.

**62**

## Threshold resummation for squark-and gluino hadroproduction

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The production of SUSY particles (sparticles) at the LHC is dominated by processes involving coloured sparticles in the final state. Since these processes are of great importance for SUSY searches at the LHC, precise theoretical predictions are needed. Higher-order QCD corrections are dominated by large logarithmic terms due to the emission of soft gluons from initial and final state particles. A systematic treatment of these logarithms to all orders in perturbation theory is provided by resummation methods. In this talk we will present predictions for total cross sections for the LHC which include next-to-leading order supersymmetric QCD corrections and the resummation of soft gluon emission at next-to-leading-logarithmic (NLL) accuracy.
We discuss the impact of these higher-order corrections on total cross sections, and provide an estimate of the theoretical uncertainty due to scale variation and the parton distribution functions. Furthermore we present results at next-to-next-to-leading-logarithmic (NNLL) accuracy for the production of a squark-antisquark pair.

**63**

## Effect of SUSY-QCD corrections on the dark matter relic density

**Author:** Julia Harz[1]

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A powerful method to constrain the parameter space of theories beyond the Standard Model is to compare the predicted dark matter relic density with data from cosmological precision measurements like WMAP. In many models one of the main uncertainties on the relic density calculation arises from the (co-)annihilation cross sections of the dark matter particle. I will motivate why it is important to take SUSY-QCD corrections at next-to-leading order into account when calculating the neutralino relic density and give a status report of the package DM@NLO. This package will allow to include these corrections to the public codes MicrOMEGAs and DarkSUSY.

**64**

## Precise Prediction for the W boson mass in models beyond the SM

**Author:** Lisa Zeune[1]

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Electroweak precision observables are of utmost importance for testing
and constraining physics beyond the Standard Model (SM). The indirect
constraints on new physics obtained from precision observables
are complementary to the direct searches for new physics carried out
at the LHC and elsewhere.
The MW-MZ interdependence is highly sensitive to quantum effects
from the entire particle spectrum of a given model. In order to
fully exploit the improved experimental accuracy expected at the LHC,
a precise theoretical prediction for the W boson mass in various models beyond the SM is desired.
We present results for the W boson mass prediction in the MSSM with complex parameters, including all known higher-order corrections of SM- and SUSY-type.
The implications of LHC search limits on electroweak precision observables are discussed.

**65**

## Non-Gaussianity in single field models without slow-roll

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In inflationary theories, single field models are typically considered subject to slow-roll conditions. However, as I will show in this talk, current observational constraints allow significant violations of these conditions. Focusing on non-Gaussian signals, I will discuss a variety of new observational signatures that can be found for fast-rolling single fields.

**66**

## Towards Matter Inflation in Effective Heterotic Supergravity Theories

**Authors:** Johanna Erdmenger[1]; Koushik Dutta[2]; Sebastian Halter[1]; Stefan Antusch[3]

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We discuss the phenomenologically interesting scenario of matter inflation in supersymmetric hybrid inflation models. The inflaton is contained in a gauge non-singlet matter multiplet and the eta-problem is solved by a "Heisenberg" symmetry. This symmetry relates the inflaton with a modulus field and we stabilize this modulus via corrections to the Kähler potential. The Heisenberg symmetry

arises naturally in the low-energy effective action for the untwisted matter fields in heterotic orbifold compactifications. We construct a class of supergravity models which may be suitable to realise inflation in heterotic orbifolds. Moduli stabilization within the extended setup is discussed.

**67**

## SHARP GAMMA-RAY SPECTRAL FEATURES IN INDIRECT DARK MATTER SEARCHES

**Author:** Francesca Calore[1]

[1] *University of Hamburg*

Gamma rays from the annihilation of dark matter particles in the Galactic halo provide a particularly promising means of indirectly detecting dark matter. Notably, pronounced spectral features near the kinematic cutoff at the dark matter particles' mass - a generic prediction for most models - represent a 'smoking gun' signature for dark matter indirect detection. In this talk, we present projected limits on such features and show that they can be much more efficient in constraining the nature of DM than the model-independent broad spectral features expected at lower energies. In particular, we discuss how they can significantly improve the sensitivity of current and future gamma-ray telescopes to dark matter signals.

**68**

## Pressure from dark matter annihilation and the rotation curve of spiral galaxies

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The rotation curves of spiral galaxies are one of the basic predictions of the cold dark matter paradigm, and their shape in the innermost regions has been hotly debated over the last decades. The present work shows that dark matter annihilation into electron-positron pairs may affect the observed rotation curve by a significant amount. We adopt a model-independent approach, where all the electrons and positrons are injected with the same initial energy E_0 ~ m_dm*c^2 in the range from 1 MeV to 1 TeV and the injection rate is constrained by INTEGRAL, Fermi, and HESS data. The pressure of the relativistic electron-positron gas is determined by solving the diffusion-loss equation, considering inverse Compton scattering, synchrotron radiation, Coulomb collisions, bremsstrahlung, and ionization. For values of the gas density and magnetic field that are representative of the Milky Way, it is estimated that pressure gradients are strong enough to balance gravity in the central parts if E_0 < 1 GeV. The exact value depends somewhat on the astrophysical parameters, and it changes dramatically with the slope of the dark matter density profile. For very steep slopes, as those expected from adiabatic contraction, the rotation curves of spiral galaxies would be affected on ~kpc scales for most values of E_0. By comparing the predicted rotation curves with observations of dwarf and low surface brightness galaxies, we show that the pressure from dark matter annihilation may improve the agreement between theory and observations in some cases, but it also imposes severe constraints on the model parameters (most notably, the inner slope of halo density profile, as well as the mass and the annihilation cross-section of dark matter particles into electron-positron pairs).

Wechakama M., Ascasibar Y.,2011, MNRAS, 413, 1991, arXiv:1007.3179

**70**

## Chirality inducing G4-flux in F-theory compactications

**Author:** Sven Krause[None]