Astrophysics Seminar Speakers 2019-20

Jon Lapington (University of Leicester)

The Small-Sized Telescope for the Cherenkov Telescope Array

9 October 2019

The Cherenkov Telescope Array (CTA) is the next generation ground-based observatory for gamma-ray astronomy at very-high energies. It was first conceived in 2006 as a successor to H.E.S.S, MAGIC and VERITAS, to provide ten times higher sensitivity and with better angular and energy resolution. With more than 100 telescopes located in the northern and southern hemispheres, CTA will be the world's largest and most sensitive high-energy gamma-ray observatory. In this talk I will focus on the evolution of the CTA Small-Sized Telescope (SST) optimized for the highest energies up to 300 TeV, from the three competing SST designs which have been developed, through to the recent selection of Compact High Energy Camera (CHEC) and the ASTRI telescope structure.

Romeel Dave (University of Edinburgh)

Tales of Black Hole Feeding and Feedback From the Simba Simulation

23 October 2019

The growth of supermassive black holes and their role in quenching massive galaxies is a key unsolved problem in galaxy formation. I present a new suite of cosmological hydrodynamic simulations called Simba, which builds on our successful Mufasa simulations to include a novel torque-limited black hole accretion model and AGN feedback using observationally-constrained bipolar kinetic jets. I will describe the physical motivations behind Simba, and show that they yield a galaxy and black hole population in agreement with numerous observations across cosmic time. Simba's AGN feedback has dramatic and unforeseen effects on, among other things, intergalactic gas and green valley galaxy profiles, suggesting new avenues for constraining AGN feedback models.

James Matthews (Cambridge University)

How are the highest energy particles in the universe accelerated?

6 November 2019

The origin of ultrahigh energy cosmic rays (UHECRs) - protons and nuclei striking our atmosphere with energies extending beyond 1e20 eV - has been an open question for decades. In this talk I will explore, in general terms, how these particles are accelerated, focusing particularly on diffusive shock acceleration (DSA). I will discuss some aspects of plasma physics pertaining to DSA, which can be used to derive some general requirements for possible sources. Aided by hydrodynamic simulations, I will show that shocks can be formed in backflows in radio galaxies and that these shocks can accelerate particles to high energy. I will then discuss a model in which 'dormant' sources such as Centaurus A and Fornax A act as slowly-leaking UHECR reservoirs. These radio galaxies may be able to explain the observed UHECR arrival directions. Finally, I will explore ongoing work regarding the physics of particle acceleration in variable jets and discuss possible links between different energies and observing frequencies.

Clare Dobbs (University of Exeter)

Star formation in spiral arms

20 November 2019

I will present ongoing work investigating the formation of molecular clouds and stellar clusters from galaxy scales to individual clouds. I will first highlight main presults from previous simuations of spiral galaxies which show the formation of giant molecular clouds via self gravity and cloud-cloud collisions. In these simulations, stellar feedback is found to be important both to limit the star formation rate, and determine the properties of the clouds. I will also show results from recent models of the galaxy M33, which are able to reproduce the observed properties of molecular clouds in that galaxy. I will then move on to smaller scale simulations which are better able to resolve stellar feedback, including ionsiation, and stellar clusters. We study the effects of photoionsation and find that unlike isolated cloud type simulations, ionisation fronts traverse from star forming clouds to other material. The ionisation is able to compress this material into denser filaments and clouds, triggering star formation. After an initial stage of triggered star formation, the star formation rate is then reduced compared to the case without any stellar feedback. The ionisation also produces less gravitationally bound clusters compared to without ionisation. Finally I will present some results from simulations of colliding clouds, showing the formation of young massive clusters (YMCs), and highlighting the conditions under which YMCs can be expected to form.

Geoffrey Ryan (University of Maryland)

Structured Jets At All Angles

11 December 2019

Gamma-ray bursts (GRBs) associated with gravitational wave events are, and will likely continue to be, viewed at a larger inclination than GRBs without gravitational wave detections. Viewing GRBs and their afterglows at large inclination can massively effect the observed electromagnetic emission, as demonstrated by the binary neutron star merger event GW170817. Analyzing this event and future ones requires an extension of the common GRB afterglow models which typically assume emission from a structureless (top-hat) jet viewed on-axis. I will review the evidence for inclination effects in GRB afterglows, and present a characterization of afterglows viewed at all angles from jets with and without structure. We find new closure relations for off-axis structured jets: the slope of the light curve is found in many cases to be a simple function of the inclination angle. With our theoretical tools in hand I will discuss new candidate events found in the GRB archive, showing features very similar to GW170817. Finally, I will discuss our numerical model to calculate synthetic light curves and spectra, publicly available as the open source Python package afterglowpy.

Elisabeth Stanway (Warwick University)

Interpreting Extreme Stellar Populations with Improved Modelling

12 February 2020

Interpreting the photometry and spectroscopy of galaxies often requires consideration of their integrated light. For this, models which accurately represent the emission from a stellar population as a function of its age, metallicity and other properties are essential. Such stellar population modelling is a mature field where old, metal-rich stellar populations are concerned. However galaxies exist at all redshifts which are much younger and lower in metal enrichment than a typical local galaxy. Amongst distant galaxies, or the hosts of stripped-envelope transients, such systems become the norm. Modelling these population requires a detailed understanding of massive star evolution and its effects on the integrated light. In particular, it has become clear that interactions between stellar binaries and other multiples may have significant effects on the observed population. Here I will discuss the current status of stellar population synthesis modelling and its applications with a particular focus on transients and the distant universe.

Dan Perley (Liverpool John Moores University)

An Explosive View of our Dynamic Universe

26 February 2020

Starting with the days of Messier and continuing through to the Hubble Ultra-Deep Field, observational studies of the Universe beyond our Milky Way have largely been based on direct searches for the populations of galaxies that reside within it. While we owe much of what we know about the cosmos to these methods, they are poorly suited to a variety of circumstances: galaxies below the detection limit, phases of galaxy evolution that are very short, or regions heavily cloaked by dense gas and dust. I will discuss an alternative probe well-suited to illuminating these dark corners: supernovae and their exotic kin, such as gamma-ray bursts (GRBs). I will discuss several ongoing projects to trace broader questions of cosmic history using this technique, including: (1) constraints on the starburst duty-cycle of dwarf galaxy evolution via core-collapse supernovae; (2) studies of cosmic metal abundance, dust properties, and the faintest galaxy populations using GRBs at very high redshifts; (3) studies of the role of obscured star-formation at cosmic high-noon using a VLA-ALMA survey of GRB hosts; (4) insight into the conditions around supermassive black holes as illuminated by extreme supernovae and radio transients.

Rhaana Starling (Leicester University)

Gamma-ray bursts: the emerging class of ultra longs

4 March 2020

Gamma-ray bursts (GRBs) are transient astrophysical events that signal the death of a massive star, or the merger of two compact objects. Typical GRBs begin with one or more flares at gamma-ray energies and transition to a steady decline in brightness, an afterglow, at lower energies and both of these emission eposides likely originate in a relativistic outflow from the central engine. A new class of transient, the ultralong gamma-ray bursts (ULGRBs), was proposed following the Swift satellite detection throughout 2010-2013 of three new transients active for thousands of seconds at gamma-ray energies and with afterglows as luminous as typical GRBs. The puzzle of either sustaining the injection of energy into the jet, or reactivating the central engine, has occupied the field since the observations of bursts with precursors, X-ray plateau phases and late-time X-ray flares. Ultralong GRBs bring new information to this problem. Ideas to generate such long-lasting emission include the collapse of a larger progenitor star than those thought responsible for classical long GRBs, while other studies looked at mechanisms that could combine with a classical GRB scenario such as late-time energy injection from fall-back material.

The definition of a ULGRB must currently be restricted to its initial gamma-ray and subsequent early X-ray characteristics. New facilities such as SVOM and THESEUS will have lower energy triggering capability, bringing more examples and potentially revealing the extent of the ultralong population. Wide-field monitoring and prompt optical and radio observations will plug gaps in the spectral coverage required to understand energy generation mechanisms and constrain the progenitors.

Here I will present multiwavelength data of GRB 121027A, in the context of ultralong-duration GRB origins.