PROSPECTS IN LOW MASS DARK MATTER

Report of Contributions

https://indico.mpp.mpg.de/e/dmworkshop

Contribution ID: **3** Type: **not specified**

Production mechanisms for sterile neutrino Dark Matter

Monday, 30 November 2015 18:15 (45 minutes)

Given the absence of a clear WIMP signal, we have to seriously investigate alternative Dark Matter (DM) candidates. Sterile neutrinos with a mass of a few keV are such an alternative, which have to be produced in the early Universe by a mechanism different from ordinary thermal freeze-out.

After an introduction to the topic, I will review the different proposals on the market for sterile neutrino DM production mechanisms and will show how non-trivial the resulting velocity distributions can be. I will touch on how to use the non-trivial DM spectra to possibly attack the known small scale structure formation problems of cold DM.

In general, I will give you the reasons at hand why sterile neutrino DM is not an exotic outsider view, but rather a serious alternative to WIMPs, which we will need to investigate with full force in case WIMP detection attempts keep on not delivering a clear picture.

Primary author: Dr MERLE, Alexander (Max-Planck-Institut fuer Physik)

Presenter: Dr MERLE, Alexander (Max-Planck-Institut fuer Physik)

Session Classification: Session C

Contribution ID: **4** Type: **not specified**

Search for dark photons using CRESST-II data

Monday, 30 November 2015 18:00 (15 minutes)

The dynamics of gallaxies and gallaxy clusters give many hints for the existence of cold dark matter. However, the nature of dark matter remains unknown and is subject to direct dark matter searches. Many of these searches focus on the observation of dark-matter particles scattering off target nuclei.

Several theories predict dark-matter particles interacting mainly with
the electrons of the target material. Such events can not be istinguished from natural radioactivity and cosmogenics on an event-by-event basis.

We present the current status of the search for drak-matter particles interacting with the electrons of calcium tungstate. Using data from CRESST-II phase 2 we search in particular for dark photons.

Primary author: Dr GÜTLEIN, Achim (Austrian Academy of Sciences)

Presenter: Dr GÜTLEIN, Achim (Austrian Academy of Sciences)

Session Classification: Session C

Contribution ID: **5** Type: **not specified**

DAMIC experiment for low mass dark matter in CCDs

Tuesday, 1 December 2015 09:00 (30 minutes)

The DAMIC (Dark Matter In CCDs) experiment is an experiment using silicon sensors, with low-noise readout to detect dark matter. DAMIC is operated in SNOlab, and is currently being upgraded with 100 grams of thicker, lower noise CCDs, as well as improved shielding for DAMIC 100 which will be operational in 2016. I will discuss preliminary DAMIC 2014 results, expected DAMIC 100 results, and the potential for DAMIC-1 kg to reach close to the neutrino floor for masses below 10 GeV.

Primary author: Prof. KILMINSTER, Ben (University of Zurich)

Presenter: Prof. KILMINSTER, Ben (University of Zurich)

Session Classification: Session D

Contribution ID: **7** Type: **not specified**

A new QCD dark matter axion search using a dielectric resonant cavity

Tuesday, 1 December 2015 15:15 (20 minutes)

Axions are hypothetical low-mass bosons which are predicted to exist by the Peccei-Quinn mechanism that can explain the absence of CP-violating effects in quantum chromodynamics (QCD). Axions could also provide the cold dark matter of the universe and as such are among the few particle candidates that solve simultaneously two major problems of nature. All existing experimental efforts focus on a range of axion masses below 20 ?eV which is motivated by the traditional re-alignment mechanism of the axion field. If the Peccei-Quinn symmetry was restored after inflation, decaying topological defects could lead to an axion population providing all of the cold dark matter with an axion mass in the range of 100–300 ?eV.
We present a new project based on the idea of axion photon conversion at the transition between two media with different dielectric constants. With a homogeneous magnetic field at such a transition layer, coherent photon production in the microwave regime could be generated by the hypothetical dark matter axion field. A significant boost in photon conversion can be achieved when using several layers with alternating dielectric constants. The additional surfaces are forming coupled resonant cavities and could enhance the axion-photon conversion rate significantly. A resonator with a boost factor of ~10^4 within a magnetic field of order 10T could be enough to achieve an axion-photon conversion rate within a reasonable volume to be unambiguously detected with state of the art radiometer technology within a reasonable time per frequency band. The experimental idea and the proposed design for an experiment will be discussed in some detail. First results from measurements of the expected preamplifier noise and the microwave radiation transmission behavior of a prototype resonant dielectric cavity will be discussed. The prospects for reaching a sensitivity enough to cover the parameter space predicted for QCD dark matter axions with mass in the range 100-300 ueV will be presented.

Primary author: Dr MAJOROVITS, Bela (MPI Physik)

Presenter: Dr MAJOROVITS, Bela (MPI Physik)

Session Classification: Session F

Contribution ID: **8** Type: **not specified**

DARK MATTER [AND NEUTRINO] PHYSICS WITH SUB-KEV GERMANI-UM DETECTORS

Tuesday, 1 December 2015 11:30 (30 minutes)

Germanium detectors with sub-keV sensitivities offer a unique opportunity to study neutrino interactions and properties as well as to search for light WIMP Dark Matter. The TEXONO and CDEX Collaborations has been pursuing this research program at the Kuo-Sheng Neutrino Laboratory (KSNL) in Taiwan and in the China Jinping Underground Laboratory (CJPL) in China. We will present highlights of the detector R&D program which allow us to experimental probe this new energy window. The results, status and plans of our dark matter program will be discussed.

Primary authors: Prof. WONG, Henry (Academia Sinica); Prof. YUE, Qian (Tsinghua University)

Presenter: Prof. WONG, Henry (Academia Sinica)

Session Classification: Session E

Contribution ID: **9** Type: **not specified**

The NEWS-SNO project

Tuesday, 1 December 2015 15:35 (20 minutes)

The existence of Dark Matter in our Universe is nowadays well established, however, its exact nature still remains unknown. The goal of the NEWS-SNO (New Experiments with Spheres in SNOLAB) project is to search for particle candidates in mass regions not yet accessible by existing experiments. The planned NEWS-SNO detector consists of a spherical TPC (time-projection-chamber) out of ultrapure copper filled with up to 10bar of CH4 and He gas mixtures which is read out with one small central sensor set at high voltage. Thanks to the very light nuclear mass of the employed targets as well as the detector's very low energy threshold, the detection of spin-independent interacting WIMPS down to masses of 0.1 GeV/c2 is aimed at. This mass range for Dark Matter particles is motivated in a number of models based on dark sector forces and, e.g., millicharged models. Changing the nature and/or mixture of gas, the pressure, the applied high voltage or the sensor, respectively, are different handles that could be used to check a potential dark matter like signal.

An overview and status of the planned experiment at SNOLAB and of the prototype detector SEDINE currently taking data in the LSM underground laboratory in France will be given.

Primary authors: Prof. GERBIER, Gilles (Physics Department, Queen's University); Dr ROTH, Sabine (Physics Department, Queen's University)

Presenter: Dr ROTH, Sabine (Physics Department, Queen's University)

Session Classification: Session F

Contribution ID: **10** Type: **not specified**

Perspectives for low mass dark matter searches with the LUX and LZ experiments.

Monday, 30 November 2015 16:45 (30 minutes)

The Large Underground Xenon (LUX) experiment is a 350kg liquid xenon time projection chamber (TPC) designed to directly detect galactic dark matter, in particular as Weakly Interactive Massive Particle (WIMP). Currently deployed 1 mile underground in the Sanford Underground Research Facility in Lead, South Dakota, LUX completed its first physics run in 2013 collecting 85.3 live-days of science data. The profile-likelihood based analysis has shown no evidence for signal, setting the best limit on spin independent WIMP-nucleon cross section with a minimum of 7.6 × 10−46 cm2 for WIMP mass of 33 GeV/c2 at 90% C.L. LUX is presently conducting a 300-day data taking. The LUX-ZEPLIN (LZ), the successor of LUX, is a second-generation dark matter detector also based on TPC technology, with total liquid xenon mass of about 10 tonnes.
The detectors are optimised for discovering WIMP in the mass range from few GeV/c2 to hundreds of TeV/c2 . However new techniques for nuclear recoil (NR) and electron recoil (ER) calibration enhance the potentiality also for light WIMP and axion searches. Multiple scattering of mono-energetic 2.45 MeV neutrons are used for NR, allowing precision calibration of liquid xenon at energies down to 1.2 keV for light yield and 0.8 keV for charge yield, and various diffused sources are employed for ER, enabling to reach down to 190 eV. We will present these techniques along with the analysis specifically dedicated to light dark matter searches based on identifying charge only events.
We will also present the design of the LZ technical systems, the instrument expected backgrounds and science performance. In addition to the ionisation only analysis the combined exploitation of the TPC together with the outer detector systems, and the novel development of software tools, will broaden the LZ sensitivity to more exotic dark matter scenarios.

Primary author: Dr BELTRAME, Paolo (University of Edinburgh - School of Physics and Astronomy)

Presenter: Dr BELTRAME, Paolo (University of Edinburgh - School of Physics and Astronomy)

Session Classification: Session B

Contribution ID: **11** Type: **not specified**

SEARCH FOR LOW-MASS WIMPS WITH THE EDELWEISS-III EXPERIMENT

Tuesday, 1 December 2015 11:00 (30 minutes)

The EDELWEISS-III experiment is a direct search for WIMP dark matter that uses an array of twenty-four 800 g heat-and-ionization cryogenic detectors fully covered with interleaved electrodes for the rejection of near-surface events.
An 8-month search has been recently concluded. Detector performances and in particular the improvement of experimental resolutions relative to the previous phase of the experi- ment has made possible to reduce the analysis threshold down to 2.4 keV nuclear recoils, and extend significantly the sensitivity to lower WIMP masses. We will present the limit obtained on the spin-independent WIMP-nucleon cross-section from a fiducial exposure of 582 kg.day.
The present limitations and the future prospects of the experiment will be discussed, with the emphasis on the important gain in sensitivity achievable in the near future for WIMP within the mass range from 1 to 20 GeV range, notably by using the Luke-Neganov amplification of the heat signal to reduce experimental thresholds, and at longer term in a 100-kg scale experiment installed in an improved facility such as the one currently being planned at SNOLAB by the SuperCDMS collaboration.

Primary author: Prof. GASCON, Jules (IPNL Universite Lyon 1 and CNRS/IN2P3)

Presenter: Prof. GASCON, Jules (IPNL Universite Lyon 1 and CNRS/IN2P3)

Session Classification: Session E

Contribution ID: **12** Type: **not specified**

Search for Low-Mass Dark Matter with the CRESST Experiment

Monday, 30 November 2015 16:15 (30 minutes)

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment aims at the direct detection of dark matter particles. The recent dark matter run was operated for 2 years with a total target mass of 5kg. With respect to previous measuring campaigns the intrinsic radiopurity of $CaWO_4$ crystals and the capability to reject recoil events from alpha surface contamination have been significantly improved. We analyzed the data acquired by two $CaWO_4$ detectors which combine an unprecedented background level with a trigger threshold as low as 300eV. In this talk, we present a new detector design and a low-threshold analysis which set stringent limits for the spin-independent dark matter particle-nucleon cross section. These results show the high potential of CRESST for the exploration of low-mass dark matter. The status of the currently ongoing preparations towards the next phase of the experiment (CRESST-III) and the strategy beyond will be discussed.

Primary author: Dr STRAUSS, Raimund (MPI für Physik München)

Presenter: Dr STRAUSS, Raimund (MPI für Physik München)

Session Classification: Session B

Contribution ID: **13** Type: **not specified**

DEPFET DEVICES FOR THE DETECTION OF LOW MASS WIMP INTERACTIONS

Tuesday, 1 December 2015 12:00 (15 minutes)

The use of scientific grade CCD detectors in the scope of the DAMIC experiment has demonstrated the usefulness of solid state detectors for the search for WIMP interactions with matter. The bulk material of the detector (here: silicon) serves as both interaction medium and detector at the same time. The low readout noise, in combination with the low mass of the silicon nucleus, makes the instrument especially sensitive to nuclear 2recoils with keV scale energies from WIMPs with masses < 10 GeV/c .
Hereby, the sensitivity in terms of recoil energy deposition is above all depending on the readout noise of the detector. In this context, the technique of repetitive non-destructive readout (RNDR) of the detectors is a very promising option to drastically push the sensitivity limit.
Measuring the deposited charge repetitively in a statistically independent way yields an average value, whose effective noise (i.e. the variance) corresponds to the readout noise of a single measurement divided by the square root of the number of measurements. Detector structures based on the combined detector-amplifier structure DEPFET (DEpleted P-Channel FET) are an ideal platform for the implementation of RNDR. The DEPFET structure is integrated on a fully depleted substrate and stores the bulk-generated charge in a potential minimum directly underneath its external gate, where it influences the channel conductivity. Signal acquisition is usually done by comparing the values before and after the removal of the signal charge. For the implementation of RNDR, a sensor pixel is composed of two DEPFET devices, between which the charge can be transferred. Each transfer then corresponds to a complete measurement.
DEPFET devices based on state-of-the-art technology exhibit a readout noise of 3-4 e- ENC. Noise levels of 0.2 e- ENC and below have been demonstrated with RNDR DEPFETs based on this technology. Additional functional features provide for an extremely low level of instrument-generated background. The pixel size and substrate thickness can be adapted over a wide range of sizes to the experimental requirements, making large area RDNR arrays promising candidates for a solid state detector based low mass WIMP detection experiment.

Primary author: Dr TREIS, Johannes (MPG Semiconductor Laboratory)

Presenter: Dr TREIS, Johannes (MPG Semiconductor Laboratory)

Session Classification: Session E

Contribution ID: **14** Type: **not specified**

Challenges of Indirect Detection of low mass (below 50 GeV) Dark Matter

Tuesday, 1 December 2015 12:15 (45 minutes)

Indirect detection of Dark Matter (i.e. the search for cosmic rays produced by DM annihilations or decays in the galactic halo, or beyond) is usually considered as a promising approach, rightly so. However, when DM is relatively light, say in the sub-WIMP regime, the technique faces some challenges, essentially because astrophysics gets too much in the way. I will give a general overview of DM ID and then discuss some example of studies in the low mass region, in particular related to antiprotons (and solar modulation) and gamma rays (including from secondary radiation: Inverse Compton, bremsstrahlung, synchrotron radiation).

Primary author: Dr CIRELLI, Marco (LPTHE Jussieu CNRS)

Presenter: Dr CIRELLI, Marco (LPTHE Jussieu CNRS)

Session Classification: Session E

Contribution ID: **15** Type: **not specified**

LOW MASS WIMP SEARCH WITH THE CDMS LOW IONIZATION THRESHOLD EXPERIMENT

Monday, 30 November 2015 15:15 (30 minutes)

SuperCDMS employs cryogenic germanium detectors to search for interactions of Weakly Interacting Massive dark matter Particles (WIMPs) with ordinary matter. In standard operating mode phonon and ionization signals are measured for each event for an effective discrimination between background electron recoils and dark matter candidate nuclear recoil events down to a few keV, giving sensitivity for WIMPs down to about 4 GeV/c2.
In the CDMS Low Ionization Threshold Experiment (CDMSlite) we apply a much higher potential for the charge collection, generating a large additional phonon signal from the drifting charge carriers and thus allowing the measurement of very low ionization signals through the phonon channels. This method compromises event-by-event discrimination but gives access to much lower recoil energies and thus lower mass WIMPs.
After an initial demonstration of the method, an extended CDMSlite run was performed in 2014, collecting ~70 kg days net exposure and reaching a threshold as low as 56 eV (electron recoil equivalent). Improvements in background were achieved in the analysis with a new fiducialization scheme. CDMSlite reached world leading sensitivity 2for spin-independent WIMP-nucleon cross sections between 1.7 and 5.6 GeV/c .
This presentation introduces the basic idea of voltage assisted phonon amplification which is the basis of this experiment, before discussing in detail the most important of the recent improvements and their effect on the final results.

Primary author: Prof. RAU, Wolfgang (Queen's University, Kingston)

Presenter: Prof. RAU, Wolfgang (Queen's University, Kingston)

Session Classification: Session A

Contribution ID: **16** Type: **not specified**

Toward ~eV resolution phonon mediated detectors for SuperCDMS SNOLAB low mass Dark Matter search and beyond

Tuesday, 1 December 2015 09:30 (20 minutes)

Using Neganov-Luke phonon amplification in very low temperature germanium detectors, CDMSlite is reaching unprecedented RMS resolution of 14 eVee and currently the most sensitive experiments for WIMPs of mass < 5 GeV/c^2. However to further improve the Neganov-Luke phonon gain, CDMSlite is currently limited to an applied electric field < 24 Volts/cm. Our recent studies points to the electrode/absorber interface and carrier leakage through that interface as the main source of this limitation. In particular, we demonstrated x2 improvement in resolution using improved electrode contacts. I will discuss, our recent R&D to improve SuperCDMS HV electrode interface and expected resolution gain. Concurrently, we are designing new phonon sensor geometry to improve SuperCDMS threshold independently from the Neganov-Luke gain. The combination of the two methods will result in detectors with beyond SuperCMDS SNOLAB expected performance.

Primary author: Prof. MIRABOLFATHI, Nader (Texas A&M University)

Presenter: Prof. MIRABOLFATHI, Nader (Texas A&M University)

Session Classification: Session D

Contribution ID: **18** Type: **not specified**

Dark matter at the LHC, models and interpretations

Monday, 30 November 2015 14:30 (45 minutes)

The LHC results on dark matter from Run-1 were mostly interpreted in the framework of effective filed theories. Simplified models involve new mediators between the Standard Model and the Dark Sector and allow for richer phenomenology and more complex interpretations. Complementarity of the collider, direct and indirect dark matter searches will be discussed and possible search strategies at the LHC in Run-2 will be outlined.

Primary author: Dr SALEK, David (GRAPPA)

Presenter: Dr SALEK, David (GRAPPA)

Session Classification: Session A

Contribution ID: **19** Type: **not specified**

Improving the sensitivity to low-mass WIMPs with XENON detectors

Monday, 30 November 2015 17:15 (30 minutes)

Dark matter experiments based on dual-phase Xe TPCs such as XENON100 and the upcoming XENON1T currently place the most stringent limits on the spin-independent WIMP-nucleon cross section for WIMP masses above 10GeV/c^2. In this talk, strategies to improve the sensitivity to lower WIMP masses such as using only the charge signal or increasing the light collection efficiency will be discussed.

Primary author: Dr VON SIVERS, Moritz (Albert Einstein Center for Fundamental Physics, University of Bern)

Presenter: Dr VON SIVERS, Moritz (Albert Einstein Center for Fundamental Physics, University of Bern)

Session Classification: Session B

Contribution ID: **20** Type: **not specified**

Dark Matter: the Big Picture

Monday, 30 November 2015 13:45 (45 minutes)

I will review the status of dark matter searches, and discuss present and upcoming efforts to identify the nature of this mysterious component of the Universe.

Primary author: Prof. BERTONE, Gianfranco (University of Amsterdam and GRAPPA)

Presenter: Prof. BERTONE, Gianfranco (University of Amsterdam and GRAPPA)

Session Classification: Session A

Contribution ID: **21** Type: **not specified**

Ultralight dark matter

Tuesday, 1 December 2015 14:30 (45 minutes)

The dark matter of the Universe could be made of ultralight particles.
In this talk I briefly review the motivation and status of the searches for well stablished candidates such as axions and recently described axion-like particles, dark photons and other "Exotica". The search techniques involved are completely different than those employed for massive dark matter candidates, and indirect effects on astrophysics and cosmology can also be quite spectacular.

Primary author: Dr REDONDO, Javier (Zaragoza University)

Presenter: Dr REDONDO, Javier (Zaragoza University)

Session Classification: Session F

Contribution ID: **23** Type: **not specified**

DARKSIDE: RECENT RESULTS WITH UNDERGROUND ARGON AND OUTLOOK

Tuesday, 1 December 2015 08:30 (30 minutes)

DarkSide-50 is a two-phase 50 kg liquid argon TPC, shielded by a liquid scintillator neutron veto and by a water Cherenkov muon veto, running at LNGS since October 2013. In the first run, DarkSide-50 operated with atmospheric argon (1,422 kg day exposure), collecting and completely rejecting about 16 millions of background events in the region of interest, mostly originating from 39Ar. Operations with underground argon, started in March 2015, demonstrated an 39Ar suppression factor larger than 1,000. The 39Ar suppression factor in underground argon combined with the exceptional electron recoil rejection power are paving the way towards the next DarkSide phase, the 20-tonne fiducial DarkSide-20k detector.

Primary author: Dr FRANCO, Davide (Laboratoire Astroparticule et Cosmologie)

Presenter: Dr FRANCO, Davide (Laboratoire Astroparticule et Cosmologie)

Session Classification: Session D

Contribution ID: **24** Type: **not specified**

Going Beyond WIMPs: Exploring Light Dark Matter

Tuesday, 1 December 2015 09:50 (45 minutes)

Primary author: Prof. VOLANSKY, Tomer (Tel Aviv University)

Presenter: Prof. VOLANSKY, Tomer (Tel Aviv University)

Session Classification: Session D

Contribution ID: **25** Type: **not specified**

Welcome

Monday, 30 November 2015 13:30 (15 minutes)

Session Classification: Session A

Contribution ID: **26** Type: **not specified**

Prospects in low mass dark matter

Tuesday, 1 December 2015 16:30 (1 hour)

Primary author: Prof. MASIERO, Antonio (Univ. of Padova and INFN)

Presenter: Prof. MASIERO, Antonio (Univ. of Padova and INFN)

Session Classification: MPP colloquium