45th SLAC Summer Institute

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SLAC

Poster Session

Book of Abstracts

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2-FAST: Fast and Accurate Computation of Projected Two-point Functions

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We present the 2-FAST (2-point function from Fast and Accurate Spherical bessel Transformation) algorithm for a fast and accurate computation of integrals involving one or two spherical Bessel functions. These types of integrals occur when projecting the galaxy power spectrum $P(k)$ onto the configuration space, $\xi_\ell^\nu(r)$, or spherical harmonic space, $C_\ell(\chi, \chi')$. With the Hankel transformation of the power spectrum, we first divide the calculation into cosmology-dependent coefficients and cosmology-independent integration of basis functions multiplied by spherical Bessel functions. We find analytical expression for the latter integrations in terms of special functions, for which recursion provides a fast and accurate evaluation. The algorithm, therefore, circumvents direct integration of highly oscillating spherical Bessel functions.

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Dark Matter Relics and Scalar Tensor Theories

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The expansion rate of the universe had a strong influence on the origin of the dark matter abundance during the early stages of the universe's evolution, mainly prior to big-bang nucleosynthesis. Any departure of the expansion rate of the universe from the standard cosmological model during that time can modify the dark matter abundance. In this poster, I will show the role played by a scalar field on the modification of the expansion rate of the universe arising from scalar-tensor theories of gravity coupled both conformally and disformally to matter, and also, I will show how these variations to the expansion rate would modify the dark matter content of the Universe.

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Early Dark Energy & the Hubble Tension

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We explore a scenario with a new exotic energy density that behaves like a cosmological constant at early times and then decays quickly at some critical redshift z_c. This work was motivated by tensions between the value of the Hubble constant H_0 determined from the CMB and that measured in the local universe. By increasing the expansion rate at early times, the very precisely determined angular scale of the sound horizon at decoupling can be preserved with larger H_0. We find, however, that the Planck temperature power spectrum tightly constrains the magnitude of the early dark-energy density and thus any shift in H_0 obtained from the CMB. In the process, we derive strong constraints to the contribution of early dark energy at the time of recombination - it can never exceed ~2% of the radiation/matter density for $10 \leq z_c \leq 10^5$.

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Elastically Decoupling Dark Matter

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We present a novel dark matter candidate, an Elastically Decoupling Relic (ELDER), which is a cold thermal relic whose present abundance is determined by the cross-section of its elastic scattering on Standard Model particles. The dark matter candidate is predicted to have a mass ranging from a few to a few hundred MeV, and an elastic scattering cross-section with electrons, photons and/or neutrinos in the 10^{−3} – 1 fb range.

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Cosmological Constraints and Detection Prospects for Sub-MeV Dark Matter

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Sub-MeV dark matter remains relatively unconstrained by direct detection, and several well-motivated candidates in this mass range have aroused great interest. Electron recoil experiments have been proposed as a technique to detect such a light particle, but little is known about the extent of cosmological restrictions on a light species coupled to electrons. We perform a systematic study of cosmological constraints on a light dark matter particle coupled to electrons by one of a comprehensive set of effective operators, which approximate a broad class of models with a heavy mediator. Specificially, we study constraints from primordial nucleosynthesis, the dark matter relic abundance, and the effective number of neutrino species (N_{eff}) at CMB formation. We demonstrate the implications of our results for proposed electron recoil experiments, and highlight the regions of parameter space which may be amenable to direct detection.

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Heavy Photon Search

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Compelling motivations, including promising classes of dark matter models compatible with various observed astrophysical anomalies, motivate the existence of a massive gauge boson carrier of a $U'(1)$ gauge symmetry beyond the Standard Model. This hypothesized “heavy photon” (abbreviated A') would interact feebly with the SM, through kinetic mixing with the SM photon. Our experiment seeks to produce the A' in a laboratory setting by striking a tungsten foil target with a continuous electron beam. An A' may be produced in a process analogous to bremsstrahlung, and then decay into an e^+e^- pair. Our detector setup consists of a silicon vertex tracker surrounded by a large magnet for tracking the pair, and an electronic calorimeter for triggering. To find the A' signal amongst the much larger QED background, we use resonance search (bump-hunt) and displaced-vertex search techniques. We have taken data with two beam energies: 1.05 GeV during our 2015 engineering run, and 2.3 GeV in our 2016 production run. This poster describes the experimental setup and presents preliminary results for the two datasets, as well as projected reach for future running.

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Dielectric Haloscopes: A New Way to Detect Axion Dark Matter

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We propose a new strategy to search for dark matter axions in the mass range of 40–400 μeV by introducing dielectric haloscopes, which consist of dielectric disks placed in a magnetic field. The changing dielectric media cause discontinuities in the axion-induced electric field, leading to the generation of propagating electromagnetic waves to satisfy the continuity requirements at the interfaces. Large-area disks with adjustable distances boost the microwave signal (10-100 GHz) to an observable level and allow one to scan over a broad axion mass range. A sensitivity to QCD axion models is conceivable with 80 disks of 1 m^2 area contained in a 10 Tesla field.

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Uncertainties in the Calculation of Dark Matter Observables

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The LHC's null results for searches beyond the the Standard Model have ruled out the simplest and most constrained version of supersymmetry (SUSY). Many more formulation of SUSY remain viable and to be tested by experiments, but these require detailed computations to be carried out. Numerous publicly available software packages have been developed for such calculations, and comparisons of their results help us assess their reliability. Such studies have been carried out hitherto, but have focused on the regime of SUSY ruled out by the LHC. We present here results from such a comparative study that focuses on the high mass region of the SUSY parameter space. We find notable differences between calculation of the sparticle mass spectrum and of dark matter observables by the publicly available calculators. Furthermore, the differences in the mass spectrum easily propagate into stark differences in the calculation of dark matter observables.

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Going underground to look at the Sun: recent results on solar neutrinos by Borexino

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Since they barely interact with matter, neutrinos are ideal messengers to investigate the inner processes of astrophysical objects. Solar neutrinos are produced in the Sun as a consequence of the nuclear reaction which take place in its core. Therefore, a detailed study of solar neutrinos is bound to provide
unique direct information on stellar interior, as well as validity of existing theoretical models for the structure and evolution of the Sun and other stars. Solar neutrinos offer also unique chances for studying neutrino particle physics through the observation of solar neutrino oscillations.

Being very elusive particles, large and radiopure underground detectors are required to observe solar neutrinos: cosmic rays and natural radioactivity can in fact easily mimic their rare signal. Borexino is a liquid scintillator detector designed to perform sub-MeV real-time solar neutrino spectroscopy and it is taking data since May 2007. The key feature of Borexino is the unprecedented low background level, obtained thanks to its location deep underground at the Gran Sasso National Laboratory (Italy) and to the extremely high radiopurity of detector materials. So far, Borexino is the only detector capable of observing the entire spectrum of solar neutrinos simultaneously. In this contribution, the Borexino experiment will be described, together with its latest results on solar neutrinos.

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Estimate CIB Contamination in $\kappa - y$ Cross-Correlation

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This study is basically a noise analysis in an existing result. We reconstructed a y map using NILC method to null CMB and galactic dust signal. We then constructed a CIB-subtracted y map. We estimated the fraction of CIB contamination in the $\kappa - y$ cross-correlation in the reconstructed y map by comparing the cross correlation signal in the two y maps. The result suggest that The result suggests that $\kappa - \mathrm{CIB}$ contributes $7.75\% \pm 5.21\%$ with only 1.87σ significance. So the reconstructed y map is not significantly contaminated by CIB.

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Exploring circular polarization in the CMB due to conventional sources of cosmic birefringence

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Circular polarization of the CMB is currently assumed to be zero in the standard cosmological model. Here we explore the actual level of circular polarization in the CMB by looking at conventional sources of cosmic birefringence. The sources studied include the following: photon-photon scattering, spin polarized hydrogen atoms, static non-linear polarizability of hydrogen and plasma delay. The strongest effect comes from the photon-photon scattering at a level of $\sim 10^{-14}$ K. Our results are consistent with a vanishing circular polarization of the CMB in comparison with the linear polarization.

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FAST-PT: An Extremely Efficient Algorithm For Cosmological Perturbation Theory

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Cosmological perturbation theory is a powerful tool to model observations of large-scale structure in the weakly non-linear regime. However, even at next-to-leading order, it results in computationally expensive mode-coupling integrals. In this poster presentation, I will focus on the physics of our extremely efficient algorithm, FAST-PT. I will show how the algorithm can be applied to calculate 1-loop power spectra for several cosmological observables, including the matter density, galaxy bias, galaxy intrinsic alignments, the Ostriker-Vishniac effect, the secondary CMB polarization due to baryon flows, and redshift-space distortions. Our public code is written in Python and is easy to use and adapt to additional applications.

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Search for the lepton flavour violating decay Bs,d → e+μ− at the LHCb experiment

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Rare leptonic $b \to s\ell\ell$' processes are sensitive indirect probes for new effects beyond the Standard Model (SM). Recent deviations from the SM observed in LHCb suggest lepton flavour universality violation effects that could imply the existence of lepton flavour violation processes at an accessible energy scale. In particular it is interesting to search for $b \to s\ell\ell$' processes where the effect of a new boson arising from a local gauge symmetry between lepton and quarks could significantly enhance their branching fractions.
LHCb's design is optimal for these searches.
Recent results on $B_{s,d} \to e^{+-}$ searches at LHCb will be presented.

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Imprints on the CMB angular power spectrum from relativistic species that decouple late

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The phase shift in the acoustic peaks in the angular power spectrum of CMB temperature and polarization anisotropy plays an important role as a probe of the nature of contribution to Neff. It can determine whether the extra species are free-streaming particles, like neutrinos, or tightly-coupled, like the photons, during eras probed by the CMB. On the other hand, some extensions of the standard model produce new relativistic particles that decouple from the primordial cosmic plasma after neutrinos, but prior to photons. We study the signature of new relativistic species that decouple during this intermediate epoch. We shall argue that a new type of phase shift occurs in the acoustic peaks, different from the usual constant phase shift on small scales. For intermediate decoupling times, the shape and amplitude of the phase shift depends not only ΔNeff but the redshift(zdec) at which the new species decoupled. One of the applications of this theoretical study is to predict the effect that the new relativistic entities from new BSM models, e.g. Nnaturalness, have on CMB power spectrum in terms of phase shift of acoustic peaks.

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Characterizing dark matter in LHC dilepton spectra

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Spectral features in LHC dileptonic events may signal radiative corrections from dark matter and mediators. It is shown using simplified models how these features may reveal the fundamental properties of the dark sector, such as the self-conjugation, spin and mass of DM, and the quantum numbers of the mediator. Distributions of both the invariant mass mll and the Collins-Soper scattering angle cos\theta are studied to pinpoint these properties. Constraints on the models are derived from LHC measurements of mll and cos\theta, which are competitive with direct detection and jets + MET searches.

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Primordial gravitational waves produced in bouncing models

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The primordial background of gravitational waves is investigated for a Universe with a bounce, i.e.,a Universe that has a contraction before its expansion. The bounce is caused by quantum effects. It is shown the spectrum is scale dependent,which is different from the standard inflation models. The model investigated is evolved with three non-interacting fluids, with sound velocities equal to 0, 1/3 and almost 1. The primordial gravitational waves emerge from quantum tensorial fluctuations in the far past of the Universe. It is concluded that for low frequencies ($10^{-18} \sim 10^{-10} Hz$), the energy density is proportional to a power of the frequency, $f^{\frac{2(9\omega-1)}{1+3\omega}}$, where ω is the sound velocity of the dominant fluid when the wave crosses the Universe curvature scale, and amplitude of gravitational waves is related to the minimum size of the scale factor.