Sydney Spring School 2022

Wednesday, 30 November 2022 - Friday, 2 December 2022

University of Sydney

Scientific Programme

Jenni Adams (U. Canterbury): Neutrino astrophysics
With the detection of astrophysical neutrinos the era of neutrino astronomy has begun. In these lectures the following topics will be covered:
-Neutrino sources and detectors
-Relationship of high-energy neutrinos to cosmic ray physics
-Interpreting results from neutrino telescopes
-Recent astrophysical neutrino results and their implications

Pippa Cole: (GRAPPA): Primordial black holes
Review of models, bounds, and future searches for primordial black holes as a dark matter candidate

Will DeRocco (UCSC): Stellar probes for BSM physics
In this lecture, we will cover the basic theory of stellar evolution, following a star through the various stages of its lifecycle. Along the way, we will discuss how observations of a particular stage allow us to probe Beyond the Standard Model physics. During our journey, we will touch upon cooling bounds, constraints from the tip of the red giant branch, white dwarf explosions, supernova indirect detection bounds, neutron star heating, black hole superradiance, and more.

Ulrik Egede: (Monash) Flavour anomalies
The weakly decaying bound states of heavy flavour hadrons act as a laboratory for searches of new physics. I will place the current searches for New Physics with data from the LHCb and BELLE II experiments within a historical perspective. We will then review the theoretical framework that New Physics searches are placed within, before we will dive into some of the details for the current "flavour anomalies" in the experimental results. We will conclude with a discussion about how current and future measurements will allow us to distinguish between signatures of New Physics and QCD effects that are not accounted for.

Theresa Fruth: (U. Sydney): Experimental techniques for dark matter detection
One avenue in the search for dark matter are earth-based detectors in which scientists aim to observe the interaction of dark matter particles with baryonic matter. These experiments face many challenges as the dark matter interactions would be rare and of low energy. In this lecture, I will go through the fundamental assumptions and calculations direct detection searches are based on. I will then give an overview of the different approaches past, current and future experiments employ to overcome these challenges.

Yann Mambrini: (IJCLab Paris-Saclay, CNRS / CERN): (Dark) matter production in the (very) early stage of the Universe
I will present in this lectures the subject of the production of
particles (thermal bath as well as dark matter), in the earliest stage of the Universe, from the preheating phase to the reheating time and then during the thermal phase. Depending on the nature of dark matter (WIMP, FIMP, gravitational coupling...) the production modes are different, as well as the source or the mechanism. The first lecture will review the classical WIMP framework, where the dark matter is produced
from the thermal bath, then we will look into detail the possibility of feebly interacting
particles produced through the inflaton oscillation before moving on gravitational production and parametric resonance.

Ciaran O'Hare: (Sydney): Axions
Covering the motivation for the QCD axion as a solution to the strong CP problem, the production of axions as dark matter, finishing with constraints from experiments and astrophysical probes

Yevgeny Stadnik: (Sydney) Phenomenology of ultralight scalar dark matter
Ultralight bosonic particles produced non-thermally in the early Universe may subsequently form an oscillating classical field that can comprise the observed cold dark matter. The very high number density of such dark-matter particles can give rise to characteristic wavelike signatures that are distinct from the more usual particle signatures of WIMP-like dark matter. In particular, ultralight scalar dark matter may induce apparent variations of the fundamental “constants” of Nature. I discuss the basic principles of and recent results in searches for ultralight scalar dark matter using precision low-energy experiments, such as atomic spectroscopy, optical cavities, interferometry and accelerometers.