Influence of the cluster environment on the galaxy-halo connection

Speaker: Dr. Anna Niemiec (University of Michigan)
Time: March 29, 2019 - 3:00 PM
Location: Loyola 171

Galaxy clusters are large structures in the Universe, composed of tens or hundreds of galaxies bound by gravity. In the hierarchical formation model, they form and grow by accretion of smaller groups or isolated galaxies. In this scenario, understanding how these accreted galaxies interact with the very dense cluster environment is an important step towards explaining the global picture of galaxy evolution and structure formation. Indeed, during infall, galaxies are subject to numerous interactions with the host cluster, both at the level of the baryonic and dark matter component, and these interactions influence their properties. In particular, both observations and numerical simulations suggest that its dark matter halo is stripped by the tidal forces of the host. In this talk I will present our measurements of the stellar-to-halo mass relation for the galaxies in the redMaPPer clusters with the galaxy-galaxy weak lensing technique, using shear data from the DES-SV, CFHTLenS and CS82 surveys. To help interpret these results I will then discuss our analysis of the evolution of subhaloes in the Illustris hydrodynamical simulation. Finally, I will present the ongoing BUFFALO HST survey, which is dedicated to enlarging the sky area covered by the six Hubble Frontier Fields (HFF) that focused on very rich galaxy clusters. By adding HST coverage to the weak lensing region of the 6 clusters, BUFFALO will allow us to map the dark matter distribution of these 6 clusters with great fidelity, both at the scale of the cluster itself and its component galaxies.

Distant Galaxy Clusters Revealed by Spitzer and HST

Speaker: Dr. Gaël Noirot (SMU)
Time: March 22, 2019 - 3:00 PM
Location: Sobey 260

As the most massive virialized structures in the universe, galaxy clusters are important probes for studying structure evolution and cosmology, and also represent ideal laboratories to study how environment affects the evolution of galaxies. While rich environments have been well studied up to intermediate redshifts, distant (i.e., $z > 1.5$) clusters represent a largely unexplored key epoch in cosmic evolution, with increased star formation and AGN activity. High-redshift

clusters are efficiently identified in the mid-infrared due to a combination of the unique red colors of distant galaxies and a negative *k*-correction in the 3-5 μm range which makes such galaxies bright. I will present our latest results and efforts on two different projects which use these properties and were built to improve by more than an order of magnitude the census and characterization of the most distant clusters to date, namely CARLA (Clusters Around Radio-Loud AGN; Wylezalek et al. 2013, 2014) and SACS (the *Spitzer* Archival Cluster Survey; Rettura et al. in prep, Noirot et al. in prep).
Radio-Loud AGN (RLAGN) tend to reside in the most massive dark matter halos, and have a long history of being used to efficiently identify rich, high-redshift structures (i.e., clusters and protoclusters). CARLA was a 400-hr *Spitzer* program surveying 420 RLAGN (type 1 and type 2) at $1.3 < z < 3.2$ across the full sky. CARLA identified 200 cluster candidates as significant overdensities of red color-selected *Spitzer*/IRAC galaxies around the RLAGN. I will introduce this high-redshift cluster survey and present results from our follow-up 40-orbit *HST* program of the 20 densest CARLA cluster candidates. We spectroscopically confirm 16 of the 20 distant structures associated with the RLAGN, out to z=2.8, and for the first time at these epochs statistically investigate the star-formation content of member galaxies (Noirot et al. 2016, 2018). Finally, I will also present our ~700 deg2 SACS survey, which is a comprehensive search for the most distant galaxy clusters across all *Spitzer* extragalactic pointings in the archive. SACS aims to discover ~2000 candidate clusters at $1.3 < z < 2.5$, thereby providing the ultimate catalog for mid-infrared selected clusters and a lasting legacy for *Spitzer*.

The Nature of the Ionizing Spectrum in Early Star-Forming Galaxies

Speaker: Dr. Kimihiko Nakajima (DAWN, University of Copenhagen)
Time: March 1, 2019 - 3:00 PM
Location: Atrium 101

The ionizing output of early star-forming galaxies is key to understanding their role in cosmic reionization. Major uncertainties include the number of ionizing photons per UV luminosity (i.e. ionizing photon production efficiency, xi_ion) and the fraction that can escape (f_esc). Since neither can be directly observed for sources beyond z=6, it is important to measure these parameters for suitable analogs at lower redshift. We have thus embarked a detailed survey of a large sample of z=3 Lyman alpha emitters (LAEs) as useful analogs of galaxies in the early universe. In this talk, we present the rest-frame optical and UV diagnostic emission lines to

characterize LAEs. Using measures of Balmer and UV emission lines in conjunction with photoionization models, we demonstrate that LAEs typically present xi_ion larger than continuum selected Lyman break galaxies at similar redshifts. By referring to our on-going programs to measure Lyman continuum leakage and hence f_esc, we discuss whether early star-forming systems are powerful sources of ionizing photons to drive cosmic reionization.

Direct observations of ionizing photons from high-redshift galaxies and AGNs with Subaru Telescope and CFHT / CLAUDS

Speaker: Dr. Ikuru Iwata (SMU & NAOJ Subaru Observatory)
Time: January 18, 2019 - 3:00 PM
Location: Loyola 171

Identification of hydrogen ionizing radiation sources responsible for cosmic reionization is one of major goals of the observational cosmology. Because ionizing photons (Lyman Continuum; LyC) are easily absorbed by neutral hydrogen clouds in intervening intergalactic space, direct observation of LyC during the epoch of reionization is practically impossible, and we should explore LyC from objects at redshift less than five to examine how LyC escapes from the objects into intergalactic space. We are tackling this issue using direct imaging method using bandpass filters which trace LyC from objects at z>3. In this talk, our recent results using a special narrow-band filter for Subaru Telescope / Suprime-Cam are presented. By combining the observations for the two independent fields, we examine LyC from more than 400 star-forming galaxies at z>3, and place a stringent 3 sigma upper limit of 8% for the LyC escape fraction of UV-faint star-forming galaxies at redshift around 3.1. I will also report about on-going research projects on LyC using the data from the Subaru Strategic Program with Hyper Suprime-Cam strategic (HSC-SSP), the associated HSC narrow-band survey (CHORUS), and the CFHT Large Area U-band Deep Survey (CLAUDS).

Galaxies, AGN and their environments

Speaker: Anna Sajina (Tufts University)
Time: November 30, 2018 - 3:00 PM
Location: Atrium 101

A key direction in observational extragalactic astrophysics is the study of the evolution of galaxies and their black holes in the context of their local and large scale environments. This is now possible thanks to current and upcoming generations of large area photometric and spectroscopic surveys. Crucially, for a complete picture, such studies need to account for both unobscured and obscured star-formation and black hole growth. I will present current work in my group involving characterizing the environments of galaxies in 5sq.deg of the XMM-LSS field which has extensive photometric and spectroscopic coverage. This includes constraints on dust obscured galaxies and AGN thanks to Herschel and SCUBA2 surveys. We use the same methodology as used for the COSMOS field, but now with a combined area >3x the size of COSMOS alone, we can explore the role of environment in galaxy build-up and quenching as well as the role of AGN therein -- all with improved statistics and over a larger range of environments. Lastly, I will discuss the future prospects for even better galaxy properties characterization and improved sampling of the cosmic web thanks to several planned large area photometric and spectroscopic surveys.

Winds of Change Around Black Holes

Speaker: Gregory Sivakoff (University of Alberta)
Time: November 23, 2018 - 3:00 PM
Location: Atrium 101

Accretion disks, where matter with angular momentum spirals down through a disk, occur around objects ranging from the youngest stars to supermassive black holes. But not all of this material reaches the center of the disk. Instead, some material is accelerated away from the disk. These outflows can be ejected in a narrow opening angle (what astronomers call "jets") or can be relatively unfocused (what astronomers call “winds”). While we do not know the precise processes that accelerate and collimate winds and jets, magnetic fields almost certainly play a key role. My team and I study black hole X-ray binaries, stellar-mass black holes accreting from a nearby star. We combine observations across the electromagnetic spectrum to learn about the physics of accretion and jets. In this talk, I will discuss how we have revealed two new windows onto the physics of inflows and outflows in X-ray binaries: fast variability measured across the electromagnetic spectrum (which provides the potential to accurately identify the accretion physics that launch relativistic jets) and the modelling of changes in the X-ray brightness of black hole X-ray binaries (which implies that strong winds from the accretion disk are universal).

With the advent of new and upcoming facilities, we have a huge potential to take advantage of these winds of change in the next decade.

The Brightest Light in Canada

Speaker: Jeff Warner (Canadian Light Source)
Time: November 21, 2018 - 3:00 PM
Location: AT305

The Canadian Light Source National Synchrotron began collecting data in 2005 and has been under continual construction, upgrading or adding new capabilities, since that time. Synchrotrons provide extremely bright tunable x-rays that are relevant for many different types of measurements. The current suite of techniques with some select case studies is reviewed as well as new strategic directions. Programs such as our small molecule and powder x-ray diffraction will be introduced as well as simplified access initiatives.

White Dwarfs in Globular Clusters and the Field

Speaker: Jason Kalirai (STScI)
Time: November 9, 2018 - 3:00 PM
Location: Atrium 101

The lifecycles of most stars in the Universe end in the white dwarf phase, where stars have exhausted their nuclear fuel and fade over time by radiating their stored thermal energy into space. The simplicity of these stars and their straightforward cooling physics provides remarkable insights into their properties, and a link to the evolution of their parent populations. Without knowing the distance, a spectrum of an individual white dwarf can reveal its temperature, surface gravity, mass, cooling age, and luminosity. Through a combination of high-performance space-based imaging and high-throughput ground-based spectroscopy, we've now probed the properties of white dwarfs in a wide range of populations, from the field Milky Way to open and globular clusters spanning a broad range of ages. Interpretation of these data are providing new insights on stellar mass loss, stellar evolutionary time

scales, the chronology of the Milky Way, the dynamical evolution of clusters, the initial mass function, and more. In this talk, I'll summarize the latest results from observations of white dwarfs in the Milky Way, and offer some thoughts on how we can best leverage the next generation large ground-based telescopes and JWST to extend this work into new dimensions.

Enabling Infrared Surveys of Galaxies with Innovative Imaging Spectrographs

Speaker: Suresh Sivanandam (Dunlap Institute, University of Toronto)
Time: November 2, 2018 - 3:00 PM
Location: Atrium 101

Optical integral field (imaging) spectroscopic surveys of large numbers of galaxies are now becoming the norm. These surveys allow detailed studies of individual galaxies, such as their kinematics and stellar ages/metallicities. With a sufficiently large sample, these types of observations are the best tools for understanding the formation and evolution of galaxies. However, similar surveys in the infrared remain challenging. There are two significant gaps that need to addressed: the rest-frame infrared has been untapped for nearby systems due to the lack of wide integral field infrared spectrographs (IFSes), and observations of the distant universe have been limited to small samples from the lack of high angular resolution, highly multiplexed IFSes.

I will discuss two instruments that will directly address these gaps: one recently commissioned, the wide integral field infrared spectrograph (WIFIS), and another recently funded, the Gemini Infrared Multi-object Spectrograph (GIRMOS). WIFIS is currently carrying out an infrared survey of nearby galaxies by studying their stellar populations, star-formation, and kinematics, complementing existing optical surveys such as CALIFA and MaNGA. On the other hand, GIRMOS will be a multi-object IFS that takes advantage of the latest developments in adaptive optics. It will be able to carry out large surveys of the distant universe by simultaneously observing multiple galaxies, which will finally complement, in a similar scale, the studies being done in the local universe.

The intergalactic medium at the end of reionization

Speaker: Laura Keating (CITA, University of Toronto)
Time: October 26, 2018 - 3:00 PM
Location: Loyola 171

Studying the luminous sources responsible for reionizing the Universe directly is difficult, as they are challenging to identify. An alternative method is to instead look for signatures of reionization in the diffuse gas between these sources. In this talk I will discuss my work modelling the intergalactic medium during the epoch of reionization, as seen through quasar absorption lines. I will make comparisons between high resolution cosmological radiative transfer simulations and observations of the high-redshift Lyman-alpha forest. I will show that the current data seem to point towards a very late reionization, with large islands of neutral gas still found below redshift 5.5.

PhD Thesis Defense: Integrated Light Stellar Population Synthesis of Globular Clusters Using Non-Local Thermodynamic Equilibrium Modelling

Speaker: Mitchell Young
Time: October 18, 2018 - 1:00 AM
Location: Loyola 188

We present an investigation of the globular cluster (GC) stellar population syn-thesis method of McWilliam & Bernstein (2008), focusing on the impact of stellar atmospheric non-local thermodynamic equilibrium (NLTE) modeling effects. For this purpose, we have generated comprehensive, fully NLTE libraries of both individual stellar spectra and continua and GC integrated light (IL) spectra and continua. The stellar library spans large ranges in Teff, log g, and [M=H], and is reproduced for 0.5 and 1 M_Sun and two degrees of alpha-enhancement, covering the parameter space of GC population members. The IL library spans 9 to 15 Gyr in age, and -1.790 to -0.253 in [M=H], covering the full range of Galactic GC ages, and the majority of the Galactic GC metallicity distribution. The IL spectral library is used to investigate Johnson-Cousins-Bessel UBV IJK IL colours, sensitivity of IL spectral features to cluster age or metallicity, and for deriving the ages and metallicities of 10 Galactic and one extragalactic GC

for which IL spectra are acquired from Colucci, Bernstein & McWilliam (2017). The IL colours cofirm previously reported trends of GC reddening with increasing age or metallicity, and demonstrate that NLTE colours to be bluer than LTE by up to a few tens of millimagnitudes, as does increased alpha-enhancement. We find a dependence of a few millimagnitudes on the discretization resolution of the population CMDs when using the 25-30 boxes suggested in the literature. This dependence is minimized when the number of boxes increased to 40-50. We found 240 spectral features sensitive to either cluster age or metallicity, of which 209 are newly identified as GC diagnostic features. We determine the best fit to the observed GC IL spectra, deriving ages for six of the 11 clusters, and metallicities for all of them. The uncertainties of both the ages and metallicities are reduced by a factor of two to three times when fit with NLTE IL spectra when compared with those from fitting LTE spectra.

Unveiling the secrets of quasar feedback: searching for multi-scale quasar winds with obscured and red quasars

Speaker: Rachael Alexandroff (Dunlap Institute, University of Toronto)
Time: October 5, 2018 - 3:00 PM
Location: Atrium 101

Black holes of masses one million to one billion times that of the sun are now believed to reside at the centers of almost all massive galaxies in the universe. Though small on the scale of a galaxy and negligible for the overall galaxy dynamics, these supermassive black holes are now thought to play a crucial role in the evolution of their host galaxy. Feedback from the actively accreting supermassive black hole or ‘quasar’, in the form of galaxy-scale winds or jets, is necessary to shut-off star formation and thus inhibit the growth of very massive galaxies and to drive correlations between black hole and galaxy properties. Nevertheless, such a mechanism is not yet well supported by observational evidence, especially at the peak of galaxy formation (z~2.5). I will present new multi-wavelength results from a sample of quasars at the peak of galaxy formation and black hole growth that may represent the “blowout phase” of AGN evolution where we see quasar feedback in action. The combination of various observational techniques allows us to probe, if indirectly, scales from the broad-line region all the way to the host galaxy and to understand the nature of the multi-component outflow (both ionized and molecular components). Keck spectropolarimetry results argue for the presence of dusty

outflows on scales of the emission line region while near-infrared spectroscopy reveals some of the most extreme ionized gas velocities observed (> 5000 km/s), indicating wind speeds too large to be contained by the galaxy potential. Finally, intriguing new results from the Very Large Array (VLA) at lower redshift open the radio regime as a new front for studying quasar feedback using synchrotron emission from the shocks generated by quasar winds. Taken together, these results provide a robust observational window into important mechanisms of galaxy growth and quenching via quasar feedback.

Rare Isotope beams (RIB) at TRIMF

Speaker: Friedhelm Ames
Time: October 4, 2018 - 3:00 PM
Location: Atrium 305

Rare isotopes are used in many scientific fields starting from basic nuclear physics to applications in material science and medicine. TRIUMF's ISAC facility is one of the worldwide leading facilities to produce rare isotopes and providing rare isotope beams (RIB) to a variety of users. The isotopes are produced by nuclear reactions in solid targets which are bombarded by a high energy proton beam. The products are ionized in a variety of ion sources and separated by mass. Experiments can be performed either at low energies up to 60 keV or with further acceleration up to 10 MeV/u. The presentation will describe the technologies and processes used. Future improvements and possibilities arising from the new ARIEL and CANREB projects will be discussed.

Galaxies in the Early Universe: The view from the newest observations with Spitzer, ALMA, and HST

Speaker: Andreas Faisst (IPAC/Caltech)
Time: September 28, 2018 - 3:00 PM
Location: Atrium 101

Less than 1 billion year after the Big Bang (< 8% of today's age of the Universe), the cosmic star formation rate and stellar mass density of galaxies increased by more than one order of magnitude, a gradient steeper than at any other time. Hence it is expected that galaxies during this early rapid growth phase show significantly different spatial and physical properties compared to galaxies at later times. I present how observations with Spitzer, the Atacama Large Millimeter Array (ALMA), and the HST help us to study and understand this important corner-stone phase of galaxy evolution. With forward modeling of the Spitzer broad-band colors, we measure the fluxes of optical emission lines in galaxies out to z = 6. This allows us to witness the rapid growth of these infant galaxies, to study (on a basic level) their inter-stellar medium (ISM) conditions, and to quantify their contribution to the reionization of hydrogen at z > 6. Observation with ALMA of the C+ emission at 158μm and the continuum bracketing it, enables a deep insight into the dust and far-infrared properties of these galaxies. Our very recent observations of a dozen galaxies at z = 6 reveal a population that has a large range in evolutionary stages already 1 billion years after the Big Bang. With our 70h ALMA program to extend these measurements to >100 galaxies at z = 4-6 (ALPINE) we will study this population in more detail.

Jetted Outflows Powered by Supermassive Black Holes

Speaker: Dr. Matthew Lister (Purdue University)
Time: September 21, 2018 - 3:00 PM
Location: Atrium 101

In the heart of many galaxies lie supermassive black holes responsible for launching extremely powerful relativistic plasma outflows that emit radiation strongly from radio to TeV gamma-rays. Because of the effects of special relativity, these jets from active galactic nuclei (AGN) can easily outshine their entire host galaxy if they are pointed
nearly directly at us. As a result, they dominate the sky away from our galactic plane, as catalogued by large surveys in gamma-rays and at short radio wavelengths. The properties of AGN jets have been studied extensively with the Very Long Baseline Array, which provides sufficiently high angular resolution that their sub-light year scale
evolution can be studied via time-lapse imaging. I will present results from the largest such study, MOJAVE, which has monitored over 400 AGN jets to date, and has revealed apparent superluminal motion, standing features, and slow precession-like behavior of energized channels within the flows. MOJAVE has also found strong correlations with AGN gamma-ray emission

detected by NASA's Fermi observatory, which has found distinct sub-divisions within the AGN jet population, based on the peak frequency of their synchrotron radiation output. I will discuss current controversies regarding the high-peaked jet population, whose slow apparent speeds and lower synchrotron output appear to be inconsistent with the high Lorentz factors inferred from emission modeling of rapid variability seen at gamma-ray energies.

Going wide and deep with the Hyper Suprime Camera Survey

Speaker: Dr. Jenny Greene (Princeton University)
Time: September 14, 2018 - 3:00 PM
Location: Atrium 101

Our ongoing imaging survey with the Hyper Suprime Camera (HSC) on the Subaru Telescope provides a rich data set for studying galaxy evolution, from the most massive elliptical galaxies to ultra low surface-brightness dwarfs. I will discuss ongoing projects that utilize the deep and wide HSC imaging to address the role of merging in the growth of black holes and galaxies, as well as our search for some of the most extreme low surface-brightness galaxies.