# Interdisciplinary Cluster Workshop on Dark Matter 2014

10-11 February 2014

Venue: MPI für extraterrestrische Physik,
Giessenbachstraße, 85748 Garching
Neuer Seminarraum (UG)

## About the workshop:

The Interdisciplinary Cluster Workshop on Dark Matter 2014 is a workshop dedicated in particular to foster new projects and collaborations in this field. Local scientists present their work in talks on these two days. Selected external scientists join this workshop. Organisation: Excellence Cluster Universe, www.universe-cluster.de

## Scientific Organising Committee:

Stefan Hofmann (LMU)
Alejandro Ibarra (TUM)
Eiichiro Komatsu (MPA)
Jean-Côme Lanfranchi (TUM)
Andreas Müller (TUM), Chair
Jochen Weller (LMU)
Simon White (MPA)

## Schedule and Talks

### SESSION: Direct detection of dark matter

**Chairman: Jochen Weller (LMU)**

**MONDAY, 10 February 2014, 9:00-10:00**

**Jean-Côme Lanfranchi (TUM): Status and future of the CRESST experiment**
CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is an experiment aimed at the direct detection of dark matter. The experiment uses scintillating CaWO4 single crystals operated at mK-temperatures to measure the recoil energy deposited by elastic WIMP (Weakly Interacting Massive Particle) nucleon scattering. By recording the heat as well as the associated scintillation light generated by an energy deposition in the crystal, CRESST is able to achieve a unique discrimination on an event-by-event level. In the data taking run from 2009 to 2011 (Run32) comprising 730kg-days of exposure a total of 67 events in the region of interest passed all cuts and were difficult to explain with contributions from common backgrounds such as alpha-, beta-, gamma-radiation or neutrons. However, the excess might be explainable by a light WIMP of the 10 GeV type or by a still

unconsidered form of background. A new data taking campaign (Run33) has started in 2013 aiming at clarifying the above mentioned experimental situation. In this talk Jean will discuss the experimental details and the status of the experiment. Finally an outlook will be given towards the future EURECA (European Underground Rare Event Calorimeter Array) experiment aimed at unifying the low-temperature experiments CRESST, EDELWEISS and possibly also the US based SuperCDMS in one setup.

**MONDAY, 10 February 2014, 10:00-10:15 – Coffee break**

**MONDAY, 10 February 2014, 10:15-11:15**

**Marc Schumann (U Bern): Direct detection of dark matter with Xenon**
Ultra-sensitive detectors using the noble gas xenon in liquid form (LXe) as dark matter target have currently reached the highest sensitivity to WIMP-nucleon interactions. Larger detectors, with target masses above 1t and with an even lower radioactive background, will come online in the next year, aiming at increasing the sensitivity by another factor of 100. Marc will discuss recent results of LXe-based detectors, such as XENON, LUX, and XMASS, the developments towards the next generation detectors, and the physics reach of multi-ton LXe dark matter detectors.

**MONDAY, 10 February 2014, 11:15-12:15**

**Georg Raffelt (MPP): Axion dark matter**
Cold dark matter in the form of axions is very different from WIMPs with regard to cosmological production and experimental searches. The motivation for axions, experimental and astrophysical limits, and ongoing and future search strategies will be reviewed.

**MONDAY, 10 February 2014, 12:15-14:00 – Lunch with Bavarian Brotzeit in the Foyer**

## SESSION: Indirect detection of dark matter

**Chairman: Jean-Côme Lanfranchi (TUM)**

**MONDAY, 10 February 2014, 14:00-14:45**

**Alejandro Ibarra (TUM): Searching for spectral features in the gamma-ray sky**
The search for the gamma-rays which are presumably produced in dark matter annihilations is hindered by the existence of large, and still poorly understood, astrophysical backgrounds. In this talk we will emphasize the importance of sharp spectral features for the identification of a dark matter signal. We will review the status of the search of the various spectral features that arise in particle physics scenarios and we will discuss the interplay with other search strategies.

**MONDAY, 10 February 2014, 14:45-15:30**

**Christoph Raab (TUM): Dark matter constraints from IceCube (and beyond)**
Neutrinos are helpful messenger particles to indirectly search for the decay or annihilation of dark matter particle and constrain a variety of dark matter models. The IceCube neutrino telescope measures Cherenkov light from charged particles created by the interaction of neutrinos in a cubic kilometer of Antarctic ice. Already during its construction period, IceCube has taken data that was put through a variety of analyses with focus on WIMPs in the Galactic halo, the Galactic center, dwarf galaxies and the sun. With the increasing number of

deployed strings, the sensitivity especially towards lower WIMP masses gradually improved and finally put new competitive limits on the spin-dependent proton scattering cross section. The planned low-energy extension PINGU would provide improved sensitivity to dark matter and after 1 year live-time cut into possible signal regions from DAMA/LIBRA and CoGeNT.

**MONDAY, 10 February 2014, 15:30-16:00 – Coffee break**

**MONDAY, 10 February 2014, 16:00-16:20**

**Sebastian Wild (TUM): Indirect dark matter detection using cosmic antideuterons – status and prospects**

The search for cosmic antideuterons has been proposed as a promising and clean method to indirectly detect dark matter, due to the very small background flux from spallations expected at the energies relevant to experiments. In this talk we discuss the prospects to observe antideuterons from dark matter annihilations or decays in current and future experiments, taking into account the important correlation of the antideuteron flux with the well-measured antiproton-to-proton fraction. We also present the more recent idea to use antihelium as a channel for indirect dark matter detection.

**MONDAY, 10 February 2014, 16:20-16:45**

**Anna Lamperstorfer (TUM): Interpretations of the positron excess**

The rise in the positron fraction that was measured by the PAMELA experiment in 2008 was recently confirmed with unprecedented precision by the AMS-02 collaboration. In this talk Anna will review the calculation of the positron fraction and discuss three possible explanations of the positron excess, namely secondary production inside supernova remnants, and electron and positron production by pulsars and by DM annihilations. Assuming a secondary positron background and an additional astrophysical source, the new AMS-02 positron data allow to derive stringent limits on annihilating and decaying dark matter.

**MONDAY, 10 February 2014, 16:45-17:15 – Discussion**

## SESSION: Astrophysics simulations and observations

**Chairman: Andreas Müller (TUM)**

**TUESDAY, 11 February 2014, 9:00-9:45**

**Matteo Viel (L'Osservatorio Astronomico di Trieste): Constraints on dark matter properties from intergalactic space**

Matteo will review the current constraints that intergalactic medium (IGM) data can place on:
1) the coldness of cold dark matter and its small scale properties;
2) neutrino masses;
3) cosmological parameters in standard and non-standard scenarios and implications for dark matter.
He will compare observational results (from high resolution and low-resolution quasar spectra) to state-of-the-art hydrodynamic simulations of the high redshift universe.

**TUESDAY, 11 February 2014, 9:45-10:00 – Coffee break**

**TUESDAY, 11 February 2014, 10:00-10:45**

**Stella Seitz (USM): The core-cusp problem tbs**

**TUESDAY, 11 February 2014, 10:45-11:30**

**Christian Wagner (MPA): Neutrino effects on structure formation**
After reviewing the basics of neutrino physics in the context of cosmology, Christian will focus on neutrino effects on the large scale structure of the universe. Especially, he will discuss how the matter power spectrum and galaxy cluster abundance are altered by the total mass of the neutrinos. Along the way, predictions of the effects using linear theory as well as N-body simulations are presented. Christian will conclude by summarizing the latest observational constraints derived from various cosmological data sets including a discussion of their possible systematics.

**TUESDAY, 11 February 2014, 11:30-12:00 – Discussion**

**TUESDAY, 11 February 2014, 12:00-13:15 – Lunch break**

**TUESDAY, 11 February 2014, 13:15-14:00**
**Simona Vegetti (MPA): Dissecting the properties of dark matter with strong gravitational lensing**
The nature of dark matter and how galaxies form in the early Universe are two major issues of modern Cosmology. Observations of the Milky Way satellite galaxies have long been used as test laboratories of the Cold Dark Matter paradigm in the small non-linear regime. These have revealed a number of potential problems that could potentially be solved by baryonic feedback processes and star formation but that may also be the signature of a different physics of the dark matter. As detecting satellite galaxies and measuring their properties can be observationally challenging, most of the observations have been limited to the Local Group, which may not necessarily be a fair representation of the Universe. Strong gravitational lensing allows us to detect low-mass dark matter satellites beyond the Local Universe and provides therefore an excellent tool to study the properties of dark matter while investigating major issues in the field of galaxy formation and evolution.

**TUESDAY, 11 February 2014, 14:00-14:45**

**Fabian Schmidt (MPA): Looking for dark matter substructure**
The standard cold dark matter (CDM) paradigm predicts a hierarchy of structure down to very small scales (of order the mass of the Earth). Detecting this substructure would not only vindicate the CDM framework, but also potentially allow for a measurement of the free-streaming scale of the dark matter particles, elucidating their production mechanism. Fabian will discuss possible avenues for detecting the substructure, both within the Milky Way halo and other galaxies, purely through its gravitational interactions.

**TUESDAY, 11 February 2014, 14:45-15:00 – Discussion**

**TUESDAY, 11 February 2014, 15:00-15:30 – Coffee break**

## SESSION: Particle physics theory

**Chairman: Alejandro Ibarra (TUM)**

**TUESDAY, 11 February 2014, 15:30-16:15**

**Frank Steffen (MPP): Theory of SUSY dark matter**
Some of the best motivated dark matter candidates appear in supersymmetric (SUSY) extensions of the standard model. The motivation and primordial production mechanisms of these candidates will be reviewed along with the impact of cosmological constraints and new LHC limits on SUSY models.

**TUESDAY, 11 February 2014, 16:15-17:00**

**Björn Garbrecht (TUM): Particle-genesis in the hot early Universe: Inclusive methods**
Björn will review recent work on the production of sterile neutrinos in the hot Universe without and with CP violation (the latter case being relevant for Leptogenesis). In the case of massive neutrinos, there are soft and collinear divergences due to radiation of weak gauge bosons in individual amplitudes, which cancel when calculating the inclusive production rates. These techniques may as well be of relevance for the production of Dark Matter particles.

**TUESDAY, 11 February 2014, 17:00-17:45**

**Antonio Palazzo (MPP): Phenomenology of light sterile neutrinos**
Light sterile neutrinos are at the center of the attention in the neutrino community due to the emergence of new anomalies in short baseline experiments and in cosmological data analyses. Antonio will review the salient phenomenological aspects and highlight the future perspectives in the hunt of these elusive particles.

**TUESDAY, 11 February 2014, 17:45-18:00 – Discussion and wrap-up**

**Contact:**
Andreas Müller, Excellence Cluster Universe
phone +49 89 35831 7104; e-mail andreas.mueller@universe-cluster.de