XVIII Frascati Spring School "BRUNO TOUSCHEK"

in nuclear, subnuclear and astroparticle physics

LNF, May 9 - 13, 2016, Frascati (Italy)

Young Researchers Workshop – Program

Monday, May 9th

16:30-16:45 **Discrete Dark Matter Model and Reactor Angle**
Jorge Mario Lamprea (UNAM, Mexico)

I present a scenario where the stability of Dark Matter and the phenomenology of neutrinos are related by the spontaneous breaking of a non-abelian flavour symmetry. In this scenario the breaking is done at the seesaw scale, in such a way that what remains of the flavor symmetry is a Z_2 symmetry, which stabilise the Dark Matter. We have proposed two models based on this idea, for which we have calculated their neutrino mass matrices achieving two-zero texture in both cases. Accordingly, we have updated this two-zero texture phenomenology finding an interesting correlation between $\sin^2\theta_{23}$ and the sum of the light neutrino masses. We also have a correlation between the $\sum m_\nu$ and the neutrinoless double beta decay regions, obtaining lower bound for this for both hierarchies, in all the cases the neutrinoless double beta decay effective mass are within the region of the nearly future experimental sensitivities.

16:45-17:00 **Saving dark matter explanation of cosmic positron anomaly with dark matter disc**
Maxim Laletin (IFPA, U. Liege, Belgium)

The overabundance of high-energy cosmic positrons, observed by PAMELA and AMS-02, can be interpreted as the consequence of dark matter decays or annihilations. However, recent cosmic gamma-ray studies, including FERMI/LAT measurement of isotropic diffuse gamma-ray background and gamma-ray observations of 25 Milky Way dwarf satellites, impose severe constraints on dark matter explanations, making them practically inconsistent. A possible way-out for dark matter explanation is related to the hypothesis of a dark matter disc. This idea was proposed in the past to solve different astrophysical problems, e.g. flaring of the interstellar gas layer or Andromeda plane of satellites, but here it is considered in the context of reanimating the dark matter explanation of cosmic positron excess. The mechanisms of dark disc formation, as well as some suitable dark matter candidates are discussed.

17:00-17:15 **Development of two-phase cryogenic avalanche detectors for dark matter search.**
Ekatherina Shemyakina
(Budker Institute of Nuclear Physics, Novosibirsk State University, Russia)

Two-phase Cryogenic Avalanche Detectors (CRADs) with THGEM multipliers have become an emerging potential technique for rare-event experiments. In this work the current status of the two-phase CRAD prototype in Ar, with electroluminescence (EL) gap and combined THGEM/GAPD-matrix multiplier, is described. The low threshold and high energy resolution of the detector is provided by the EL gap, optically read out in the VUV using compact cryogenic PMTs. The high spatial resolution of the detector is provided by the double-THGEM charge multiplier combined with a 5x5 matrix of Geiger-mode APDs (GAPDs), optically recording THGEM-hole avalanches in the Near Infrared (NIR). Proportional electroluminescence in EL gap in argon, with a minor (50 ppm) admixture of nitrogen to liquid Ar, has for the first time been systematically studied at cryogenic temperatures in the two-phase mode. The overall EL amplification parameter and the EL threshold measured in this work were in accordance with those predicted by the theory. The result on the EL threshold is particularly relevant to DarkSide and SCENE dark matter search-related experiments, where the operation electric field was thereby on the verge of appearance of the S2 signal. We also present the results on nuclear recoil detection in liquid Ar, using the two-phase CRAD and DD neutron generator, relevant in the field of energy calibration of rare-event detectors for dark matter search and coherent neutrino-nucleus scattering experiments.

17:15-17:30 **Searching for Dark Matter candidate with the AURIGA detector**
Antonio Branca (INFN Padova, Italy)

We present a search for a new scalar particle, called moduli, performed using the cryogenic resonant-mass gravitational wave detector AURIGA. The existence of moduli is predicted by String Theory and may have significant contribution to the Dark Matter (DM) in our Universe. DM clusters under the galaxies gravitational effect, forming the so called galactic halo. The interaction of ordinary matter with a DM halo composed by moduli, causes the mass of electrons, m_e, and the fine structure constant, α, to oscillate in time. This implies the oscillation of solids with a frequency equal to the mass of the DM particle [Phys. Rev. Lett. 116, 031102 (2016)]. In particular, the putative signal would appear as a sharp peak (Δf 1 mHz) in the sensitive band of AURIGA, some 100 Hz at about 1 kHz. The search sets upper limits at 95% CL on the moduli coupling to matter $d_e < 10^{-4}$ (with respect to the gravitational force strength) around moduli masses $m = 3.6 \cdot 10^{-12}\,\mathrm{eV}$.

17:30-17:45 **Search for the prompt lepton jets with the ATLAS detector**
Grygorii Sokhrannyi (Jozef Stefan Institute, Ljubljan, Slovenia)

The latest direct- and indirect-detection experiments[1002.1028, 0810.4995, 0905.0025 etc.] are aiming to prove the existence of the dark matter (DM). The attractive candidate for DM particles is Weakly Interactive Massive Particles (WIMPs). The WIMPs existence, as well as the dark sector state and dark photons are predicted by several dark sector models [0901.0283, 0909.0290, 1002.2952 etc.] Two main benchmark models which has been currently used for Run II data analysis are Falkowski, Ruderman, Volansky, Zupan (FRVZ) model [1007.3496] and Inelastic Thermal Dark Matter model (iDM) [1508.03050]. The signal collision event is the Higgs boson decays into WIMPs which are decaying into the hidden sector particles (dark photons) and in the final state dark photons decay into cascade of collimated leptons (lepton jets).

17:45-18:00 **The PADME experiment**
Gabriele Piperno
(LNF, Frascati, Italy)

The problem of the elusiveness of the dark matter can be solved speculating that it interacts with the gauge fields of the Standard Model (SM) only by means of portals that connect our world to the dark sector. An elementary model simply adds a U(1) symmetry and its vector boson A' : SM particles are neutral under this new symmetry, while the new boson couples to the SM with an effective charge equal to ϵe, and for this reason it is called dark photon. In addition, an A' with a mass in the range from 1 MeV to 1 GeV and a coupling constant $\epsilon \sim 10^{-3}$ can justify the discrepancy between the theory and the observed value of the muon anomalous magnetic moment $(g-2)_\mu$. Due to the difficulty of the A' identification, experiments must be well designed and realized. The PADME (Positron Annihilation into Dark Matter Experiment) experiment, will search for the invisible decays of A' produced in positron on target interactions at the DAFNE Linac. The collaboration aims to collect $\sim 10^{13}$ positrons on target by the end of 2018, reaching a sensitivity of $\sim 10^{-3}$ on ϵ for dark photon masses up to $\sim$ 24 MeV.

Thursday, May 12th

16:30-16:45 **Pulse shape analysis of CUORE-0 bolometers**
Daria Santone (University of L'Aquila, Italy)

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 Under- ground Observatory for Rare Events) aims to detect neutrinoless double beta decay of the 130Te. The CUORE experiment, currently in its construction phase, will consist of an array of 998 TeO2 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 TeO2 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.

16:45-17:00 **The Fermilab Muon g-2 Experiment**
Nandita Raha (INFN Tor Vergata, Rome, Italy)

The anomalous magnetic dipole moment of the muon can be both measured and computed to very high precision, making it a powerful probe to test the standard model and search for new physics such as SUSY. The previous measurement by the Brookhaven E821 experiment found a ~3 standard deviation discrepancy from the predicted value. The new g-2 experiment at Fermilab will improve the precision by a factor of four through a factor of twenty increase in statistics and a reduced systematic uncertainty with an upgraded apparatus. The experiment will also carry out an improved measurement of the muon electric dipole moment. Construction at Fermilab is well underway.

17:00-17:15 **Design, R&D and status of the crystal calorimeter for the Mu2e experiment**
Raffaella Donghia (LNF, Frascati and Roma Tre University, Rome, Italy)

The Mu2e Experiment at Fermilab will search for coherent, neutrinoless conversion of muons into electrons in the field of a nucleus with a sensitivity improvement of a factor of 10^4 over previous experiments. Such a charged lepton flavor-violating reaction probes new physics at a scale inaccessible with direct searches at either present or planned high energy colliders. The conversion electron is mono-energetic with an energy slightly below the muon rest mass. If no events are observed in three years of running, Mu2e will set a limit on the ratio between the conversion rate and the capture rate $R_{\mu e}$ of $\leq 6 \times 10^{-17}$ (@ 90% C.L.). The experiment complements and extends the current search for $\mu \to e\gamma$ decay at MEG as well as the direct searches for new physics at the LHC. We briefly present the physics motivation for Mu2e, the current status of the experiment and the design of the muon beamline and the detector, devoting particular attention to the R&D phase of the electromagnetic calorimeter.

17:15-17:30 **Interpreting a 2 TeV resonance in WW scattering**
Pere Arnan Vendrell (U. Barcelona, Spain)

A diboson excess has been observed — albeit with very limited statistical significance — in WW, WZ, and ZZ final states at the LHC experiments using the accumulated 8 TeV data. Assuming that these signals are due to resonances resulting from an extended symmetry breaking sector in the standard model and exact custodial symmetry, we determine using unitarization methods the values of the relevant low-energy constants in the corresponding effective Lagrangian. Unitarity arguments also predict the widths of these resonances.

17:30-17:45 **BFKL phenomenology: resummation of high-henergy logs in semi-hard processes at LHC**
Francesco Giovanni Celiberto
(University of Calabria and INFN-Cosenza, Italy)

In this talk a study of differential cross sections and azimuthal observables for semi-hard processes at LHC energies, including the BFKL resummation effects, will be presented. In the case of two-body emission, particular attention will be paid to the behaviour of the azimuthal correlation momenta, when a couple of forward/backward jets or identified hadrons is produced in the final state with a large rapidity separation.

17:45-18:00 **Kantowski-Sachs model in Einstein-Dilaton-Gauss-Bonnet gravity**
Luca Parisi (University of Salerno, Italy)

The Kantowski-Sachs model is considered in the framework of Einstein-dilaton-Gauss-bonnet gravity. A qualitative analysis of the cosmological equations is presented. The role played by the the modification of the Einstein-Hilber action in physically interesting aspects such as isotropization, bounce is discussed.