43rd SLAC Summer Institute

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SLAC

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Anomalies in the Indirect Detection of Dark Matter

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A Truth Study Using Transverse Variables to Characterise Nuclear Effects in neutrino–nucleus scattering.

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In the past few years it has become clear that nuclear effects impose significant uncertainties on precision measurements in neutrino physics of the few GeV energy region.
A number of convoluted effects in the nuclear model, affecting both the initial nucleon momentum spectrum and intranuclear hadronic transport, result in different interaction types giving the same hadronic final state and also affects the hadronic kinematics.
This is a problem for both exclusive cross-section measurements and event-by-event energy reconstruction.

We propose the use of variables defined in a plane transverse to the incoming neutrino momenta to directly study such nuclear effects.
We focus on the predictions from four of the most commonly used neutrino event generators (GENIE, GiBUU, NEUT, and NuWro) including their predictions for the initial neutrino interaction model, the initial states of all particles in the interaction, and the final states.

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Background Reduction Strategies for the MAJORANA DEMONSTRATOR

Author: Ian Guinn[1]

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The MAJORANA Collaboration is seeking neutrinoless double-beta decay ($0\nu\beta\beta$) using an array of P-type point contact (PPC) high-purity germanium (HPGe) detectors isotopically enriched in ^{76}Ge. For inverted hierarchy neutrinos, a tonne-scale array with backgrounds of < 1 ct/ROI-t-y in the 4 keV region of interest (ROI) around the 2039 keV Q-value for double-beta decay in ^{76}Ge will be sensitive to $0\nu\beta\beta$ decay. In order to demonstrate the feasibility of such an experiment, the MAJORANA DEMONSTRATOR is being constructed at the 4850' level of the Sanford Underground Research Facility (SURF). The DEMONSTRATOR will consist of an array of 40 kg of PPC HPGe detectors, 30 kg of which will be enriched to 87% in ^{76}Ge.The background goal for the DEMONSTRATOR is < 3 cts/ROI-t-y, which is expected to scale down to < 1 ct/ROI-t-y for a tonne-scale experiment. A variety of strategies are employed in order to acheive such a low background, including the development of low background materials and components, clean handling of components, a compact shield, and an extensive background estimation and verification campaign. This poster will describe several examples of the use of these strategies for the MAJORANA DEMONSTRATOR.

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Neutron Majorana mass from exotic instantons

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A Majorana mass for the neutron could result from non-perturbative quantum gravity effects peculiar to string theory. In particular, ‘exotic instantons” in un-oriented string compactifications with D-branes extending the (supersymmetric) standard model could indirectly produce an effective operator $\delta m\, n^t n + h.c.$ In a specific model with an extra vector-like pair ofquarks’, acquiring a large mass proportional to the string mass scale (exponentially suppressed by a function of the string moduli fields), δm can turn out to be as low as $10^{-24} - 10^{-25}$ eV.

The induced neutron-antineutron oscillations could take place with a time scale $\tau_{n\bar{n}} > 10^8 s$ that could be tested by the next generation of experiments.
On the other hand,
proton decay and FCNC's are automatically strongly suppressed and are compatible with the current experimental limits.

Depending on the number of brane intersections, the model may also lead to the generation of Majorana masses for R-handed neutrini.
Our proposal could also suggest neutron-neutralino or neutron-axino oscillations, with implications in UCN, Dark Matter Direct Detection, UHECR and Neutron-Antineutron oscillations.

This suggests to improve the limits on neutron-antineutron oscillations, as a possible test of string theory and quantum gravity.

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Phenomenology in Non-minimal Universal Extra Dimensions

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We present a model with universal extra dimensions in the presence of boundary localized kinetic terms for electoroweak gauge bosons. This model can realize that the lightest Kaluza-Klein particle is a mixture of KK B^1 and KK W_3^1. Depending on boundary localized parameter (r_B, r_W) the KK dark matter is more like KK Z or KK photon. We showed current bounds on (r_B, r_W) from EWPT by 4-Fermi interaction operators.

Summary:

In this work, we investigate boundary localized kinetic terms for electroweak gauge bosons. The mass matrix allows mixing between two KK neutral gauge bosons. In general, the LKP becomes a mixture of KK B^1 and KK W_3^1. We found a stringent bounds on R^{-1} or equivalently mass of LKP from 4-Fermi operators in r_W, r_B plane.

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Search for new phenomena in dijet distributions using pp collision data at centre-of-mass energy 8 TeV with the ATLAS detector

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The dijet final state at high transverse momentum probes the highest energies reached in a collider experiment. This corresponds to the largest reach in mass for the production of new particles, but also to resolving the smallest distances. Several phenomena described by models of physics beyond the Standard Model could be seen in the angular and mass distributions of dijets. This poster shows recent results at $\sqrt{s} = 8$ TeV, using data with an integrated luminosity of 20.3 fb^{-1}, collected by the ATLAS detector.

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Redshift space distortions and interacting dark sector models

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We have proposed cosmological scenarios with interaction in the dark sector as a means of alleviating the coincidence problem. Now we want to test the validity of our models and constrain their parameters through recent observational data such as Planck Collaboration, $H(z)$, supernovae and Redshift Space Distortions. Here we present a brief review of the linear theory of redshift space distortions and their related observables for cosmology.

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An introduction to a CC1π^0 exclusive analysis using the ND280 Tracker + ECal

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Poster Abstract

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The Tokai to Kamioka (T2K) experiment in Japan is designed to investigate properties of neutrinos. A beam of muon neutrinos is produced at the J-PARC facility in Tokai. The beam's flux, composition, energy spectrum and interaction cross section is measured 280 m downstream of the production point at the near detector (ND280). This is measured again after 295 km at the Super-Kamiokande detector. By comparing these two measurements, oscillation parameters can be obtained.

As it is possible for decay photons from neutral pions to be mis-identified as electron neutrino events in Super-Kamiokande, it is of great importance that we clearly understand the mechanisms by which these are produced. This analysis will focus on the muon neutrino charged current single π^0 interactions which occur in the ND280. These interactions will be investigated by selecting events where a muon is produced in one of the fine grained detectors (FGD) and the decay photons from the π^0 are identified using the electromagnetic Calorimeter (ECal) and the time projection chambers (TPCs). This poster will present ideas and preliminary work on such a selection.

Summary:

An introduction to a CC1π^0 exclusive analysis using the ND280 Tracker + ECal

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Development of a Timing Detector for the Mu3e Experiment

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The *Mu3e* experiment is designed to search for lepton flavour violation through the $\mu^+ \rightarrow e^+e^-e^+$ decay channel with a sensitivity of 1 in 10^{16}, thus improving by four orders of magnitude the present experimental limit. To achieve such precision we need highly granulated tracking detector complemented by an accurate timing system. The current work offers an introduction to the requirements of the experiment, followed by a discussion on the development of a timing sub-detector which is based on scintillating fibres readout by silicon photo-multipliers. We conclude by presenting the most recent prototype testing results.

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Pulse shape analysis of CUORE-0 bolometers

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Neutrinoless double beta decay is a decay mode in which two neutrons are converted in two protons and two electrons are emitted. This process can take place only if neutrino is its own antiparticle. Thus it is a unique tool to probe the Majorana nature of the neutrino. CUORE (Cryogenic Underground Observatory for Rare Events) aims to detect neutrinoless double beta decay of the ^{130}Te. The CUORE experiment, currently in its construction phase, will consist of an array of 998 TeO_2 bolometers and will be operated at 10 mK temperature in Laboratori Nazionali del Gran Sasso.

CUORE-0, the first tower of CUORE, an array of 52 TeO_2 crystals, has been operated in the last two years as a full CUORE prototype.
The large amount of data collected by CUORE-0 makes it ideal to study in detail the performances of bolometric detectors.

The goal of my analysis is to study of CUORE-0 detectors response and behaviour. The bolometric technique is based on the measurement of the energy released by an interacting particle converted in to phonons. Despite the simple model of an ideal bolometer the actual response is much more complex. Finding the different components of the CUORE-0 pulses and correlating them to physics parameters will allow a better understanding of the detectors and possible improvements of the response. In my analysis I first defined a set of variables to describe the pulse shape. Then I started the study of correlation between pulse shape parameters and detector response.

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Systematic Sources of Uncertainty in NaI(Tl) Dark Matter Detectors

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Despite over a decade of exploring everything from detector systematics to exotic dark matter models, there has yet to be a satisfactory explanation of the DAMA results. Construction is currently underway for an experiment that will be able to determine whether an environmental or operational parameter could be responsible for DAMA's signal. This experiment features a total of 32 three-inch NaI(Tl) detectors in 4 separate locations to monitor the radioactive decay of various isotopes, including ^{40}K. The experiment will feature comprehensive monitoring of environmental and operating conditions and an advanced data acquisition, which will allow for event-by-event analysis and correlation studies. Together with an artificial pulser, this allows a measurement of the absolute rate of each isotope, as opposed to the traditional method of measuring the activity relative to a reference source. We expect that this approach will allow us to accurately determine the impact of various environmental parameters to the apparent decay rate in order to determine the source of DAMA's variations, as well as potential pitfalls to other dark matter experiments.

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TPC monitoring for LUX-ZEPLIN experiment

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In this poster, some preliminary results of the temperature and electromagnetic monitoring in the proposed LUX-ZEPLIN experiment will be presented. It discusses the difficulty and the importance of monitoring TPC.

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HOLMES, an experiment for a direct neutrino mass measurement

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Measuring the neutrino mass is one of the most compelling challenges of modern physics.
HOLMES is a new experiment recently founded by the European Research Council to directly measure the neutrino mass. HOLMES will perform a calorimetric measurement of the energy released in the electron capture decay of 163Ho in order to reach a sensitivity as low as 0.4 eV on the neutrino mass. HOLMES will deploy a large array of low temperature microcalorimeters with implanted 163Ho nuclei in a Bismuth-Gold absorber coupled to a Transition Edge Sensor.
The R&D activities necessary to optimize the 163 Ho isotope production, the source embedding, the

detector optimization and the multiplexed readout, are already in progress. We outline here the project with its technical challenges and perspectives.

Summary:

HOLMES is a new experiment aiming to measure the electron neutrino mass from the electron capture decay spectrum of 163Ho with sub-eV sensitivity. In order to reach a sensitivity of 0.4 eV a large array of 1000 low temperature microcalorimeteres will be operated starting from 2016 for three years time. Tags: HOLMES, neutrino mass direct measurement, 163 Ho electron capture.

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The DarkSide-50 Dark Matter Detector

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DarkSide-50 is the first physics detector of the DarkSide dark matter search program. The detector features a dual phase underground argon Time Projection Chamber (TPC) of 50 kg active mass surrounded by an organic liquid scintillator neutron veto and a water-Cherenkov muon detector. The TPC is currently fully shielded and operating underground at Gran Sasso National Laboratory (LNGS) using research grade atmospheric argon. Exploiting the high rate of electronic recoils from ^{39}Ar in regular argon to collect the background statistics expected in a few years of data taking with low-radioactivity underground argon, this first run is focused on the study of the detector response and its performance in background suppression.

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LSST Camera Sensor Characterization

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The Large Synoptic Survey Telescope (LSST) will use a 3.2 Gigapixel CCD camera to conduct a deep ($M_r < 27.5$) wide-field survey of the Southern sky in six optical bands (u, g, r, i, z, and y) over 10 years. The science drivers of the survey, particularly precision measurements of weak lensing, place tight constraints on camera performance in terms of both photometry and galaxy shape measurement.

This poster describes the program of sensor testing and characterization that has been developed to meet these camera performance goals, focusing primarily on methods developed to characterize pixel size uniformity and the flux-dependence of the PSF (the 'brighter-fatter effect').

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TITUS- An intermediate near detector for Tokai to HyperKamiokande neutrino oscillations

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The Tokai Intermediate Tank for the Unoscillated Spectrum (TITUS) is a water cerenkov near detector proposed in addition to the Hyper-Kamiokande experiment to measure the unoscillated neutrino beam from the J-PARC accelerator. The 2kton detector will be placed off-axis and optimised for the delta cp measurement. Studies to determine the improvement in sensitivity from a 0.1% Gadolinium doping and a magnetised muon range detector are currently underway.

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Spin-One Top Partner: Phenomenology

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Cai, Cheng, and Terning (CCT) suggested a model in which the left-handed top quark is identified with a gaugino of an extended gauge group, and its superpartner is a spin-1 particle. We perform a phenomenological analysis of this model, with a focus on the spin-1 top partner, which we dub the **swan**. We find that precision electroweak fits, together with direct searches for Z' bosons at the LHC, place a lower bound of at least about 4.5 TeV on the swan mass. An even stronger bound, 10 TeV or above, applies in most of the parameter space, mainly due to the fact that the swan is typically predicted to be significantly heavier than the Z'. We find that the 125 GeV Higgs can be easily accommodated in this model with non-decoupling D-terms. In spite of the strong lower bound on the swan mass, we find that corrections to Higgs couplings to photons and gluons induced by swan loops are potentially observable at future Higgs factories. We also briefly discuss the prospects for discovering a
swan at the proposed 100 TeV pp collider.

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The AmC calibration source induced background at Daya Bay Experiment

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The Daya Bay experiment has made the most precise measurement of the neutrino mixing angle theta13 and the first independent measurement of the effective mass splitting in the electron antineutrino
disappearance channel utilizing measured reactor anti-neutrino rate and spectral shape. A thorough understanding of backgrounds is crucial for the measurement. Among all the backgrounds at
Daya Bay, one comes from the AmC calibration source parked on top of the anti-neutrino detectors, which is an especially major background contributor at the far site. Many efforts have been made to better evaluate this background and constrain related systematics, including an in-situ measurement using a much stronger AmC source to directly measure the background spectra and benchmark our simulations. Details of the measurement and evaluation of the AmC background will be presented in
this poster.

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Sensitivity analysis of JUNO to large extra dimensions

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The upcoming JUNO (Jiangmen Underground Neutrino Observatory) project is a multipurpose neutrino experiment that has as main purpose to determine the hierarchy of massive neutrino states with a confidence level between 3σ and 4σ by collecting data for a period of six years. Also JUNO will determine with a precision better than 1% the oscillation parameters $\sin^2\theta_{12}$, Δm^2_{21} and $|\Delta m^2_{31}|$ and will measure the neutrinos produced by supernova explosions, geo-neutrinos, solar and atmospheric neutrinos. JUNO will have an energy resolution $3\%\sqrt{E_{\text{vis}}/1\text{MeV}}$ which can be used to put bounds on new physics. We shall do a sensitivity analysis of JUNO to large extra dimensions, consedering that the space-time has four flat space dimensions, and we shall compare our results with the ones obtained by other researchers in the experiment Daya Bay.

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Dark Matter Annihilations in the Causal Diamond

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We investigate the implications of dark matter annihilations for cosmological parameter constraints using the causal entropic principle. In this approach cosmologies are weighted by the total entropy production within a causally connected region of spacetime. We calculate the expected entropy from dark matter annihilations within the causal diamond and investigate the preferred values of the cosmological constant and the mass and annihilation cross section of the annihilating dark matter and their dependence on the assumptions in the models. For realistic values of the cross section we typically find preferred values of Λ on the order of 10^{-5} of the present value assuming dark matter annihilations are the primary source of entropy production. The greatest amount of entropy production from dark matter within the causal diamond is likely to occur with light keV scale dark matter with low annihilation cross section. We also investigate the effect of combining this entropy with the entropy production from stars, and show that if the primary source of entropy production is from stars, varying the dark matter cross section directly produces a preferred value of Ω_m in excellent agreement with observations.

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Higgs Gravitational Interaction, Weak Boson Scattering, and Higgs Inflation in Jordan and Einstein Frames

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We study gravitational interaction of Higgs boson through the unique dimension-4 operator ξH^{\dag}HR , with H the Higgs doublet and R the Ricci scalar curvature. We analyze the effect of this dimensionless nonminimal coupling ξ on weak gauge boson scattering in both Jordan and Einstein frames. We demonstrate that the weak boson scattering amplitudes computed in both frames are equal in flat background. We explicitly establish the longitudinal-Goldstone equivalence theorem with nonzero ξ coupling in both frames, and analyze the unitarity constraints. We study the ξ-induced weak boson scattering cross sections at O(1–30)TeV scales, and propose to probe the Higgs-gravity coupling via weak boson scattering experiments at the LHC (14 TeV) and the next generation pp colliders (50 – 100 TeV). We further extend our study to Higgs inflation, and quantitatively derive the perturbative unitarity bounds via coupled channel analysis, under large field background at the inflation scale. We analyze the unitarity constraints on the parameter space in both the conventional Higgs inflation and the improved models in light of the recent BICEP2 data.

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Dedicated Trigger for Highly Ionising Particles at ATLAS

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In 2012, a new algorithm novel trigger was designed at ATLAS to detect signatures of Highly Ionising Particles (HIPs) such as magnetic monopoles with the ATLAS trigger system. With proton-proton collisions at a centre-of-mass energy of 8 TeV, those the algorithm trigger
was designed to detect ionising signatures of HIPs were recorded using the Transition Radiation Tracker (TRT). With this new approach it is possible to probe The new trigger is capable of probing higher monopole masses and charges than before, as well as other HIP
signatures such as QBalls and dyons.

We will give a description of the algorithm and its performance during the 2012 data-taking, as well as a comparison to the triggers used so far to detect HIPs in ATLAS. Furthermore an improved algorithm is presented which is expected to efficiency record the events of
interest in the challenging environment of Run 2 due to the increased center-of-mass energy and pile-up condidtions.

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The Direct Detection of Boosted Dark Matter at High Energies and PeV events at IceCube

Authors: Aritra Gupta[1]; Atri Bhattacharya[2]; Raj Gandhi[3]

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We study the possibility of detecting dark matter directly via a small but energetic component that is allowed within present-day constraints. Drawing closely upon the fact that neutral current neutrino nucleon interactions are indistinguishable from DMnucleon interactions at low energies, we extend this feature to high energies for a small, non-thermal but highly energetic population of DM particle χ, created via the decay of a significantly more massive and long-lived non-thermal relic φ, which forms the bulk of DM. If χ interacts with nucleons, its cross-section, like the neutrino-nucleus coherent cross-section, can rise sharply with energy leading to deep inelastic scattering, similar to neutral current neutrino-nucleon interactions at high energies. Thus, its direct detection may be possible via cascades in very large neutrino detectors. As a specific example, we apply this notion to the recently reported three ultra-high energy PeV cascade events clustered around 1 − 2 PeV at IceCube (IC). We discuss the features which may help discriminate this scenario from one in which only astrophysical neutrinos constitute the event sample in detectors like IC.

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Adulterated Dirac neutrinos in a type-I seesaw

Author: Ernesto MATUTE[1]

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Recently we proposed a type-I seesaw with two right-handed (RH) neutrinos per generation naturally leading to light Dirac neutrinos. These have an adulterated nature in the sense that their ordinary RH components are integrated out and replaced by the extra ones of much weaker couplings. The great disparity between their couplings is guaranteed by an underlying symmetry defined with one RH neutrino by transformations exchanging lepton and quark bare states with equal charges. Here we briefly review our findings.

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The SuperCDMS Active Neutron Shielding Concept

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Future large scale cryogenic dark matter experiments –such as EURECA or SuperCDMS - will focus on the exploration of low mass WIMPS reaching for unparalleled sensitivities for the cross section of spin-independent WIMP-nucleon interactions. This requires an unprecedented suppression of the background in the nuclear recoil band down to 1 event/ton/year in the region of interest. External and internal shielding together with an active veto system have to be installed to suppress multiple sources of background –an important of which being radiogenic and cosmogenic neutrons. In this poster, we will focus on the development of the SuperCDMS active neutron shied –a loaded scintillator in the vicinity of the detectors acting as a dedicated ambient neutron veto.

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Electroweak precision of Higgs sneutrino models

Author: Jeff Dror[1]

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In supersymmetric models the (down-type) higgs has the same quantum numbers as the sneutrinos. This suggests that if supersymmetry is realized at the TeV scale it can take an exciting form where the recently discovered higgs is also the first supersymmetric partner to the Standard Model. This has foundational implications in terms of electroweak precision tests as well as neutrino masses and their interactions. In this poster I present novel bounds on such models and classify their different types. I show that not only can neutrino masses be naturally small, but can also predict a small θ_{13} mixing angle.

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In-situ measurement of the light attenuation in liquid argon in GERDA

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The acronym GERDA emerges from Germanium Detector Array and is an experiment searching for neutrinoless double beta decay in ^{76}Ge. It uses germanium detectors which are enriched in ^{76}Ge and operates them naked in liquid argon (LAr), which serves both as a coolant and a shield for external radiation. For Phase II of GERDA it is planned to reach an exposure of 100 kg · yr with a background index (BI) of 10^{-3} cts/(keV · kg · yr). One of the major improvements to further reduce the BI is to instrument the LAr to act as an additional background veto. The attenuation of the scintillation light in LAr creates a constraint on the effective active volume of the LAr veto and is therefore a key parameter to characterize the instrumentation.

In order to measure the light attenuation in LAr, a dedicated setup was designed that could be deployed directly into the GERDA cryostat. This setup consists of a movable beta source and a PMT to measure scintillation light at different distances.

The poster will present the setup, the measurement inside the GERDA cryostat and the analysis of the acquired data.

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Role of electroweak radiation in predictions for dark matter indirect detection

Authors: Leila Ali Cavasonza[1]; Mathieu Pellen[2]; Michael Kraemer[2]

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A very exciting challenge in particle and astroparticle physics is the exploration of the nature of dark matter. The striking evidences of the existence of dark matter

are also the strongest phenomenological indications for physics beyond the Standard Model.
A huge experimental effort is currently made at colliders and via astrophysical experiments to shed light on the nature of dark matter.
More specifically dark matter may be produced at colliders or detected through direct and indirect detection experiments.
The interplay and complementarity between these different approaches and techniques offers extraordinary opportunities to improve our understanding of
the nature of dark matter or to set constraints on dark matter models.

In indirect detection, in particular, one searches for dark matter annihilation products, that produce secondary antimatter particles like positrons and antiprotons.
Such antimatter particles propagate through the Galaxy and can eventually be detected at Earth by astrophysical experiments.

A particularly interesting point is the importance of electroweak (EW) corrections to the predictions for the expected fluxes at Earth.
The inclusion of EW radiation from the primary dark matter
annihilation products can actually significantly affect the spectra of the secondary SM particles.
The EW radiation can be described using fragmentation functions, as done for instance in QCD.
We study the quality of this approximation in a simplified supersymmetric model and in a Universal Extra Dimension model.

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Cosmogenic Background Discrimination at SNO+

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Co-author: Steven Biller [1]

[1] *University of Oxford*

High energy muons produced in cosmic ray showers create radioactive elements in otherwise radiopure materials via spallation and neutron capture. Such cosmogenics are an important backgrounds in low energy searches. The SNO+ experiment is searching for Neutrinoless Double Beta Decay (0nu) in 130Te, which can be cosmogenically activated. Purification 2km underground at SNOLAB will eliminate near 100% of cosmogenics formed at the surface.

As additional contingency a new statistical technique is presented here, based on timing and calibrated on internal backgrounds, that distinguishes between a 0nu signal and cosmogenic decays.

98

Dual-phase Liquid Xenon Detector Development at UCLA

Author: Yixiong Meng[1]

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The current leading experiments of direct dark matter detection use liquid xenon as the detecting medium. The strongly motivated dark matter candidates Weakly Interacting Massive Particles (WIMPs) are expected to create nuclear recoils in the liquid xenon. During the long measurement period, the detectors face a great challenge of an overwhelming radioactive background in the form of electronic recoils.

Therefore, a comprehensive understanding of the liquid xenon responses to both nuclear and electronic recoils is of great interests to the dark matter detection with liquid xenon, especially in the low energy region where the liquid xenon is more sensitive to dark matter while current knowledge is severely constrained.

A dual-phase liquid xenon detector as an R&D effort is developing at UCLA, aiming to map the parameters of liquid xenon responses to both nuclear and electronic recoils. This measurement will be of a great help in interpreting the dark matter detection results from liquid xenon detectors such as XENON and LUX.

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A Model of Partially Interacting Dark Matter

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We present a microscopic model of partially interacting dark matter.

87

Signatures of Dark Matter Scattering Inelastically Off Nuclei

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Co-authors: Achim Schwenk [2]; Javier Menendez [2]; Laura Baudis [1]; Rafael Lang [3]

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Direct dark matter detection focuses on elastic scattering of dark matter particles off nuclei. In this poster, we investigate inelastic scattering in which the target nucleus is excited to a low-lying state of ˜10-100 keV, with a subsequent prompt de-excitation. We calculate the inelastic structure factors of the odd-mass xenon isotopes based on state-of-the-art large-scale shell-model calculations with chiral effective field theory WIMP-nucleon currents. For these cases, we find that the inelastic channel is comparable to or can dominate the elastic channel for momentum transfers ˜150 MeV. We calculate the inelastic recoil spectra in the standard halo model and compare them to the elastic case. We then discuss the expected signatures in a liquid xenon detector, such as XENON1T, along with implications for current and future experiments. XMASS has provided first limits on WIMP scattering off Xe-129 that are derived exclusively from data of inelastic scattering.

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Dark matter and computational geometry

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Traditional N-body simulations discretize the dark matter distribution into an ensemble of point particles. However, estimating the local density for a set of point particles is difficult due to Poisson noise. Abel et al. (2012) instead describe the phase-space distribution of dark matter as a 3D manifold tessellated into tetrahedra. This has the advantage of giving an unambiguous value for the density everywhere in configuration-space. Analyzing such a collection of tetrahedra requires a method for projecting a tetrahedron onto a uniform grid (voxelization). Various schemes have been tried (e.g. Angulo et al. 2013, Hahn et al. 2013), though each has its advantages and drawbacks.

I present here a new method for voxelizing polytopes. This method computes the exact intersection volume between the polytope and each voxel, so it is noiseless and exactly mass-conserving. In addition, polynomial functions defined over the polytope can be exactly voxelized, giving the ability to apply mass interpolation schemes over the phase-space sheet.

My implementation of this method yields an unprecedentedly smooth and continuous dark matter density field, with exciting prospects for studying the phase-space structure of dark matter haloes, WIMP annihilations, gravitational lensing, and more.

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Numerical evolution of two autogravitating scalar fields with spontaneous symmetry breaking

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We solve numerically the Einstein equations in spherical symmetry for a system of two coupled real scalar fields that exhibits spontaneous symmetry breaking,
and where one of the fields, initially massless, acquires an effective mass due to the coupling. We study first the evolution of the homogeneous fields, and then we add
Gaussian pulses in one of them. We find the evolution of the density contrast and the regions of the initial condition space in which these pulses collapse into
black holes during the time of the simulation. This system may be of interest for studying the evolution of perturbations in a hybrid inflation-like scenario.

63

Cosmic Ray Excesses from Multi-component Dark Matter Decays

Authors: Chao-Qiang Geng[1]; Da Huang[2]; Lu-Hsing Tsai[1]

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AMS-02 collaboration published their measurement on the positron fraction in the cosmic rays, confirming the excesses by PAMELA. Also, the Fermi-LAT data on the total $e^+ + e^-$ flux also showed excess above 20 GeV. In this talk, I shall show that the multi-component decaying dark matter (DM) scenario can naturally explain these two anomalies. By performing the ^{2} fits, we find that two DM components are already enough to give a reasonable fit of both AMS-02 and Fermi-LAT data. As a byproduct, the fine structure around 100 GeV observed by AMS-02 and Fermi-LAT can be naturally explained by the dropping due to the lighter DM component. With the obtained model parameters by the fitting, we calculate the diffuse γ-ray emission spectrum in this two-component DM scenario, and find that it is consistent with the data measured by Fermi-LAT. Finally, a microscopic particle DM model is constructed to naturally realize the two-component DM scenario, which points out an interesting neutrino signal which is possible to be measured in the near future by IceCube.

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Inflation with an oscillating field

Authors: Pisin Chen[1]; Yu-Hsiang Lin[2]

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We propose that if there is a massive scalar field oscillating at its vacuum during the slow-roll inflation, its settlement will distort the primordial power spectrum from the simple power law. At the scales which exit the Hubble radius during the oscillation, the power of curvature perturbations oscillates on top of the nearly scale-invariant spectrum. Assuming that the last stage of inflation goes like the chaotic inflation at the energy of 10^{16} GeV, we find that a scalar field oscillating at about 60 e-folds before the end of inflation will impose some wiggles to the lower modes of the cosmic microwave background temperature spectrum, therefore relieving the persisting tension between the low-ℓ and high-ℓ spectra. The comparison to the Planck observation and the likelihood are given.

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Vortices in Axion BEC (Bose-Einstein Condensate) dark matter.

Author: Nilanjan Banik[1]

Co-author: Pierre Sikivie [1]

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We present an analytic study of vortices in Axion BEC dark matter and their effects on galactic angular momentum distribution of baryons and dark matter in disk galaxies.

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A search for indirect cosmological evolution of dark matter

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We propose a scenario of creation of dark matter from a decaying cosmological constant. Arc-like pattern found on the Cosmic Microwave Background Radiation (CMBR) were shown to result from the dark matter particles in the Q-phase of the interacting cosmological constant (ICC) model. In the present work, an investigation is made into how the corresponding decay of such dark matter particles might influence these signatures, in view of the recent data from PLANCK and the diffuse glow of the anomalous microwave radiation. We also discuss the constraints on such decay imposed by the interaction of the cosmological constant with the background. In this way, we believe that the CMBR pattern must be a highly significant tool to study the dark matter evolution indirectly. The predictions made in the ICC model can be verified in the concordance space of multiple observations.

Summary:

We propose a scenario of creation of dark matter from a decaying cosmological constant. Arc-like pattern found on the Cosmic Microwave Background Radiation (CMBR) were shown to result from the dark matter particles in the Q-phase of the interacting cosmological constant (ICC) model. In the present work, an investigation is made into how the corresponding decay of such dark matter particles might influence these signatures, in view of the recent data from PLANCK and the diffuse glow of the anomalous microwave radiation. We also discuss the constraints on such decay imposed by the interaction of the cosmological constant with the background. In this way, we believe that the CMBR pattern must be a highly significant tool to study the dark matter evolution indirectly. The predictions made in the ICC model can be verified in the concordance space of multiple observations.

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Constraining light Shadow Z with low energy precision tests

Author: We-Fu Chang[1]

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A neutral vector boson, dubbed shadow Z', which stems from a hidden $U(1)_s$ gauge sector can weakly couple
to the standard model fermions through the kinematic mixing between the $U(1)_s$ and the hypercharge $U(1)_Y$.
If the shadow Z' is light, $< m_Z$, it can easily evade all collider constraint as long as the kinematic mixing
term is small. We study the feasibility of probing the
light shadow Z' gauge boson with the
low energy parity violating $e-p$, $e-d$, and $e-e$ scattering and the correlations among the experiments.

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Prospects for testing models of coupled dark matter-dark energy via 21 cm Power Spectrum after Reionization

Author: Ricardo Landim[1]

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The hydrogen 21 cm line has been used as an interesting tool of cosmology, and among its several applications there is the possibility of testing models of modified gravity via comparing both modified gravity and Λ-CDM 21 cm Power Spectrum. The present work goes in the same direction, aiming to study models of interation between dark energy and dark matter using this approach. The basic concepts of 21 cm line and its related PS will be presented, with the purpose of comparing the 21 cm PS after reionization from coupled dark matter-dark energy with that one from Λ-CDM.

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H.E.S.S. Analysis of Sgr A*

Author: Helen Poon[1]

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The mysterious Galactic Center is an interesting region with frequent flaring activities from the radio to X-ray bands. However, VHE flux always remains steady. In 2012, a gas cloud G2 was discovered to be travelling straight to the GC. It is expected to pass the pericenter in 2014. During pericenter passage, it will be so closed to the GC that it will be completely disintegrated by the black hole. VHE flaring activities are expected. In this talk, I am going to present the results of our analysis of the GC using HESS.

Summary:

So far, there has been no variability. G2 is passing the pericenter this year. We continue to monitor it to search for variability.

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Geometry from probability: A possible origin of dark energy or the inflaton

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A principle is proposed that relates probability to geometry. That principle is then used to motivate the introduction of nonlinear differential operators on spacetime manifolds. Such operators are difficult to handle mathematically, hence a geometric interpretation of the Universal Covering Group for tensors is undertaken. The principle can then be understood as equivalent to a Lagrangian of

classical and quantum fields. Taking a subalgebra based on geometric objects formed of direct sums of scalar and vector fields, it is possible to define the analog of the metric and curvature. Unlike the old Kaluza-Klein theory, which it resembles, the fiber bundle structure is isomorphic to that of ordinary four dimen- sional spacetime, and the fields are dependent on only four dimensions. Using the dynamics of particles responding to the extended metric, it's possible to read off the non-zero equivalent of Cristoffel symbols from the equation of motion. It turns out that a simple set of constraints on the standard Klein-Gordon Cristoffel symbols yield the same results. The equivalent Ricci tensor of this geometry yields vacuum general relativity and electromagnetism, as well as a Klein-Gordon-like quantum field. With a generalization of the stress-energy tensor, an exact solution for a plane-symmetric dust can be found where the scalar portion of the field drives early universe inflation, levels off for a period, then causes later enhanced universal acceleration. That suggests that some version of this theory may be of utility in modeling the effects of the inflaton or dark energy.

Summary:

This work develops a new geometry that is a simple extension of standard tensor analysis, applying it to create a Kaluza-Klein-like theory. An exact cosmological solution for a plane-symmetric dust gives a dynamic universe with early inflation and later accelerated expansion.

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Non-Existence of Black Holes with Non-Canonical Scalar Fields

Author: Rahul Jha[1]

Co-author: Alexander Graham [1]

[1] *DAMTP, University of Cambridge*

In this talk we'll study the existence of black holes with non-canonical scalar fields as matter source and prove a simple no-hair theorem which rules out the existence of stationary, asymptotically flat black holes possessing scalar hair for a wide class of such models. This applies in particular to K-essence theories like the ghost condensate model, and large sectors of the dilatonic ghost condensate and Dirac-Born-Infeld models.

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KM3NeT: the next-generation neutrino telescope in the Mediterranean Sea

Author: Daan van Eijk[1]

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This poster presents KM3NeT: the next-generation neutrino detector in the Mediterranean Sea, which is currently under construction.

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XENON1T detector

Authors: Jacques Pienaar[1]; Mayra Daniela Cervantes Valdovinos[2]; Richard Shayne[1]

Co-author: Rafael Lang

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The XENON1T detector is a dual-phase time projection chamber with a total of 3200kg of liquid xenon to search for dark matter. XENON1T is currently under construction at the Gran Sasso underground laboratory for commissioning early 2015. With a fiducial volume of at least 1000kg and a background more than two orders of magnitude below that of XENON100, the XENON1T experiment will be able to probe a particularly rich region of the electroweak-scale parameter space, with a sensitivity \sigma_{\n{SI}}\sim 2\times10ˆ{-47}\,\n{cm}ˆ2 within 2 years of operation. This poster will present the detector, some design aspects, and its sensitivity.

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Adulterated Dirac neutrinos in a type-I seesaw

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Recently we proposed a type-I seesaw with two right-handed (RH) neutrinos per generation naturally leading to light Dirac neutrinos. These have an adulterated nature as their ordinary RH components are integrated out and replaced by the extra ones of much weaker couplings. The great disparity between their couplings is guaranteed by an underlying electroweak symmetry defined with one RH neutrino by transformations exchanging lepton and quark bare states with equal charges. Here we briefly review our findings.

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Texture or Minor zeros in Lepton Mass Matrices

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The phenomenology of lepton mass matrices with texture zeros or minor zeros are discussed. The flavor symmetry realization of the models are shown.

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Calibration Systems of the XENON1T Dark Matter Experiment

Author: Jacques Pienaar[1]

Co-authors: Mayra Cervantes [1]; Rafael Lang [1]; Sean Macmullin [1]; Shayne Reichard [1]

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The XENON1T detector, currently under construction at the Gran Sasso underground laboratory, will contain 3200kg of liquid xenon. A liquid noble element detector needs to be calibrated to understand its responses to both electronic and nuclear recoils. The additional volume of XENON1T poses new opportunities and new challenges. The greater volume makes it possible to use neutron double scatters from a DD-fusion generator to achieve an in situ nuclear recoil energy calibration. However, introducing sufficient activity into the inner volume to perform electronic recoil calibrations becomes challenging due to the larger volume. Dissolved sources in the liquid xenon offer a solution to this challenge. Thorium-228, the daughters of which produce a low-energy beta spectrum of interest, has been identified as one potential dissolved source. The calibration systems of XENON1T are presented in this poster.

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Charge migration in the germanium detectors of the EDELWEISS-III experiment

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EDELWEISS-III is a direct dark matter search program looking for WIMPs using cryogenic germanium bolometers. A system of electrodes produces a homogeneous electric field in the inner region of the germanium crystals. The simultaneous readout of the heat increase and the ionization signal from scattered particles allows the discrimination of germanium nuclei recoils from electron recoils. For a discrimination of γ-ray background (electron recoils) of the order of 10^5 the charge collection has to be as complete as possible.
In this poster the principle of modeling the charge migration in high purity germanium crystals at low temperatures ($20\,\mathrm{mK}$) and low electric fields ($< 10\,\mathrm{V/cm}$) is presented. Results from measurements with a test detector, that is produced the same way as the EDELWEISS-III detectors, are shown.
This work is supported by the DFG graduate school KSETA (Karlsruhe School of Elementary Particle and Astroparticle Physics: Science and Technology)

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Status of the PandaX Dark Matter Search Experiment in China

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PandaX is a large dual-phase xenon detector experiment at China JinPing Deep-Underground Laboratory in China for direct dark-matter detection.
The detector has been running stable since late March of this yeay. And the poster will give the most recent status of the experiment including the detector calibration, data taking, first data analysis, etc.

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Neutrino mass hierarchy from atmospheric neutrinos

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The current global analysis of neutrino oscillation experiments shows no significant information regarding the neutrino mass hierarchy, either normal or inverted. In the near future, there will be a strong experimental effort to discriminate these hierarchy options. One of the most promising methods is based on atmospheric neutrino oscillations in matter, e.g. in PINGU (Precision IceCube Next Generation Upgrade). This method requires, apart from a very large statistics, accurate theoretical calculations and a refined analysis of systematic uncertainties. In such a context, we revisit some aspects of the theoretical calculations of the event spectra, and we analyze in detail the impact of spectral shape systematics, focusing on possible error sources which may play a significant role in spectral measurements. We show that the inclusion of such systematic uncertainties may alter the prospective hierarchy sensitivity in a non negligible way, and thus deserve further, dedicated studies. We also discuss the interplay between the mixing angle θ_{23} and the PINGU sensitivity to the hierarchy.

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A Cyclic Universe Approach to Fine Tuning

Authors: Marcelo Gleiser[1]; Sam Cormack[1]; Stephon Alexander[1]

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We present a closed bouncing universe model where the value of coupling constants is set by the dynamics of a ghost-like dilatonic scalar field. We show that adding a periodic potential for the scalar field leads to a cyclic Friedmann universe where the values of the couplings vary randomly from one cycle to the next. While the shuffling of values for the couplings happens during the bounce, within each cycle their time-dependence remains safely within present observational bounds for physically-motivated values of the model parameters. Our model presents an alternative to solutions of the fine tuning problem based on string landscape scenarios.

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Supernova keV Sterile Neutrinos

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We consider the production of keV sterile neutrinos in the cooling phase of the Supernova. A matter enhanced conversion from active to sterile neutrino is analyzed, leading to a strong bound on the sterile neutrino $\sin^2 2\theta - m_{\text{sterile}}$ parameter space from Supernova energy loss. In addition, we analyzed the impact of the standard production mechanism via interactions which is small compered to the aforementioned MSW.
We also consider $\nu_s \to \nu_a \gamma$ loop process, with respect to a possible observable photon signal, and obtain a limit using data from satellites which are sensitive in the MeV photon energy range.

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Tracker Commissioning for the SuperNEMO experiment

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The SuperNEMO experiment will search for neutrinoless double beta decay in the Modane Underground Laboratory. The existence of this process implies the existence of Majorana fermions and new lepton number violating interactions in the weak sector. The SuperNEMO demonstrator module is the first stage of the experiment, containing 7 kg of 82Se, with an expected sensitivity of T1/20ν>6.6x1024y after 2.5 y. Full topological event reconstruction is achieved through the use of a wire tracker operating in geiger mode combined with scintillator calorimeter modules. To achieve the low backgrounds required, all materials must achieve stringent radiopurity limits, and the modules constructed in a clean room environment. Construction of the tracker for the demonstrator module is underway in the UK, and the detector design, construction status and results from commissioning the first section of the tracker are presented.

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Impact of Gravitational Slingshot of Dark Matter on Galactic Halo Profiles

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Co-authors: Lance Labun [2]; Pisin Chen [1]; Yi-Shiou Duh [1]

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[2] *The University of Texas at Austin*

We study the impact of gravitational slingshot on the distribution of cold dark matter in early and modern era galaxies. Multiple gravitational encounters of a lower mass dark matter particle with massive baryonic astrophysical bodies would lead to an average energy gain for the dark matter, similar to second order Fermi acceleration. We calculate the average energy gain and model the integrated effect on the dark matter profile. We find that such slingshot effect was most effective in the early history of galaxies where first generation stars were massive, which smeared the dark matter distribution at the galactic center and flattened it from an initial cusp profile. On the other hand, slingshot is less effective after the high mass first generation stars and stellar remnants are no longer present. Our finding may help to alleviate the cusp-core problem, and we discuss implications for the existing observation-simulation discrepancies and phenomena related to galaxy mergers.

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Flavor ratios of extragalactical neutrinos and neutrino shortcuts in extra dimensions

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The recent measurement of high energy extragalactic neutrinos by the IceCube Collaboration has opened a new window to probe non-standard neutrino properties. Among other effects, sterile neutrino altered dispersion relations (ADRs) due to shortcuts in an extra dimension can significantly affect astrophysical flavor ratios. We discuss an MSW-like resonant conversion arising from geodesics oscillating around the brane in an asymmetrically warped extra dimension. We demonstrate that the second case has the potential to suppress significantly the flux of specific flavors such as ν_μ or ν_τ at high energies.

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Neutrino Masses and Sterile Neutrino Dark Matter from the PeV Scale

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The Higgs boson mass of 125 GeV is suggestive of superpartners at the PeV scale. We show that new physics at this scale can also explain the observed active neutrino masses via a modified, low energy seesaw mechanism and provide a sterile neutrino dark matter candidate with keV-GeV scale mass. These emerge in a straightforward manner if the right-handed neutrinos are charged under a new symmetry broken by a scalar field vacuum expectation value at the PeV scale. The dark matter relic abundance can be obtained through active-sterile oscillation, freeze-in through the decay of the heavy scalar, or freeze-in via non-renormalizable interactions at high temperatures. The low energy effective theory maps onto the widely studied νMSM framework. We also demonstrate how the recent observations of PeV energy neutrinos at IceCube and the 3.5 keV X-Ray line arise in our framework.

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Detection of supernova ν_e in water Cherenkov and liquid scintillator detectors

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We develop a new way to isolate supernova ν_e, using gadolinium-loaded water Cherenkov detectors. The forward-peaked nature of $\nu_e + e^- \to \nu_e + e^-$ allows an angular cut that contains the majority of events. Even in a narrow cone, near-isotropic inverse beta events, $\bar{\nu}_e + p \to e^+ + n$, are a large background. With neutron detection by radiative capture on gadolinium, the background events can be individually identified with high efficiency. The remaining backgrounds are smaller and can be measured separately, so they can be statistically subtracted. Super-Kamiokande with gadolinium could measure the total and average energy of supernova νe with ~ 20% precision or better each (90% C.L.).

The main detection channels for supernova ν_e in a liquid scintillator are its elastic scattering with electrons and its charged-current interaction with the ^{12}C nucleus. In existing scintillator detectors, the numbers of events from these interactions are too small to be very useful. However, at the 20-kton scale planned for the new detectors, these channels become powerful tools for probing the νe emission. We find that the νe spectrum can be well measured, to better than ~40% precision for the total energy and better than ~25% precision for the average energy. This is adequate to distinguish even close average energies, e.g., 11 MeV and 14 MeV, which will test the predictions of supernova models.

Based on arXiv:1311.6407 and arXiv:1412.8425

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The Daya Bay Reactor Neutrino Experiment

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The Daya Bay reactor neutrino experiment has observed the disappearance of $\bar{\nu}_e$ from nuclear reactors at $\sim$kilometer baselines. Utilizing powerful nuclear reactors as antineutrino sources and tall mountains that provide ample shielding against cosmic-rays, we have performed a relative comparison of the $\bar{\nu}_e$ rate and spectrum with an array of eight identically-designed detectors positioned in near and far locations. As a result, we have achieved unprecedented precision in measuring the neutrino mixing angle θ_{13} and the neutrino mass square difference $|\Delta m^2_{ee}|$ in the $\bar{\nu}_e$ disappearance channel. This poster describes our experimental setup and our detector design. It also presents our latest results on neutrino oscillations, the search for a light sterile neutrino, and the high-statistics measurement of the absolute reactor antineutrino flux and spectrum.

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Hidden Sector Dark Matter Models for the Galactic Center Gamma-Ray Excess

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The gamma-ray excess observed from the Galactic Center can be interpreted as dark matter particles annihilating into Standard Model fermions with a cross section near that expected for a thermal relic. Although many particle physics models have been shown to be able to account for this signal, the fact that this particle has not yet been observed in direct detection experiments somewhat restricts the nature of its interactions. One way to suppress the dark matter's elastic scattering cross section with nuclei is to consider models in which the dark matter is part of a hidden sector. In such models, the dark matter can annihilate into other hidden sector particles, which then decay into Standard Model fermions through a small degree of mixing with the photon, Z, or Higgs bosons. After discussing the gamma-ray signal from hidden sector dark matter in general terms, we consider two concrete realizations: a hidden photon model in which the dark matter annihilates into a pair of vector gauge bosons that decay through kinetic mixing with the photon, and a scenario within the generalized NMSSM in which the dark matter is a singlino-like neutralino that annihilates into a pair of singlet Higgs bosons, which decay through their mixing with the Higgs bosons of the MSSM.

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Ruling out bosonic repulsive dark matter in thermal equilibrium

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Self-interacting dark matter, especially bosonic, has been considered a promising candidate to replace cold dark matter (CDM) as it resolves some of the problems associated with CDM. Here, we rule out the possibility that dark matter is a repulsive boson in thermal equilibrium. We develop the model first proposed by Goodman in 2000 and derive the equation of state at finite temperature. Isothermal spherical halo models indicate a Bose–Einstein condensed core surrounded by a non-degenerate envelope, with an abrupt density drop marking the boundary between the two phases. Comparing this feature with observed rotation curves constrains the interaction strength of our model's dark matter particle, and Bullet Cluster measurements constrain the scattering cross-section. Both ultimately can be cast as constraints on the particle's mass. We find these two constraints cannot be satisfied simultaneously in any realistic halo model –and hence dark matter cannot be a repulsive boson in thermal equilibrium. It is still left open that dark matter may be a repulsive boson provided it is not in thermal equilibrium; this requires that the mass of the particle be significantly less than a millivolt.

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Searching for the neutrinoless double beta decay with the SuperNEMO experiment

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The SuperNEMO experiment is looking for the neutrinoless double beta decay which, if observed, would prove the Majorana nature of the neutrino. Under the assumption neutrinos are indeed identical to their antiparticles, the detector could not only constrain the effective neutrino mass but also identify precisely the mechanism responsible for the neutrinoless double beta decay among the several hypothesized today (light Majorana neutrino exchange, Right-Handed Currents,etc…).
The unique detector design combines tracking and calorimetry techniques allowing a full event topology reconstruction and thus, a powerful background identification and rejection. It also gives

access to other rare processes such as the double beta decay to the excited states of the daughter nucleus.

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Identification of multi-site events in coplanar grid CZT detectors for the COBRA experiment

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COBRA is a next-generation experiment searching for the existence of neutrinoless double beta decay ($0\nu\beta\beta$-decay). The aim is to clarify the nature of neutrinos as either Dirac or Majorana particles. Furthermore, the study of $0\nu\beta\beta$-decay could allow for the identification of the neutrino mass hierarchy realized in nature and the determination of the effective Majorana neutrino mass in case of a signal.

Currently a demonstrator setup at the underground facility LNGS (Italy) built of $4\times4\times4$ coplanar grid (CPG) detectors collects high quality low background physics data with FADC pulse shape sampling. The detectors are made of natural abundant CdZnTe, which is a commercially available room temperature semiconductor. It contains several double beta isotopes, the most promising of which is Cd-116 with a Q-value of 2813.5 keV – which is well above the highest naturally occurring prominent gamma lines. One of the key instruments to further reduce background is the discrimination of so called single-site events (SSE) and multi-site events (MSE). The signal of a double beta decay is expected to be a single detector event with a single-site energy deposition in the crystal. Hence, all MSEs for the same energy can be vetoed as background.

This poster summarizes a newly developed approach to identify MSEs via pulse shape analysis and first efficiency calculations.

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Loop Effects of an Effective Dark Matter Model on Dilepton Production

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While LHC searches for new resonance states (Z' models) are ongoing in the neutral-current Drell-Yan process, one of the cleanest channels to seek New Physics, it is important to also look for non-resonant effects. In particular, box diagrams with hidden sector TeV-scale states can interfere with the Standard Model to produce spectacular dilepton spectra. To this end, I will motivate an effective theory with a hidden sector that provides a dark matter candidate, and discuss the role of dispersion relations in producing these new signals. I will conclude with constraints from the dark matter relic abundance, and direct detection and collider experiments.

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The XENON Dark Matter Project

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The XENON Experiment aims to detect dark matter particles by WIMPs scattering off a nucleus. It operates a dual phase time projection chamber with liquid xenon as detection material. XENON100 was the most sensitive experiment to spin-independent WIMP-nucleon interaction for WIMP masses above 8 GeV/c² from 2010 to 2012.
XENON1T is the future experiment whose aim is an increased sensitivity by a factor 100. For this a background reduction by a factor 100 compared to XENON100 is required. Highly sensitive gas analytic and screening methods have been developed in order to guarantee these low background rates of $5 \cdot 10^{-5}$ events/day/keV/kg.

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Data Acquisition for the MAJORANA Demonstrator

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The MAJORANA DEMONSTRATOR is a low-background array of germanium detectors constructed to demonstrate the feasibility of future neutrinoless double-beta decay measurements in ^{76}Ge. Low-background non-accelerator experiments have unique requirements for their data acquisition and environmental monitoring, which we must consider. Background signals can easily overwhelm the signals of interest, so events which could contribute to the background must be identified or prevented. Data acquisition is a detailed process that runs from the detector itself through a variety of electronics into a digitized signal, and eventually into the readout software and analysis toolchain. This system is designed to be scalable into a large-scale detector array. This poster will summarize this full path of data acquisition for the MAJORANA DEMONSTRATOR.

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Overview and Performance of the ATLAS IBL Detector

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For Run 2 of the LHC a fourth, innermost Pixel Detector layer on a smaller radius beam pipe has been installed in the ATLAS Detector to add redundancy against radiation damage of the current Pixel Detector and to ensure a high quality tracking and b-tagging performance of the Inner Detector over the coming years until the High Luminosity Upgrade. State of the art components have been produced and assembled onto support structures known as staves over the last two years. In total, 20 staves have been built and qualified in a designated Quality Assurance setup at CERN of which 14 have been integrated onto the beam pipe. Results from the testing are presented and represent the performance of the detector before integration into ATLAS.

Summary:

During the Phase 0 upgrade of the ATLAS Detector an additional layer of the Pixel Detector, the Insertable B-Layer (IBL), is being installed. The IBL is composed of 14 carbon fibre staves with integrated titanium pipes for CO_2 cooling. Each stave hosts 32 FE-I4 chips, adding more than 12M read out channels in total. Two different sensor types are chosen: a planar design based on the current ATLAS Pixel sensor and 3D sensor designs which find their first application in high energy physics experiments. After full assembly and transportation to CERN the staves undergo Quality Assurance (QA) testing which will be described in this document.
The QA procedure covers important measurements to qualify a stave for integration around the beam pipe. This includes cold operation to simulate run time conditions as well as various calibration and data taking modes. The outcome of the stave QA procedure is used as a basis to select staves for integration and it provides a deeper understanding of the assembled detector.
In total, 20 staves have been produced as IBL candidates, for which the 14 highest ranked staves are to be installed in the IBL. Hence results from the QA represent a projection of the performance of the IBL after installation into the ATLAS Detector.

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Production of Tetraquarks at LHC

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Since ten years ago a host of exotic resonances have challenged the ususal quarkonium picture. A number of ideas have been put forward to explain these new states, but a comprehensive framework is still missing. We present here results on $X(3872)$ production in $pp(\bar{p})$ collisions obtained with Monte Carlo hadronization methods and illustrate what can be learned from their use to improve our understanding of exotic states. A comparison with antideuteron production is proposed. Hadronization might be the key to solve the problem of the extra states expected in diquark-antidiquark models.

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Probing Nuclear Effects at the T2K Near Detector Using Transverse Kinematic Variables

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With the latest generation of neutrino-nucleus scattering experiments we are now well within a precision era of neutrino interaction physics. Consequently we now find it increasingly important to develop a more detailed understanding of our nuclear targets. We propose to address this through a set of neutrino scattering measurements on a carbon target at the Tokai to Kamioka (T2K) off-axis near detector (ND280), using variables projected into the plane transverse to the beam of incoming muon neutrinos. These measurements will allow us to characterise the nuclear effects on the observables in neutrino scattering, thus providing valuable constraints on the systematic uncertainties associated with neutrino oscillation measurements.

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Improving Fermi-LAT Angular Resolution with CTBCORE

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The Large Area Telescope on the *Fermi* Gamma-ray Space Telescope has a point spread function with large tails, consisting of events affected by tracker inefficiencies, inactive volumes, and hard scattering; these tails can make source confusion a limiting factor. The parameter CTBCORE, available in the publicly available Extended *Fermi* LAT data, estimates the quality of each event's direction reconstruction; by implementing a cut in this parameter, the tails of the point spread function can be suppressed at the cost of losing effective area. We implement cuts on CTBCORE and present updated instrument response functions derived from the *Fermi* LAT data itself, along with all-sky maps generated with these cuts. Having shown the effectiveness of these cuts, especially at low energies, we encourage their use in analyses where angular resolution is more important than Poisson noise.

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How dark matter, baryons, and radiation imprint scales on galaxy clustering today

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The growth of structure around the time of matter-radiation equality, z˜3000, is determined by both the matter and radiation. Outside the sound horizon, inhomogeneities in the radiation contribute gravitationally to the growth of perturbations, as do inhomogeneities in the matter. In contrast, inside the sound horizon, the radiation inhomogeneities contribute less and less. This difference most strongly affects the growth of perturbations entering the horizon around matter-radiation equality, and is typically cast as a wavenumber-dependent transfer function that evolves the primordial spectrum of perturbations. Previously, analytic solutions have been found for both the small-wavenumber (outside the horizon) and large-wavenumber (deep inside the horizon) limits, and a full transfer function derived by interpolation between the two. This approach offers but inexact treatment of modes entering the horizon around matter-radiation equality. Here we present an analytic derivation of the transfer function valid on all scales. In particular, it accurately treats modes entering the horizon at equality, and also includes the baryon acoustic oscillations (BAO). Essentially, we offer a unified, simple picture of the growth of perturbations on all scales, valid in the linear regime of structure formation (z>100). This picture illustrates how the interplay of dark matter, baryons, and radiation imprints the horizon at both matter-radiation equality and at decoupling on the clustering of galaxies today.

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First Steps Towards ν_μ Charged Current Inclusive Cross Section Measurements With the NOνA Near Detector

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NOνA is a long-baseline experiment that uses the NuMI beam, at Fermilab, to study muon neutrino to electron neutrino oscillations. The experiment is located 14.6 *mrad* off the beam axis which allows access a narrow band of neutrino energies centered at 2 *GeV*. NOνA is a two-detector experiment with one located underground at Fermilab (Near Detector), and the other one located on the surface in northern Minnesota (Far Detector), 810 *km* away from Fermilab. The design of the two detectors is identical, varying only in their mass: 14 *kton* for the Far Detector, and 300 *ton* for the Near Detector. The similarities between the detectors allow the initial event rate of muon and electron neutrinos, measured by the Near Detector, to yield a nearly bias-free normalization of the event rate at the Far Detector. The NuMI beam is currently delivering power in the order of 450 *kW*, and it will go up to a maximum of 700 *kW* in the near future. With the current power, the beam delivers protons on target on the order of 10^{13} per spill, which accounts for an average of 5 neutrino interactions in the Near Detector. This high rate of neutrino interactions favors measurements such as neutrino cross sections, and in particular, muon neutrino cross sections due to the high purity of the muon neutrino beam. This poster presents the first steps towards measurements of the muon neutrino charged current inclusive cross section, using the NOνA Near Detector, at a neutrino energy region centered at 2 *GeV*.

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Inflation and the Measurement Problem

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Inflation is a very successful paradigm in cosmology, solving the Horizon, Flatness and Monopole problems with the Hot Big Bang theory. But perhaps the biggest selling point of inflation is that, it provides an elegant, quantum mechanical origin of large scale structure in the universe, described originally in [Starobinsky 1980, Guth and Pi 1982] and others. However, while this description of the emergence of primordial structure from quantum zero-point fluctuations of the inflaton field has been studied in detail for decades [Prokopec et al 1992, Polarski and Starobinsky 1995, Kiefer et al 2007], a number of prominent authors acknowledge important gaps in our understanding of the mechanism [Weinberg OUP 2008, Lyth and Liddle CUP 2009, Padmanabhan CUP 1996]. (For a review see [Sudarsky et al 2005]). Even some of the leading proponents of the theory concede that the current description, the so-called quantum-to-classical transition, is only "pragmatic" and needs eventually to be fully justified. [Kiefer and Polarski 2009] In our upcoming paper [Alexander, Jyoti and Magueijo (to appear)], we discuss and define this cosmological quantum measurement problem, and propose a solution. Our work is similar in spirit to that of [Martin et al 2012, Cañate et al 2012], except that we propose an effective collapse mechanism arising from interaction of Fourier modes, rather than a fundamental modification to the Schrodinger equation. This Measurement problem in Inflation is a rich and compelling arena for both foundational issues of quantum mechanics as well as a deep understanding of early universe cosmology, and our research may potentially teach us about aspects of quantum gravity.

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Analysis Techniques for the MAJORANA DEMONSTRATOR

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The MAJORANA DEMONSTRATOR is a low-background array of approximately 40 kg of germanium detectors searching for neutrinoless double-beta (0nbb) decay in germanium-76, deployed 4,850 feet underground at the Sanford Underground Laboratory in Lead, South Dakota, USA. Our primary objective is to demonstrate background levels low enough to justify constructing a ton-scale experiment with the same design principles which will be able to fully probe the inverted-hierarchy region of the 0nbb decay phase-space. In addition to reducing background through materials-selection and experimental design, we are developing a range of analysis-based background-suppression cuts. Examples of these cuts include timing cuts, pulse-shape cuts, and coincidence cuts. This poster will present an overview of those analysis cuts.

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Nucleon final state interaction in NEUT

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This work describes the nucleon final state interaction (FSI) model in NEUT. Nucleon rescattering inside a nucleus can alter the kinematics of outgoing nucleon from a neutrino interaction, therefore understanding nucleon interaction inside nucleus is crucial to be able to acquire precise incident neutrino energy for accurately measuring oscillation parameters. The nucleon scattering Monte Carlo generated by NEUT is compared to external data and these can be used to tune and estimate uncertainty of parameters of the FSI model.

Summary:

This work describes the nucleon final state interaction (FSI) model in NEUT.

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Cosmological Axion and neutrino mass constraints from Planck 2015 temperature and polarization data

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In the primordial Universe the axion particles, which solve in an elegant way the CP problem in QCD, can be produced both thermally, contributing to the hot dark matter of the Universe, or not thermally, contributing to the cold dark matter.

I will show the recent constraints from cosmology for the thermal axion mass and the total neutrino mass, using the Planck 2015 temperature and polarization data.

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A Direct Construction of the Nuclear Effective Interaction from Scattering Observables

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The calculation of nuclear matrix elements (dark matter & neutrinos) and other observables rely on the construction of a nuclear effective interaction, usually in a harmonic oscillator basis. The standard strategy for constructing the interaction is to first fit a potential formed by the product of a large number of pairs of coefficients and symmetry allowed operators to scattering observables (phase shifts and mixing angles). A momentum cutoff is then applied, commonly followed by a unitary transform to decouple high and low momentum states and finished by integrating out high quanta states. These steps introduce errors, break translation invariance and induce 3+ body forces, which are often untracked.
We demonstrate an alternative wherein we directly construct the effective interaction in a small harmonic oscillator basis by fitting to scattering observables at a range of continuum energies. The result is validated by computation of bound state energies and comparison of wave functions to the projection of numerical results.

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Searching for Dark Matter Annihilation into Neutrinos with Super-Kamiokande

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Summary:

This poster presents indirect searches for dark matter (DM) as WIMPs (Weakly Interacting Massive Particles) using neutrino data recorded by Super-Kamiokande from 1996 to 2014. The results of the search for WIMP-induced neutrinos from the Sun and the Milky Way are discussed. We looked for an excess of neutrinos from the Sun/Milky Way compared to the expected atmospheric neutrino background. Event samples including both electron and muon neutrinos covering a wide range of neutrino energies (GeV to TeV) were used, with sensitivity to WIMP masses down to tens of GeV. Various WIMP annihilation modes were taken into account in the analyses.

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The MAJORANA DEMONSTRATOR Neutrinoless Double-Beta Decay Experiment

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Neutrinoless double-beta decay is the only experimentally viable process which can distinguish whether the neutrino is Majorana or Dirac in nature. Observation of this rare decay would prove that the neutrino mass is generated, at least in part, by Majorana mass terms. This implies that the neutrino is its own antiparticle, and that lepton number is not a conserved quantity. The MAJORANA collaboration is constructing the DEMONSTRATOR to search for neutrinoless double-beta decay in germanium-76 at the 4850-foot level of the Sanford Underground Research Facility in Lead, South Dakota. The DEMONSTRATOR is an array of both natural and ^{76}Ge-enriched HPGe detectors assembled using low-background components, situated within layers of active and passive shielding. The modular cryostat design has allowed physics runs with the first module of enriched detectors to begin while construction proceeds on the second module. Presented here is an overview of the experiment, focusing on the current status and potential physics reach of the DEMONSTRATOR.