School on DM & Nu 2018

School and Workshop on Dark Matter and Neutrino Detection

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Poster Abstracts

Scintillating bubble chambers for Dark Matter and Neutrino detection

24 Jul

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Despite the growing scientific interest of the last three decades, the nature of dark matter is still an enigma. This field of research is closely related to that of neutrinos, they can for example share the same detection techniques. In this poster, I show the main features and research capabilities of a new experimental facility: a scintillating liquid argon bubble chamber, which could serve for both low-mass dark matter search and neutrino interactions detection (e.g. coherent elastic neutrino-nucleus scattering). Scintillating bubble chambers are a compelling new technology for WIMP detection beyond the second-generation program. These detectors combine the extreme electron rejection and simple instrumentation of a bubble chamber with the event-by-event energy resolution of a liquid scintillator.

Study of the energy spectra obtained by exposing a CCD to a 252Cf source

24 Jul

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The energy spectra obtained by exposing a CCD to a 252Cf neutron source were studied. Neutrons coming from the radioactive source are elastically scattered by the Si nuclei inside the CCD. Some of the recoiling nuclei can be channeled through the crystal lattice depending on their energy, on their recoil angle and on the crystallographic axes or planes along which they move. In order to identify a possible dependence in the recoiling nuclei energy with the direction of the incident neutrons, the radioactive source was placed in different positions relative to the CCD. Moreover, as the recoiling nuclei energy measured by the detector depends on the quenching factor, which is different for channeled and unchanneled nuclei, three different expressions of this factor were considered when studying the energy spectra.

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24 Jul

DUNE Potential for Supernova Neutrinos

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Some stars heavier than the Sun arrive to the end of their lives as a Supernova, which has been the source of many researches, discoveries and growing development of science. However, the physical mechanisms that are leading to core collapse and explosion in a Supernova are not fully understood. Neutrinos of all flavors are emitted a few seconds after the core collapse, carrying important information for neutrino physics and science in general. We present in this poster a work in progress of neutrino physics studies that can be performed at DUNE, such as neutrino absolute mass.

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24 Jul

Contribution of a Z' gauge boson to the t $\rightarrow$ cγ decay

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In this work we have studied the decay of the quark top t $\rightarrow$ cγ mediated by a neutral gauge boson V which produces flavour changing couplings at tree level. Such a boson can be induced in some theories beyond the Standard Model with an extended gauge group. t $\rightarrow$ cγ decay is induced by one loop and the amplitude is generated by three Feynman diagrams in the unitary norm: two bubble diagrams and one triangle diagram. We have used the Feynman parametrization method to calculate the one loop integrals and we considered the dimensional regularization method in order to isolate the ultraviolet divergences and verify their cancellation. Using tensorial integrals we have obtained analytic expressions that contain parametric integrals for the AL and AR coefficients, these terms define the amplitude. We considered the Z' gauge boson contribution predicted in models with extended U(1)' gauge symmetry, this boson is a candidate for dark matter. Finally we show the branching ratio numerical analysis BR(t $\rightarrow$ cγ) as a function of boson Z' mass.

First direct detection constraints on eV scale hidden photon dark matter with DAMIC at SNOLAB

24 Jul

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The DAMIC (Dark Matter in CCDs) experiment at SNOLAB employs the bulk silicon of scientific-grade CCDs as a target for ionization signals produced by interactions of particle dark matter from the galactic halo. In this work, we present the search for hidden photons, massive vector bosons proposed as candidates to explain the origin of the dark matter in the Universe, with DAMIC probing masses in the range 1.2-30 eV/c^2. Under the assumption that the local dark matter is entirely constituted of hidden-photon, the experimental sensitivity to the kinetic mixing parameter (mixing between the field strength tensors of electromagnetism and its hidden counterpart) is competitive with constraints from solar emission and provides the most stringent direct detection constraints on hidden-photon dark matter in the galactic halo with masses 3-12 eV/c^2.

Contribution of neutral scalar particles to flavour changing neutral current in t $\rightarrow$ cγ decay.

26 Jul

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The top quark is the heaviest elementary particle known, thus it has a wide range of decay modes. Studying this fermion phenomenology it could be possible to explore New Physics (NP) effects. If we onsider the Standard Model (SM) Strong and Electro-Weak interactions, Flavor Changing mediated by Neutral Currents (FCNC) do not exist at tree level and such processes just can success at one loop level or higher orders but highly suppressed. However, this is not true at all in Beyond Standard Models (BSM), then it is possible that decay widths of processes with FCNC have an appreciable increment copared with SM decay widths. Therefore in this work we show a calculation of thet $\rightarrow$ cγraretop quark decay with FCNC at one loop level. In particular, we focus in a neutral scalar bosson contribution with flavour changing couplings, which can rise in many BSMs. Along this work some particle physics concepts are exposed , such as: SM Lagrangian of weak interactions for quarks, top quark production and decay modes in a hadronic collider, FCNC, etc. Here we show the compute ofthet $\rightarrow$ cγdecay widthby using the Feynman parametrization method and we exemplified the numerical analysis of results obtained considering the case of one Higgs singlet and two Higgs doublets models with scalar dark matter candidates, where FCNC at tree level exist in quark sector mediated by scalar a pseudoscalar neutral bossons.

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26 Jul

LIDRAE water Cherenkov array

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The Laboratory for Instrumentation of High Energy Radiation Detectors (LIDRAE, from the Portuguese Laboratório para a Instrumentação de Detectores de Altas Energias) of the Federal University of ABC aims to research in high energy physics through the study of radiation detectors. The laboratory has various electronic equipment and detectors, capable of detecting high energy particles produced by cosmic rays in the atmosphere. One experiment in progress is an arrangement of 1000-liter Cherenkov water tanks with three underground tanks in a triangular array and equipped with Hamamatsu photomultiplier tubes (R5912). The array uses electronic NIM and VME modules, which were previously calibrated, to perform the acquisition, processing, and study of the detected signal. In this work, we present the progress and results obtained with the LIDRAE tanks. We will discuss the results of the calibration of the arrangement, the events obtained in single and triple coincidence, and preliminary results of the lateral distribution reconstruction for the electromagnetic and muonic components of the air shower.

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26 Jul

Gamma-rays from MeV Dark Matter in light of CMB constraints

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Dark Matter (DM) remains one of the great mysteries of modern cosmology. It encompasses roughly 26% of the Universe and yet so far we have no clue about its fundamental properties. If we believe dark matter can somehow interact with the Standard Model of Fundamental Particles, we can expect direct or indirect detections. Astrophysical signals such as gamma-rays and cosmic-rays are an open window to test a vast spectrum of DM models. Future experiments aim to test a new energy-regime in the quest of DM searching. The space mission e-ASTROGAM is being designed to study gamma-rays in the low MeV regime. Such signals can be produced if we assume a low mass DM particle. Some part of this work is to test the plausibility of finding a strong signal in such experiment coming from different DM models and compare it with current CMB constraints.

Operation and Calibration of a DAMIC CCD

26 Jul

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The DAMIC experiment (Dark Matter in CCDs) located at the Snolab laboratory in Canada, 2 km below the surface, has taken data since 2012 in search of WIMPs. The experiment employs CCDs (Charge Coupled Devices) to detect nuclear recoil caused by incident particles, being able to detect energy depositions from 50 eV for masses lower than 20 Gev/c^2. In this work, the WIMPs detection prospects will be presented, as well as the calibration and performance of the detector. The data analysis obtained in the experiment will be also presented, to mainly understand the background of the system and to show the latest results of the experiment.

Quantum Decoherence and CPT Violation at DUNE

26 Jul

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We study the possibility to measure CPT violation effects due to quantum decoherence within the context of the neutrino system. Considering the previous, we develop analytical formulas for the vacuum case. Moreover, we numerically evaluate the effects of matter and CPTV using the ν_μ and $\overline{\nu}_\mu$ disappearance channels, in the framework of the DUNE experiment. For the optimal case, we find 5 σ of confidence for $\Gamma \sim 4 \times 10^{-23}$GeV and $\delta_{\rm CP} \approx 3\pi/2$.

Constraints on neutrino decay scenarios with electron anti-neutrino disappearance experiments

27 Jul

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Neutrino decay provides for a very interesting case for the beyond PMNS neutrino physics. It has been shown that this phenomenon can also explain some of the anomalies seen in neutrino experiments. We study the constraints that $\bar{\nu}_e$ disappearance experiments like JUNO and KamLAND can put on neutrino decay scenarios. In particular, we consider a model where a heavier neutrino can decay giving active daughter neutrinos which can then be detected in these experiments. We find that the experiments JUNO and KamLAND can together constrain $\tau_3/m_3 \geq 10^{-10}$ s/eV for the normal hierarchy amd $\tau_2/m_2 \geq 10^{-9}$ s/eV for the inverted hierarchy. We discuss an interesting physics case because of which the bounds are better for the inverted hierarchy.

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27 Jul

Data analysis of the CONNIE experiment

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The CONNIE (COherent Neutrino-Nucleous Interaction Experiment) experiment, located 30 meters from de center of the Angra 2 nuclear power plant in Rio de Janeiro, has as its main objective the detection of the coherent elastic scattering between an atomic nucleus and a neutrino (CEnNS). Although predicted by the Standard Model of particle physics more than 40 years ago, this interaction was only recently measured by the COHERENT experiment. The reason behind this delay is the great experimental difficulty of detecting the CEnNS due to its very low energy recoil. Because of these experimental difficulties, such measurement only became possible with very sensitive and low-noise detectors, which have recently been developed for the direct detection of dark matter.

In the case of the CONNIE experiment, the detectors used are the Charge Coupled Devices (CCDs), solid-state detectors with low energy threshold that have been recently gaining prominence in particle physics experiments. Operating since 2014, in 2016 the experiment went through a major upgrade, increasing significantly its active mass and using a new generation of CCD detectors. Such detectors are located inside a copper box kept in vacuum at 70 K and covered with a passive shield.

In this work, the detector performance and energy calibration were analyzed considering the last 2 years of operation. For this purpose, a code was developed for particle identification that allowed to separate the different types of particles based on their geometric characteristics and energy deposition in the CCDs. Thereby, the background contamination of alpha particles was determined and compared in the different moments of the experiment. The high alpha particle rate found indicated an internal contamination in the shield, resulting in the change of the copper box in the first upgrade of the experiment. The evolution of the muon flux was also studied for determination of the stability of the system.

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27 Jul

Mass ordering from SN neutronization burst

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The Deep Underground Neutrino Experiment (DUNE) will be able to detect neutrino bursts from core-collapse supernovae. As the experiment will be sensitive to the detection of electron neutrinos, it will be possible to characterize the "neutronization burst" of neutrinos, providing valuable information for the mass hierarchy estimation. In this poster, we will show some studies on mass ordering using information of the neutronization burst, as well as a preliminary result of mass ordering discrimination for different uncertainty levels for the estimation of supernova distance.

Majorana neutrinos in LHeC, Effective Couplings, Asymmetries

27 Jul

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The possibility of producing heavy sterile Majorana neutrinos is considered in the Large Hadron Electron Collider (LHeC), which is under consideration as an LHC update. We study the process whose final state is $\mu^+ + 3jets$, which due to the lepton number violation is a clear signal of the contribution of intermediaries Majorana neutrinos. The interactions between these neutrinos and ordinary matter are obtained from the formalism of effective Lagrangian. The angular distribution of the final lepton is studied and the forward-backward asymmetry, defined for this angle, is used as a way to study the contribution of the different invariant gauge operators. The cuts reported in the literature are used to improve the signal/background relationship.

New formulas for neutrino oscillation including non-standard interaction effects

27 Jul

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Mass-induced neutrino oscillation, nowadays, is the best explanation for a lot of experiments performed in the last three decades. It has explained solar, atmospheric, reactor and accelerator neutrino data. The next generation of precision neutrino experiments starts in the coming decade. A notable one is DUNE, the long baseline accelerator experiment with the largest matter effect and high energy resolution already achieved on neutrino oscillation experiments. Due to the large matter effect, if non-standard interactions exist, DUNE may be able to detect NSI effects on neutrino oscillation. Thereat, due to understanding how non-standard interaction effects oscillation, simple analytical formulas are needed. In this regard, perturbation formulas were derived through Minakatas approach. We found perturbative probabilities of neutrino oscillation under the influence of non-standard interactions. As a result, for neutrinos traveling up to DUNE baseline, our formulas are in a good agreement with numerical results and enable the use of larger non-standard parameters than the usual ones. In addition, for a neutrino propagating on a step function density medium, formulas including NSI were developed. Those last, explains the density ordering effect on electron neutrino appearance and may be used in future topography technologies.
