Talk Titles and Abstracts

Astrophysical Dark Matter and Gravitational Lensing – Rachel Webster (Melbourne University)

Dark Matter Theory and New Searches – Rebecca Leane (Melbourne Univeristy)

Scaling Laws for Dark Halos of Dwarf and Giant Galaxies – Ken Freeman (RSAA/ANU)

The dark halos of dwarf galaxies have central densities up to 3 dex higher than those of bright spirals. This reflects the mean density of the universe at the epochs of formation of these galaxies. The slopes of the scaling laws (density and core radius vs luminosity of the parent galaxy) are as expected from the slope of the P(k) fluctuation spectrum.

Dark Matter Haloes, Two-Part Story: Limits of Cosmological Simulations and Subtle Signatures of Non-Standard Dark Matter – Pascal Elahi (UWA)

Dark Matter Flows – Alan Duffy (Swinburne)

Dark matter detection rates typically assume a simple headwind model with the Earth's motion through a static dark matter halo. We have used zoom in simulations of Milky Way-like galaxies to create a more realistic expectation for the dark matter motion finding high velocity flows and streams can complicate this picture and highlight the need for directional detection experiments.

Missing Neutrinos: How Late Kinetic Decoupling can Change N_{eff} – James Diacomis (UNSW)

We consider dark matter models in which dark matter scatters elastically with a relativistic species such as photons or neutrinos and remains in kinetic equilibrium until fairly late in the universe's evolution. We show that this coupling allows energy to be transferred from the visible sector to the dark sector through collisions between the two particle species and we calculate the amount of energy which will be transferred for different dark matter masses and coupling strengths. We demonstrate that this effect can change the effective number of relativistic degrees of freedom in the universe $N_{\textrm{eff}}$ and use this to provide constraints on various late kinetic decoupling scenarios. This scenario is parsimonious as it can solve problems associated with small-scale structure formation as well as ameliorating the existing tension in measurements of the Hubble parameter H_{0} from Planck and the Hubble Space Telescope without the need for introducing new particle species.

Self-Consistent Dark Matter Simplified Models with an s-Channel Scalar Mediator – Giorgio Busoni (Melbourne University)

We examine Simplified Models in which fermionic DM interacts with Standard Model (SM) fermions via the exchange of an s-channel scalar mediator. The single-mediator version of this model is not gauge invariant, and instead we must consider models with two scalar mediators which mix and interfere. The minimal gauge invariant scenario involves the mixing of a new singlet scalar with the Standard Model Higgs boson, and is tightly constrained. We construct two Higgs doublet model (2HDM) extensions of this scenario, where the singlet mixes with the 2nd Higgs doublet. Compared with the one doublet model, this provides greater freedom *for the masses and mixing angle of the scalar mediators, and their coupling to SM fermions. We outline constraints on these models, and discuss Yukawa structures that allow enhanced couplings, yet keep potentially dangerous flavour violating process under control. We examine the direct detection phenomenology of these models, accounting for interference of the scalar mediators, and interference of different quarks in the nucleus. Regions of parameter space consistent with direct detection measurements are determined.*

Particle Searches at the LHC – Millie McDonald (Melbourne University)

Searches for Dark Photons at Belle and Belle II – Caitlin MacQueen (Melbourne University)

Dark matter comprises a quarter of the known universe, but we still do not know how it interacts or what its constituent particles are. One proposed theory involves introducing a dark sector gauge boson which is charged under a dark sector gauge group, $U(1)_X$. Kinetic mixing of the dark sector and the visible sector would allow the mass eigenstate of this dark sector gauge boson, the dark photon, to interact with the SM photon and, moreover, SM fermions. This mixing is dependent on both the mass of the dark photon, $m_{A^{\prime}}$, and the mixing strength, ε. The dark photon, $A^{\prime}$, would interact in semileptonic processes via $e^+e^- \to \gamma A^{\prime}$, $A^{\prime} \to \ell^+\ell^-$ where $\ell = e$, μ. An analysis is developed using MC simulation and a preliminary search for these decay modes is performed over 37.751 fb^{-1} of data collected by the Belle detector at the KEKB collider in Japan. The results are in close agreement with published results from BaBar's 2014 search for the same decay mode. We find no significant signal and have been able to place 95% CL upper limits on the mixing strength at the order of 10^{-2} for $m_{A^{\prime}} < 2.0$ GeV/c^2 and 10^{-3} for $2.0 \leq m_{A^{\prime}} \leq 10.0$ GeV/c^2. Additionally, we consider similar dark sector searches which may be performed in the future with Belle II. Such searches will depend heavily on examinations of the trigger system and new geometry (be it partial or full) of the Belle II detector.

TeV Gamma-Ray Astronomy and Dark Matter Searches – Gavin Rowell (Adelaide)

I will review the current status of TeV gamma-ray, astronomy, focusing in particular on the HESS and CTA facilities. An emphasis will be given to their ability to indirectly search for Dark Matter via the production of TeV gamma-rays in various astrophysical settings over the coming decade.

GAMBIT and CTA (two-part talk) – Csaba Balazs (Monash)

I describe the dark matter direct detection module implemented in the Global And Modular Beyond-the-Standard-Model Inference Tool, and its potential use for SABRE.
I highlight the Australian involvement in the CTA Dark Matter working group, and show the preliminary reach of CTA in various dark matter scenarios.

Direct Detection and Astrophysics – Celine Boehm (Durham University)

Directional Detection and the CYGNUS Project – Neil Spooner (University of Sheffield)

SUPL and SABRE Update – Jeremy Mould (Swinburne), Francesco Nuti (Melbourne)

The mission of the Stawell Underground Physics Lab is to offer the first such facility in the Southern Hemisphere to experimenters whose research will benefit from this strategic location. The Chair of the Project Steering Committee will describe the opportunities available, and any short term limitations, with a particular emphasis on directional dark matter detection. Feedback on future needs will also be sought.

NITEC: A Negative Ion Time Expansion Chamber for Directional Dark Matter Search – Elisabetta Baracchini (Istituto Nazionale di Fisica Nucleare)

We will present an R&D project for the realization of an original and innovative detector for directional Dark Matter searches, that combines the advantages of a Negative Ions Time Projection Chamber (NITPC) with the benefits of triple GEM amplification and pixelated readout (GEMPix). We will present preliminary measurements of NITEC performances with innovative negative ion gas mixture based on SF6 from 100 Torr to nearly atmospheric pressure.

Progress on the Directional Dark Matter Detector, D3-milli – Thomas Thorpe (University of Hawaii)

As direct dark matter experiments get larger and gain sensitivity they will start detecting neutrinos via coherent scattering with their target nuclei. The most powerful way to discriminate neutrino scattering from dark matter is to measure which direction the source is located, a so-called directional detector. The Directional Dark matter Detector, D3, project is fabricating it's next generation prototype, D3 - milli, that will make use of a Negative Ion Time Projection Chamber (NITPC), GEM amplification, and HD pixel readout. Such a design would allow for 3-D tracking with powerful background suppression and could serve as a unit-cell for a large, future, directional detector.

Halo Structure and Direct Detection – Annika Peter (Ohio State University)

NEWAGE – Kentaro Muichi (Kobe University)

NEWAGE is a direction-sensitive direct dark matter search experiment. NEWAGE uses a micro-TPC with a detection volume of 30 by 30 by 41 cm^3 read by one of the MPGD variations, \mu-PIC. We have been performing underground measurement since 2013 with a new detector NEWAGE-0.3b'. We published the best direction-sensitive limits in PTEP (2015) 043F01s with 30 days' live time data. We continued the measurement and the results from half-a-year data will be presented. In order to improve the sensitivities, we are developing a low-radioactive \mu-PIC and a negative-ion TPC. These recent activities to improve the sensitivity will also be reported.

The Distribution of Dark Matter Velocities – Steen Hansen (Copenhagen)

The velocity distribution of dark matter near the Earth is important for an accurate analysis of the signals in terrestrial detectors. This distribution is typically extracted from numerical simulations, or simply assumed to be a truncated Maxwellian. In this short talk I will discuss if we can understand what this distribution of velocities looks like - can we derive it?

Halo-Independent Methods of Dark Matter Direct Detection Signals – Juan Herrero Garcia (Adelaide)

We have derived new halo-independent tests of dark matter direct detection signals. In the first part of the talk [based on 1502.03342 (elastic scattering) and 1512.03317 (inelastic)], I will discuss a halo-independent lower bound on the DM capture rate in the Sun from a direct detection signal, with which one can set limits on the branching ratios into different channels from the absence of a high-energy neutrino flux in neutrino telescopes. In the second part [based on 1505.05710 and 1506.03503], I will discuss a lower bound one can set on the product of the DM-nucleon cross section and the energy density from a direct detection signal that is independent of the velocity distribution, and how this bound can be combined with limits from local density measurements, the LHC and the relic abundance in order to constraint DM models. If time permits, I will also discuss a work on inelastic self-interacting dark matter and how it can solve the small scale structure problems.

Australian Axion Dark Matter Detection Experiment – Michael Tobar (UWA)

At UWA we have started work towards the first Ultra-High Frequency Dark Matter Axion Haloscope, which will complement existing low and high frequency searches worldwide. This search will aim to detect axions of the mass range 40 μeV (10 GHz photons) to 200 μeV (50 GHz Photons). This will be achieved in three steps: 1) The first search occurring at (110 ±2) μeV (currently under initial operation), to verify or refute a very recent claim of detection using superconducting Josephson Junction technology [1,2]. This will require a 26.6±0.5 GHz scan: 2) Following this, a comprehensive 10 to 30 GHz scan with the precision necessary to rule in or out current axion dark matter models. The required precision will be achieved by implementing new Axion Haloscope techniques at high frequencies developed by UWA researchers [3,4]. This method will incorporate multiple cavities, new cross-correlation techniques and quantum measurement techniques. 3) If necessary, due to null detection of steps 1) and 2), a higher frequency search from 30 to 50 GHz will be planned for the future. This search will require the acquisition of a dedicated Dilution Fridge, a high field 14 Tesla magnet and the use of Engineered Quantum Technologies.

[1] C. Beck, Possible Resonance Effect of Axionic Dark Matter in Josephson Junctions, Phys. Rev. Lett. 111, 231801, 2013.
[2] C. Beck, Axion mass estimates from resonant Josephson junctions, Physics of the Dark Universe, 7–8, 6–11, 2015.
[3] B.T. McAllister, S.R. Parker, M.E. Tobar, Axion Dark Matter Coupling to Resonant Photons via Magnetic Field, arXiv:1512.05547 [hep-ph] (in PRL 2016).
[4] SR Parker, BT McAllister, EN Ivanov, ME Tobar, Cross-correlation measurement techniques for cavity-based axion and weakly interacting slim particle searches, arXiv:1510.05775 [physics.ins-det].