Astronomy & Physics Faculty Jamboree

Friday, 25 Sep, 3-4 pm, on Zoom

Presenting (not necessarily in this order):

- Dr. Greg Christian, “Stellar explosions in the lab: Understanding the influence of nuclear physics on galactic nucleosynthesis and stellar evolution.”
- Dr. Vincent Hénault-Brunet, “Globular clusters inside out: from central black holes to the Milky Way halo”
- Dr. Luigi Gallo, “The Ins and Outs of Black Hole Accretion”
- Dr. Ritu Kanungo, “Unveiling a new era in nuclear science with rare isotopes”
- Dr. Marcin Sawicki, “Probing galaxy evolution from space and from the ground”
- Dr. Ivana Damjanov, “Galaxy evolution in the last 7 Gyr of cosmic time”

Knocking on Giants’ Doors: The evolution of the dust-to-stellar mass ratio in distant galaxies

Speaker: Dr. Darko Donevski (SISSA)
Time: October 2, 2020 - 3:00 PM
Location: Zoom

Since their initial discovery 20 years ago, the distant, dusty star-forming galaxies possess a serious challenge to the theory of galaxy formation and evolution. On one hand, these massive systems form prodigious amounts of young stars but their light is heavily absorbed by dust and re-emitted in far-infrared. On the other hand, a significant number of these dusty “Giants” have been formed in the time when the Universe was very young (e.g. < 1 billion years), questioning how such a large amount of dust has been produced so rapidly. One way of answering this question is by analysing the ratio between the dust and stellar mass in distant galaxies. In this talk, I will present how to link the state-of-the-art simulations and the observations of 300 galaxies detected with ALMA, and apply the dust-to-stellar mass ratio as a tool to understand the complex processes involved in the production of dust, metals and stars in galaxy evolution.

On the origin, diversity, and fate of gapped protoplanetary disks

Friday, 16 Oct @3pm, via Zoom

Dr. Nienke van der Marel (University of Victoria)

Protoplanetary disks with large inner cleared dust gaps are thought to host massive planetary companions. These gapped disks show a range of structures in the millimeter dust continuum, including asymmetries and one or multiple rings, caused by dust trapping in pressure bumps, and potentially vortices. However, it remains unclear why these asymmetric features appear in some disks and not in others. I will present a possible explanation for this phenomenon, based on the analysis of a sample of 16 disks with large scale dust rings and asymmetries using the local gas surface density profile. Second, I will explain which planets are likely responsible for clearing these wide gaps in addition to other features such as spiral arms, warps, and misalignments. In the second half of my talk, I will discuss the fate of gapped protoplanetary disks in comparison with disks without gaps. Disks without gaps are found to evolve faster, as dust drifts inwards. The structure of protoplanetary disks tells us directly about what kind of planets are formed and I have found a remarkable correlation between disk morphology and exoplanet demographics. I will highlight the efforts of graduate and undergraduate students in the UVic Protoplanetary disk group from the past year in the context of this work.

Stellar Clusters as the Nurseries of Black Holes

Friday, 23 Oct @3pm, via Zoom

Dr. Sebastian Kamman (Liverpool John Moores University)

The Local Group galaxies host massive star clusters across all ages, from ancient Galactic globular clusters to young massive clusters found in the Magellanic Clouds. Such clusters are the natural habitat of massive stars, which collapse into black holes once their atomic fuel is exhausted. While it is evident that many black holes will be formed in star clusters, little is known about the subsequent evolution of the newly formed black holes. Are they ejected from the clusters following natal kicks or interactions with each other? Or can they survive inside the clusters for a Hubble time? Answering these questions is of fundamental importance for interpreting the wealth of gravitational wave data expected in the coming years.

In my talk, I will describe how integral-field spectroscopy has opened a new window to search for black holes inside star clusters. In particular, I will show results from the ongoing MUSE survey of massive star clusters, which has already lead to the detection of several black holes in the Galactic globular cluster NGC3201. Such observations, in combination with sophisticated dynamical models, promise to provide us with a census of black holes in star clusters of all ages. They may also be key to finally answer the question of whether the enigmatic intermediate-mass black holes reside in the centres of massive clusters.

Deep learning algorithms for morphological classification of galaxies

Friday, 30 October @12:30 pm **note unusual time**

Dr. Helena Domínguez Sánchez (Institute of Space Sciences, Barcelona**)**

Galaxies exhibit a wide variety of morphologies that are strongly related to their star formation histories. Having large samples of morphologically classified galaxies is fundamental to understand their formation and evolution. I will present recent results on morphological classifications for SDSS and DES surveys obtained with Deep Learning (DL) algorithms using convolutional neural networks (CNN). Supervised DL algorithms are fast, accurate and efficient but they rely on large training sets (~5000) of pre-labelled galaxies. I will show how transfer learning (i.e., the ability of CNNs to export knowledge acquired from an existing survey to a new dataset), helps reducing by almost one order of magnitude the necessary training sample for morphological classification. Another important caveat is that visually classified galaxies are usually very bright. We model fainter objects by simulating what the brighter objects with well determined classifications would look like if they were at higher redshifts. The CNNs reach 97% accuracy to mr ~ 21.5, suggesting that they are able to recover features hidden to the human eye. Where a comparison is possible, our classifications correlate very well with Sérsic index, ellipticity and spectral type, even for the fainter galaxies. We provide classifications for ~27 million galaxies, the largest multi-band catalog of automated galaxy morphologies to date.

A new detailed visual morphological classification for galaxies in the MaNGA survey and a general characterisation.

Friday, 6 November @ 3pm

Dr. J Antonio Vazquez (UNAM, Mexico)

Within the current theoretical scenario of galaxy formation and evolution, the interplay between cosmic cool gas accretion onto galaxies and galaxy mergers, and other internal processes, give rise to the observed morphological diversity of galaxies (e.g., Dubois et al. 2016). In this context, a reliable morphological classification becomes crucial for understanding the properties and formation mechanisms of galaxies, and constraining models and simulations of galaxy evolution.

In the last years surveys like MaNGA (an IFU survey), offer the possibility to connect physical and morphological properties of galaxies with their spatially-resolved properties at the kpc scales (e.g., Cano-Diaz et al. 2019). This positions the study of the origin of the Hubble sequence to a new level.

In this talk, I will present the results of a direct visual morphological classification to 4600 MaNGA galaxies, the identification of tidal debris (reported in the MVM-VAC, SDSS), and a general characterisation of some MaNGA properties with morphology. The classification and identification of tidal debris are based on a new uniform treatment of the SDSS and DESI Legacy Surveys images, which allows us to identify various internal structures and low surface brightness features for a more definite morphological classification. This classification recovers morphological trends and bimodalities observed by other authors, (e.g. Nair & Abraham 2010), and its reliability is good enough to be used to improve automatic classifications based on Machine Learning (e.g., Dominguez-Sanchez et al. 2018).

Constraining galaxy evolution timescales with simulations and observations

Friday, 20 November @ 3pm

Dr. Kartheik Iyer (Dunlap Institute/UofT)

A diverse range of physical processes are responsible for regulating star formation across galaxies. Understanding their relative contributions to galaxy growth and quenching at different epochs is one of the key questions in galaxy evolution today. Since processes like mergers, winds, and feedback from supernovae and active galactic nuclei (AGN) are thought to have characteristic time-scales, studying the strength of star formation rate (SFR) fluctuations on these time-scales allows us to disentangle their relative contributions for a population of galaxies. In this talk, I will give a brief summary of current work focusing on (i) establishing a formalism to study the stochasticity of star formation at a given time-scale and analyzing a variety of cosmological galaxy evolution simulations using this formalism, and (ii) observational methods of reconstructing star formation histories, which yield constraints on the time-scales of galaxy growth, morphological transformations, and quenching. Taken together, simulations and observations leverage the predictive power against observational constraints to obtain a fuller picture of how galaxies evolve over time.

Gaia, Star Clusters and Massive White Dwarfs

Friday, 27 November @3pm, via Zoom

Prof. Harvey Richer (UBC)

In this talk I’ll present some very recent work we have been doing on trying to understand the formation of massive white dwarf stars. The route to this will be exploitation of data from the recent Gaia satellite, which I’ll discuss, and the Gemini telescope in Hawaii. The results have implications for massive star evolution. the supernova rate in the galaxy, the formation rate of neutron stars and black holes and the chemical evolution in galaxies.

Galaxies Evolution in Cluster Cores and Outskirts.

Friday, 4 December @3pm AST, via Zoom

Prof. Louise Edwards (CalPoly)

When and how does environment impact the evolution of galaxies? We will approach this question by considering two extreme environments. First, the cores of massive clusters. Here, the largest, reddest galaxies of the local universe are found, Brightest Cluster Galaxies (BCGs). These galaxies are found mixed with diffuse intracluster light (ICL) and often on top of the cooling intracluster medium (ICM). We'll explore recent results from an integral field unit survey of Local cluster cores which provides photometric and spectroscopic evidence of a break in age, between the old red and dead BCG cores, and the ICL that surrounds them. Second, cluster scale filaments. Here, galaxies find themselves in moderate density environments, where they are potentially able to interact with each other, and the intracluster medium, initiating starbursts and undergoing quenching. Recent SITELLE observations from CFHT provide clear examples of merging filament galaxies. I will also show how bent jets from supermassive black holes can measure the density of the filament medium. We'll discover how within these environments, the galaxy’s ability to interact with the surrounding medium and surrounding galaxies has the potential to drive its own evolution.

Breaking the Law and Getting it Right: A Revised View of the Relation between the Sizes and Masses of Galaxies

Friday, 15 January 2021 @3pm AST, via Zoom

Lamiya Mowla (Dunlap Institute/UofT)

Galaxy morphology is one of the fundamental and oldest observational tools used to study the formation and evolution of galaxies. Decades of observations from the ground and thousands of orbits of extragalactic imaging by the Hubble Space Telescope (HST) have constructed a picture for the relation between the sizes and masses of galaxies and how it has evolved in the last 10 Gyrs. However, the origin of the size-mass relation is impossible to comprehend using observations alone, making today's semi analytic models and cosmological hydrodynamical simulations with multi-scale models of physical processes critical deciphering tools. Using semi-analytic models, I will demonstrate that the observed size-mass relation of galaxies can be derived from the halo mass - stellar mass relation. This suggests a straightforward relation between the size scale of dark matter halos and that of galaxies, with the effects of dust and young stars being the main remaining uncertainty. I will then present results from state-of-the-art cosmological hydrodynamical simulation SIMBA with dust radiative transfer package Powderday, used to disentangle the effect of dust attenuation on the sizes of galaxies, which remarkably changes the picture of the size-mass relation as painted by HST. Resolved stellar population synthesis modelling augmented by upcoming JWST observation will be needed to verify our revised view of the size-mass relation of galaxies.

High-contrast imaging of exoplanets and disks.

Friday, 22 January 2021: **1-2pm AST (note unusual time)**

Dr. Trisha Bhowmik (Universidad Diego Portales, Chile)

Planets are formed in the circumstellar environment when dust grains start accreting material from an optically thick circumstellar disk leaving behind young planets and occasionally a debris disk. Several techniques such as radial velocity, transit, and direct imaging techniques have become popular to discover and confirm such exoplanets. The advantage of direct imaging is in observing wide orbit planets and doing spectral characterization of an exoplanet atmosphere. Yet, an Earth-like exoplanet would be 10e8 to 10e9 times fainter than its Sun-like star, in near-infrared wavelengths. This requires extremely high contrast techniques. The backbone of high-contrast imaging is the use of adaptive optics, advanced coronagraphy, and post-processing techniques. Throughout the years this technique has been very successful in imaging circumstellar disks and recently has also started discovering circumplanetary disks. In this talk, I will present the basic working principle of high-contrast imaging and the scientific advancements that have been done with this technique.

From the Eddington limit into quiescence with tidal disruption events

Friday, 29 January 2021 @3pm AST, via Zoom

Dr. Thomas Wevers (European Southern Observatory, Santiago)

Tidal disruption events have been heralded as probes of extreme accretion regimes, in particular as super-Eddington accretors, since the seminal papers over 30 years ago. However, observationally this field has only started to blossom in the last 5-10 years, with the advent of wide-field optical surveys and coordinated multi-wavelength follow-up facilities, particularly at X-ray and UV wavelengths. These efforts are now producing a steady stream of exquisite observational constraints for the formation and evolution of the accretion flows, including the disk, soft excess and the corona, in the aftermath of disruption. I will discuss TDE observations in the framework of accretion states as developed for X-ray binaries and show that they are in excellent agreement with predicted properties. I will also present new results that probe, for the first time, accretion state transitions in an individual supermassive black hole, from the Eddington limit into quiescence. These results open up a new avenue to study accretion physics and its scale (in)variance across the mass scale in the near future.

A journey into the Perseus cluster of galaxies: radio lobes, mini-halo and bent-jet radio galaxies

Friday, 5 February 2021 @3pm AST, via Zoom

Dr. Marie-Lou Gendron-Marsolais (ESO/ALMA)

Jets created from accretion onto supermassive black holes release relativistic particles on large distances. These strongly affect the intracluster medium when located in the center of a brightest cluster galaxy. On the other hand, the hierarchical merging of subclusters and groups, from which cluster originate, also generates perturbations into the intracluster medium through shocks and turbulence, constituting a potential source of reacceleration for these particles. In this talk, I will present an overview of the deep multi-scale low radio frequency observations of the Perseus cluster obtained from the Karl G. Jansky Very Large Array, probing the non-thermal emission from the old, les energetic, particle population of these outflows. Our observations of this nearby relaxed cool core cluster have revealed a multitude of new structures associated with its radio lobes, mini-halo as well as the bent-jet radio galaxies harboring the cluster. These results show how such high-quality images at low radio-frequencies can bring a whole new dimension to our understanding of a galaxy cluster and add new constraints on the complex nature of diffuse radio emission in these environments.

Properties of Dusty Galaxies at Cosmic Noon

Friday 12 February 2021, @3pm AST, via Zoom

Dr. Nicholas Martis (Saint Mary’s University/NRC-Herzberg)

Motivated by earlier findings that dusty star-forming galaxies become more prevalent both with increasing stellar mass and increasing redshift, I investigate the stellar and dust properties of a stellar mass complete sample of massive and dusty galaxies at $1<z<4$ by modelling their UV-to-infrared spectral energy distributions (SEDs) obtained from the combination of UltraVISTA DR3 photometry and *Herschel* PACS-SPIRE data using MAGPHYS. I evaluate the ability of the rest-frame UVJ color-color diagram to determine the star formation and dust obscuration properties for our sample. I construct median SEDs of massive, dusty galaxies as a function of redshift and star-formation activity (quiescent vs star-forming). Simultaneous modelling of the panchromatic SED allows us to quantify the contribution to the IR emission from dust heated by star formation rather than evolved stellar populations, which we find to be a crucial element in characterizing these galaxies correctly. I also investigate in more detail the properties of a subset of the most heavily dust-obscured sources in the UltraVISTA DR3 to determine their relationship to IR-selected and sub-millimeter galaxies (SMGs). Finally, I will propose how this line of research can be extended through my current involvement with the CANUCS program using the *James Webb Space Telescope.*

Ionized winds driven away from supermassive black holes

Friday 26 February 2021, @11:30am AST note unusual time

Dr. Junjie Mao (University of Strathclyde)

Active Galactic Nuclei (AGN) are the observed manifestation of inflow of matter onto supermassive black holes. Ionized winds driven away from black holes have also been observed, which might play an important role in the evolution of black holes and their host galaxies. In the X-ray band, three types of ionized winds have been observed so far. First, classical warm absorbers are identified with multiple narrow absorption lines with a typical outflow velocity of <1000 km/s. Second, ultrafast outflows with an outflow velocity up to a quarter of the speed of light are inferred from highly ionized Fe absorption lines in the hard X-ray band. Third, in the past few years, obscuring winds have been reported in a few nearby Seyfert galaxies. The putative disk winds lead to a pronounced flux drop in the soft X-ray band without any discrete absorption line features. It can last for several weeks (e.g., NGC 3783 and NGC 985) or years (e.g., NGC 5548 and Mrk 335). Contemporaneous observation features found in the UV and NIR bands might be associated with the soft X-ray obscuration. We still have many gaps in our understanding of AGN winds. More high-resolution and/or multi-wavelength observations are certainly required to unveil their nature.

Flows of gas around z~1 galaxies

Friday, 5 March 2021, @3pm AST, via Zoom

Dr. Johannes Zabl, Saint Mary's University

Abstract: Galaxies are embedded in a complex circumgalactic medium (CGM).
Any valid model of galaxy evolution needs to include the exchanges of gas between the CGM and the galaxy at the centre of the halo. Unfortunately, it is observationally extremely challenging and to directly measure these flows. While the low-density gas can be studied through the absorption which it imprints on bright background sources, large samples of galaxy-absorber pairs with well-constrained galaxy properties and kinematics are required to interpret the absorption measurements. Fortunately, thanks to the panoramic IFU spectrograph MUSE, it has become feasible to collect such samples at z≈1, a time when the Universe was less than half as old as it is today. In this talk, I will present statistical results for distribution, properties, and kinematics of the cool (10^4 K) CGM gas (probed by MgII), as obtained from the MusE GAs FLOw and Wind (MEGAFLOW) survey. Further, I will show that deep MUSE observations begin to directly map the CGM around typical individual galaxies through MgII emission. I will conclude my talk with a peek at my other research interests.

The rise and fall of star formation in galaxies

Friday, 12 March 2021, @3pm AST, via Zoom

Dr. Allison Man (University of British Columbia)

Abstract: Star formation and supermassive black hole growth were most active at cosmic noon (z~2). Massive galaxies appear to experience accelerated growth at early cosmic times, and eventually quench their star formation and become more bulge-dominated. Exactly why these transformations take place is unclear. Mergers and active galactic nuclei feedback are often invoked as explanations, but a consensus is yet to be reached. I will discuss how multiwavelength observations of stellar populations and multiphase gas of distant galaxies can shed new light on the complex problem of galaxy evolution.

The diversity of building up the quiescent sequence at redshift z~1

Friday, March 19 @3pm AST, via Zoom

Speaker: Dr. Sandro Tacchella (Harvard-Smithsonian Center for Astrophysics)

Abstract: How and why galaxies grow in stellar mass and cease their star formation are key open questions of galaxy formation and evolution. I present evidence for a diversity of pathways for building up the quiescent galaxy population at early cosmic times. Specifically, I will present observational constraints on star-formation histories and quenching timescales by combining Keck DEIMOS spectroscopic data with >10-band photometry. I will discuss how one can self-consistently fit both photometric and spectroscopic data together with the tool Prospector, which allows fitting for non-parametric star-formation histories and complex stellar, nebular, and dust physics. Despite the apparent diversity, we find that the most massive, compact galaxies have formed their stars the earliest and most rapidly. Furthermore, from the star-formation history constraints, I will discuss how galaxies evolve about scaling relations (such as the star-forming main sequence) with cosmic time. Finally, I will relate these findings to numerical simulations (in particular IllustrisTNG), showing that the large diversity of quenching epochs and timescales challenge numerical models and point toward a combination of internal and external quenching mechanisms.

The First Stars and the Birth of the Most Massive, High-redshift Quasars

Friday 25 March 2021 @3pm AST, via Zoom

Speaker: Tyrone Woods (NRC Herzberg Astronomy & Astrophysics)

Abstract: The discovery of billion-solar-mass quasars at redshift ~ 7 challenges our understanding of the early Universe — how did such massive objects form in the first billion years, and what can this tell us about their environments at Cosmic Dawn? Observations and theory increasingly favour a "heavy seed" or "direct collapse" scenario, in which the rapid accretion possible in some primordial halos leads to the formation of uniquely supermassive stars, which collapse to form the initial seeds of supermassive black holes. In this talk, I'll present systematic, self-consistent simulations of the evolution of these objects under realistic formation conditions, and propose observational diagnostics to decisively test the origin of high-z quasars using forthcoming next generation electromagnetic and gravitational wave observations. I'll also discuss the expected multiplicity of such supermassive stars and their subsequent interactions, as well as the unique observational signatures of primordial stellar populations which are intermediate in mass between supermassive objects and "typical" Pop III stars.