Colloquia Abstracts – Fall 2012

Friday September 7, 10:00am to 2:00pm, AT101

Undergraduate Resarch Students

Saint Mary's University

Undegraduate Symposium

Abstract TBA

Friday September 14, 11:30am, AT305

Dr. Robert Thompson
University of Calgary
A First Peek at Antihydrogen: Project ALPHA's Road to the Creation,Storage, and Initial Observation of Microwave Transitions in
Antihydrogen

Antihydrogen, or more specifically high precision spectroscopy of antihydrogen, offers some of the most promising avenues for extremely sensitive tests of CPT symmetry. However, such precision studies would require that the antihydrogen be stored at low temperature while being probed with microwave or ultraviolet laser radiation. Project ALPHA (Antihydrogen Laser PHysics Apparatus) is one of several independent experiments currently underway at the Antiproton Decelerator (AD) at CERN, each designed to generate, trap, and study antihydrogen for tests of CPT. In 2010, the ALPHA Collaboration announced the first successful storage of neutral antimatter atoms in a magnetic bottle trap1, followed in early 2012 with the announcement of the first observations of resonant microwave transitions in atomic antimatter2. This presentation will describe the techniques employed to generate and trap antihydrogen. It will discuss the challenges of mixing antiprotons and positrons to form, detect, and analyze low temperature antihydrogen in the presence of the inhomogeneous magnetic fields that make up the neutral particle trap, and provide an overview of techniques being developed to manipulate the positron and antiproton plasmas to optimize the antihydrogen formation process. Finally, an overview of recent results and an outlook on future plans in this area will be presented.

1 G.B. Andresen et al. (The ALPHA Collaboration), "Trapped Antihydrogen", Nature, 468, 673-676 (2010).

2 C. Amole et al. (The ALPHA Collaboration), " Resonant quantum transitions in trapped antihydrogen atoms", Nature 483, 439 (2012).

Friday September 14, 3:00pm, AT101

Dr. Robert Thompson

University of Calgary

Labatorials: In pursuit of effective small group instruction within large registration physics service courses

The development of new teaching pedagogies aimed at improving the engagement and success of non-physics majors in 1st-year physics courses is one of the major fields within Physics Education Research. Significant changes in pedagogy (e.g. peer instruction, just in time teaching) and technology (e.g. clickers) has garnered a lot of the external attention to this field. However, the small group components of these courses, i.e. labs and tutorials, are also the subject of extensive efforts in the physics education community. Labatorials1 are an University of Calgary approach to small group instruction currently being implemented in the Department of Physics and Astronomy. Combining aspects of labs and tutorials, these weekly units are designed to teach one or two specific concepts as they are being addressed in lectures. They employ a broad range of technologies and techniques including mini-labs, demonstrations, computer simulations, conceptual questions, and computational problems, as well as different pedagogical approaches to student instruction and evaluation. Mechanics, thermodynamics, and electromagnetism labatorials have been developed and implemented for students in science and in engineering. This presentation will outline current labatorial operational practices, describe the successes and challenges that we encountered during the past few years, and touch on some novel new areas in which the labatorial concept is being applied.

1 D. Ahrensmeier, J.M.K.C. Donev, R.B. Hicks, A.A. Louro, L. Sangalli, R.B. Stafford, and R.I. Thompson, “Labatorials at the University of Calgary: In pursuit of effective small group instruction within large registration physics service courses”, Physics in Canada 65(4), pp.214-216, (2009).

Friday September 21, 3:00pm, AT101

James Wurster

Saint Mary's University

Skeletons in the Closet: A Comparative Study of AGN Feedback Algorithms

Modelling AGN feedback in numerical simulations is both technically and theoretically challenging, with numerous approaches having appeared in the literature. I will present a study of five distinct approaches to modelling AGN feedback within gravitohydrodynamic simulations of major mergers. To constrain differences to only be between AGN feedback models, all simulations start from the same initial construction and use the same star formation algorithm. The AGN feedback algorithm itself is divided into five key aspects: black hole accretion rates, energy feedback rates and methods, particle accretion algorithms, black hole advection algorithms and black hole merger algorithms. For each model, we obtain a qualitatively and quantitatively different accretion history with differences in accretion rates of up to a factor of 2E7 at any given time. We consider models with either thermal or kinetic feedback, with the associated energy deposited locally around the black hole. Even during periods of low accretion, the feedback algorithm can drastically alter disc morphologies. The particle accretion algorithms typically maintain good agreement between the total mass accreted by \ $dot{M} dt$ and the total mass of gas particles removed from the simulation. As expected, the algorithms with fewer stochastic attributes maintain the best agreement. The black hole advection algorithms dampen inappropriate dragging of the black holes by two-body interactions. Advecting the black hole a limited distance based upon local mass distributions appears optimal, given that it is less likely to reintroduce inappropriate motions. Lastly, we instantly merge two black holes when given criteria are met, and we find a range of merger times amongst the different criteria. This is of importance since the AGN feedback rate changes across the merger, and this change varies for each accretion rate. Each of these five aspects are analysed and discussed, with comparisons being made amongst the different approaches.

Friday September 28, 3:00pm, AT101

Dr Daisuke Nagai

Yale University

A New Era of Cosmology and Astrophysics with Galaxy Clusters

Recent years have witnessed the emergence of galaxy clusters as powerful laboratories for cosmology and astrophysics. Being the largest and most magnificent structures in the Universe, clusters of galaxies serve as excellent tracers of the growth of cosmic structures. The current generation of X-ray and Sunyaev-Zel'dovich cluster surveys have provided independent confirmation of the cosmic acceleration and significantly tighten constraints on the nature of mysterious dark energy and dark matter as well as new insights into how massive galaxies and black holes form and grow in the Universe. A number of new surveys and large supercomputer simulations are underway to test our understanding of the structure formation and fundamental physics of the cosmos. In this talk, I will review recent advances and future challenges at the new crossroads of cosmology and astrophysics.

Friday October 5, 3:00pm, AT101

Dr Chris Chiara

Argonne National Laboratory and University of Maryland

When the magic goes away: The rise and fall of magic numbers in neutron-rich isotopes

It has been well established from studies of isotopes near stability that there are particular numbers of protons or neutrons that exhibit enhanced binding compared to neighboring nuclei. These are the so-called magic numbers, occurring at shell gaps in the nuclear shell model that are analogous to those of the atomic shell model. As the development of radioactive beams and new experimental techniques provides unprecedented access to nuclei farther from stability, evidence is mounting for the disappearance of some of the familiar magic numbers while new ones are surfacing. I will discuss some of the recent efforts to study this evolution of shell structure in medium-mass, neutron-rich nuclei through techniques of gamma-ray spectroscopy. Particular emphasis will be given to deep-inelastic reactions performed at Argonne National Laboratory using the powerful Gammasphere gamma-ray spectrometer. Deducing the properties of these isotopes provides valuable tests of the shell model, leading to a better global description of the neutron-rich nuclei that include the more exotic isotopes near the astrophysical r-process path.

Friday October 12, 3:00pm, AT101

Dr Carrie Black

NASA Goddard Space Flight Center

Explosive Energy Release for Space Weather Drivers: A Particle Approach

Understanding the solar origins of space weather and other energetic solar phenomena requires understanding magnetic reconnection, which is observed to play a central role in both the Earth’s magnetosphere and in solar activity. Solar wind forcing in the magnetosphere is linked with reconnection on the day and night sides of Earth. At the Sun, photospheric motions are believed to drive reconnection in the corona. The energy release is explosive in both cases, i.e., substorm events and a coronal mass ejection (CME)/flare. One of the major challenges in modeling the reconnection-driven dynamics of global heliophysical configurations such as Earth's magnetosphere or the solar corona is to quantify the interaction between large-scale evolution and microphysical processes in diffusion regions near reconnection sites. We seek to examine this by applying a magnetic field shear to both magnetohydrodynamic (MHD) and kinetic systems. In MHD codes, this is a simple matter. However, the implementation of such a driver in a kinetic, Particle-in-Cell (PIC) code is nontrivial. In this talk, I will discuss how reconnection occurs on the Sun and at Earth and our efforts to apply a realistic driver in a high performance PIC code.

Friday October 19, 3:00pm, AT101

Dr Jason Aufdenberg

Embry-Riddle Aeronautical University

Modeling Stellar Photospheres at High Spatial Resolution
Now is a very exciting time to be studying stellar atmospheres. These 'point sources' are being spatially resolved in record numbers by long-baseline interferometric telescopes. The star Vega, for example, subtends an angle roughly 600,000 times smaller than the full Moon. Yet, with a spatial resolution equivalent to that of a mirror more than 300 meters across, optical interferometers like the CHARA Array can resolve the variation of intensity across Vega's surface. Such measurements probe temperature gradients both across and into stellar photospheres and constrain fundamental stellar parameters. I will discuss my work modeling interferometric observations of bright stars and explain how these observations are testing a new generation of models which must be parametrized to include convective granulation, rotational distortion and tidal distortion in binary star systems.

Friday October 26, 3:00pm, AT101

Dr Robert Petre

NASA Goddard Space Flight Center

X-Ray Observations of Cosmic Ray Acceleration in Supernova Remnants.
Since the discovery of cosmic rays a century ago, many theories have been advanced regarding their origin. Evidence of cosmic ray acceleration in candidate sources has remained elusive, however. A major breakthrough was provided by spatially resolved X-ray spectroscopy of Galactic supernova remnants (SNRs) using the recent generation of X-ray observatories (ASCA, Chandra, XMM-Newton, Suzaku). Synchrotron X-ray emission from the forward blas wave in SN 1006 and other young SNRs is most likely produced by electrons accelerated to relativistic energies. This is the first, albeit indirect, observational evidence that diffusive shock acceleration in supernova remnants produces cosmic rays to TeV energies, possibly as high as the “knee” in the cosmic ray spectrum at ~10^{15} eV. X-ray observations have provided information about the maximum energy to which these shocks accelerate electrons, as well as indirect evidence of proton acceleration. Shock morphologies measured in X-rays have indicated that a substantial fraction of the shock energy might be diverted into particle acceleration, and provided insight into the strength and the structure of magnetic field behind the SNR blast wave. Using SN 1006 as a focal point, this presentation will summarize what we have learned about cosmic ray acceleration from X-ray observations of supernova remnants.

Friday November 9, 3:00pm, AT101

Dr Julie Hlavacek-Larrondo

Stanford University

Monster Black Holes

One of the most fascinating discoveries in modern astrophysics has been the realization that all galaxies must harbour a black hole at their centres, and that these black holes can be colossal (M_BH > 10^6 Msun). When one of these objects is actively accreting material from its surroundings, it is referred to as an Active Galactic Nucleus (AGN) and can often drive powerful jetted outflows of relativistic plasma that extend beyond the size of the host galaxy. The interplay between the accretion of material and the release of energy of a black hole is known as AGN feedback, and during this talk, I will review the status of this field while concentrating on the most massive black holes in the Universe, those that lie at the centres of massive clusters of galaxies. I will also present new results suggesting that some of these black holes are significantly more massive than previously thought, i.e. that some are ultramassive (M_BH > 10^10 Msun) as opposed to supermassive (M_BH ~ 10^9 Msun). The existence of ultramassive black holes puts stringent constraints on black hole formation models as it remains unclear how black holes can grow to such masses

Friday November 16, 3:00pm, AT101

Dr Linda Strubbe

Canadian Institute for Theoretical Astrophysics

"Studying Massive Black Holes Using the Tidal Disruption of Stars"

A star that wanders too close to a massive black hole gets shredded by the black hole's tidal gravity. Stellar gas soon falls back to the black hole at a rate initially exceeding the Eddington rate, releasing a flare of energy as gas accretes. How often this process occurs is uncertain at present, as is the physics of super-Eddington accretion (which is relevant for black hole growth and feedback at high redshift as well). Excitingly, optical transient surveys like the Palomar Transient Factory (PTF), Pan-STARRS and LSST should be able to shed light on these questions soon. To help these surveys find and interpret tidal disruption events, I predict their photometric and spectroscopic properties: Early on, much of the falling-back gas should blow away in a wind, producing luminous optical emission imprinted with blueshifted UV absorption lines. In just the last couple of years, PTF, Pan-STARRS, and surprisingly the Swift hard X-ray satellite are, for the first time, finding and following up tidal disruption event candidates in real time. I'll describe their recent discoveries in the context of our theoretical predictions, and also look to the future at what measured rates of tidal disruption will be able to teach us about massive black holes and their surrounding galactic nuclei.

Friday November 23, 3:00pm, AT101

Dr Philip Bennett

Saint Mary's University

Epsilon Aurigae

What do we really know about the enigmatic binary star epsilon Aurigae? Epsilon Aurigae is a bright (3rd magnitude) long-period binary that eclipses every 27.1 years, and has been continuously observed for more than 160 years. The observed spectrum is that of an apparently normal F supergiant. The system is enigmatic because the eclipsing companion is dark: no light is seen from this object in the optical spectrum. Nevertheless, the companion is large enough in physical extent to eclipse half of the (large) stellar disk of the supergiant star for more than a year and half. It is also massive: accurate spectroscopic orbital solutions have recently been obtained by two groups, showing the F star primary has a (large) radial velocity amplitude 14.3 ± 0.3 km/s, implying a comparably massive companion. The latest eclipse was in 2009— 2011, and was widely observed by interferometry (CHARA), in the infrared spectrum, the far ultraviolet (HST/COS), and from ground-based sites by a worldwide campaign of amateur astronomers led Robert Stencel (U. Denver) and Jeff Hopkins (Hopkins Phoenix Observatory). Epsilon Aur has also been widely observed photometrically and spectroscopically for the past 20+ years out of eclipse. Aside from the unusual nature of the companion, epsilon Aur is of interest because it contains an apparently massive, high-evolved supergiant in a binary system, implying the possibility of determining accurate fundamental stellar parameters of the F star (a first for such a highly-evolved cool star). In this talk, I will discuss the current state of knowledge of the stellar and orbital parameters, the probable evolutionary state of the system, and the prevailing model of the dark companion of this peculiar binary.

Friday November 30, 3:00pm, AT101

Dr David Turner

Saint Mary's University

Resolving the North Star’s Mysteries (Finally?)

After 55 years of observing the nearby Cepheid Polaris, the speaker has gained considerable familiarity with the star and its peculiarities. Despite everything that is known about Cepheid variables in general, Polaris presents certain anomalies that have so far defied a straightforward interpretation of the star, its reddening, distance, pulsation mode, and number of companions. New spectroscopic observations of Polaris finally reveal insights into the origins of the anomalies, and may signal the beginning of a new era in understanding the star. A brief observational history of Polaris may help to understand the long fascination the star has held to astronomers.