Archived Colloquia 2022-2023

Accelerators as windows to the dark sector: the DarkLight experiment and the hunt for a new boson

Alexa Villaum
(University of Waterloo)
Date: Friday 24 March 2023

The nature of dark matter and its relationship to the Standard Model is one of the highest-priority open questions in particle physics today. Accelerator-based experiments are a powerful tool in the search for dark matter and the new bosons that may mediate its interactions with the known particles. The DarkLight experiment will search for such a new boson in an interesting uncovered low-mass range. DarkLight is a small-scale experiment being constructed at the TRIUMF electron linear accelerator, and plans to take its first data within the next year.

What have we learned about Galaxy Formation from the First Year with JWST?

Casey Papovich
(Texas A&M)
Date: Friday 17 March 2023

In its first year, JWST has given us an amazing view of what galaxies looked like during the immediate period after the Big Bang. The JWST observations have led to a series of discoveries, many of which were wholly unexpected. In this talk, I will present some of this work using JWST imaging and spectroscopic from ``deep fields''. I will focus primarily on key results enable by the CEERS (the Cosmic Evolution Early Release Science) Survey as well as data from JWST deep fields. These results include the discovery and characterization of the properties of galaxies at the earliest times, with redshifts of 7 and higher, during the cosmic period known as reionization. The properties of these galaxies imply they are dominated by very young, massive stars, with extremely high ionizing flux, accompanied by rapidly stochastic, variable star-formation rates. Other JWST observations have demonstrated that early galaxies host ``hidden'' active galactic nuclei (AGN), obscured by gas and dust, which implies we are seeing a rapid phase of supermassive blackhole growth in early galaxies. Understanding the relation between the star-formation and blackhole growth in these galaxies will be a challenge for future JWST observations, and I will discuss some ways to disentangle these effects. Lastly, I will use these discoveries to speculate about what we may learn in the coming years with JWST.

Wind of change: revealing the power of X-ray ionised outflows in nearby AGN

Daniele Rogantini
(MIT Kavli Institute)
Date: Friday 10 March 2023

More than half of nearby active galactic nuclei (AGN) show the presence of powerful outflows of ionised gas. These winds are thought to have a strong impact on the surrounding galactic medium (e.g. quenching the star formation) and, therefore, they are considered promising candidates for driving AGN feedback on large scales. High-resolution X-ray spectroscopy of Chandra and XMM-Newton observations provided extensive information about these powerful nuclear winds. It is, however, notoriously challenging to access their kinetic power because of our limited knowledge of their density and spatial location. The key to obtaining this crucial information is to measure how the outflow responds to changes in the AGN continuum luminosity. Recently, I developed a new time-dependent photoionization model (TPHO) which allows precise mapping of the different outflow phases providing tight constraints on the kinetic energy and the mass transferred to the surrounding medium. I will summarize the state-of-art of X-ray winds in nearby Seyfert I galaxies and I will present the potential of the spectral-timing TPHO analysis of recent and future large XMM-Newton campaigns of variable AGN. I will also discuss the impact of upcoming XRISM observations (and future missions e.g. Athena, Arcus, LEM) on our understanding of the physics, structure, and energetics of X-ray outflows. Finally, I will conclude by moving to a totally different size scale showing the potential of high-resolution X-ray spectra in studying the content of cosmic dust in AGN outflows.

Accelerators as windows to the dark sector: the DarkLight experiment and the hunt for a new boson

Katherine Pachal
(TRIUMF)
Date: Friday 3 March 2023

The nature of dark matter and its relationship to the Standard Model is one of the highest priority open questions in particle physics today. Accelerator-based experiments are a powerful tool in the search for dark matter and the new bosons that may mediate its interactions with the known particles. The DarkLight experiment will search for such a new boson in an interesting uncovered low-mass range. DarkLight is a small-scale experiment being constructed at the TRIUMF electron linear accelerator, and plans to take its first data within the next year.

Satellites are ruining the night sky for everyone

Samantha Lawler
(Campion College, University of Regina)
Date: Friday 17 February 2023

Starlink has launched thousands of communication satellites in the past 3 years, and already has permission to launch and operate tens of thousands more. Several other companies have similar scale megaconstellation plans, with the goal of providing for-profit satellite internet access.

Current satellite deployment and operation plans ignore many externalities: the globally-visible light pollution from these satellites causes serious disruption to research astronomy and to all stargazers worldwide, and satellites contribute Starlink has launched thousands of communication satellites in the past 3 years, and already has permission to launch and operate tens of thousands more. Several other companies have similar scale megaconstellation plans, with the goal of providing for-profit satellite internet access. Current satellite deployment and operation plans ignore many externalities: the globally-visible light pollution from these satellites causes serious disruption to research astronomy and to all stargazers worldwide, and satellites contribute to significant atmospheric pollution and drastically increase the very real threat of Kessler Syndrome. This talk will focus on how these satellites will affect stargazers and astronomers worldwide, and what satellite operators and the general public can do to help mitigate these negative effects. to significant atmospheric pollution and drastically increase the very real threat of Kessler Syndrome. This talk will focus on how these satellites will affect stargazers and astronomers worldwide, and what satellite operators and the general public can do to help mitigate these negative effects.

Nuclear structure with swift radioactive beams

Kathrin Wimmer
(GSI Helmholtz Centre for Heavy Ion Research)
Date: 10 February 2023

The coexistence of single-particle and collective degrees of freedom in atomic nuclei gives rise to various exotic phenomena. In nuclei with very asymmetric proton-to-neutron ratios, the strong nuclear interaction drives shell evolution which alters the orbital spacing, and in some cases even the ordering present in stable nuclei. Such changes in the structure can have profound consequences for structure and dynamics of nuclei as well as the synthesis of elements in the universe. In-beam gamma-ray spectroscopy is an excellent tool to study the structure of the most exotic nuclei in the laboratory.

In this talk, I will give an overview of the experimental method and present some recent results on a wide range of topics in nuclear structure addressing collective and single-particle structure of nuclei very far from stability. I will also discuss further prospects to enhance the sensitivity of the experimental method for future physics experiments at FAIR.

New results about black hole feedback in galaxy clusters (and a new EDI initiative)

Julie Hlavacek-Larrondo
(Université de Montréal)
Date: 3 February 2023

Contrary to what their name suggests, black holes are not empty space; they are the most extreme objects in the Universe, so powerful that nothing can escape them, not even light. Filled with an exceptional amount of energy, they can easily destroy entire galaxies. The goal of my work is to understand the most massive black holes, the titans among giants. In this talk, I will review the current state of this field while focusing on how these objects, and especially their powerful radio jets, shape the properties of galaxies throughout cosmic time. In particular, I will demonstrate that clusters of galaxies play a pivotal role in our understanding of mechanical/jet- mode black hole feedback processes, as well as in multiphase gas surrounding galaxies. I will also present new results on how machine learning can (and will) play a vital role in our understanding of black hole feedback for the next decades.

Finally, I will present Parité sciences, a Quebec initiative launched in 2021 that aims to achieve gender parity in physics, mathematics and computer sciences. The heart of the project is to provide training to CEGEPs and high school teachers so that they adopt pedagogical strategies that help strengthen the scientific identity of students. I will describe the motivation behind the project, as well as some of these pedagogical strategies that can just also be applied in university courses.

Physics in Action: Ocean-atmosphere greenhouse gas fluxes in Halifax harbour and paths to Industry Employment

Martin Hellmich
(SMU/EOSENSE)
Date: Friday 27 January 2023

Trace gas flux measurements are frequently used to quantify greenhouse gas (GHG) emissions from natural processes and human activity. This information can be useful for identifying climate change mitigation opportunities, comparing agricultural practices, or simply to monitor and improve estimates of global GHG budgets. An overview of flux measurement methodologies will be given, including one that uses Open-Path Fourier Transform Infrared Spectroscopy (OP- FTIR). This technique has been applied for derivations of trace gas emissions in Halifax harbour during 2018, 2020, and 2021. Highlighted is our measurement of the ocean-air flux of N2O (a major greenhouse gas) where a significant short-term ocean source event, releasing stored N2O, was shown to be consistent with high-frequency ocean surface dynamics. This method is well suited to high-frequency coastal monitoring of trace gas fluxes and complementary to studies of climate-sensitive ocean dynamics and microbial ecology. Finally, a sample career path from undergraduate Astrophysics at SMU to gainful industry employment will be presented.

The Growth of Clusters of Galaxies from their Outskirts

Michele Pizzardo
(SMU)
Date: Friday 13 January 2023

Beginning with the discovery of dark matter, clusters of galaxies have been an important foundation for understanding the growth of structure in the universe and for limiting the cosmological parameters. Remarkably, clusters of galaxies accrete half of their mass between a redshift 0.5 and the current epoch. The outer regions of clusters where matter is still falling onto the have a particular trumpet-shaped pattern in redshift space. By exploiting this pattern in different samples, it is possible to measure that rate at which clusters accrete matter from their surroundings. So far measurement of this accretion rate is limited to relatively small samples, but future large spectroscopic projects like MSE, PFS, and WEAVES will enable more incisive measurements.

The physics of human aging: natural variables and simple dynamics

Andrew Rutenberg
(Dalhousie)
Date: Friday 2 December 2022

Living organisms age and eventually die. Humans are the best characterized organisms, with national studies containing tens of thousands of individuals. With hundreds of disparate health attributes, each individual ages with a unique health trajectory. Despite this, population dysfunction and death increase with simple exponentials. How can we study the simple underpinnings of aging? I will describe three theoretical strategies: top-down machine learning of individuals, bottom-up model building of populations, and a “middle-out” approach that has identified natural variables and simple dynamics. We are starting to apply these approaches with multiple model organisms to explore the landscape of organismal aging.

Atomic Gas in Nearby Galaxies as a Cosmological Probe

Kristine Spekkens
(RMC/Queen’s)
Date: Friday 18 November 2022

The atomic gas (HI) content of nearby galaxies provides important insight into how they form and evolve within the standard cosmology. In this talk, I will highlight some of my group's recent efforts to build statistical samples of HI disks to use as cosmological probes. I will first highlight ongoing tensions between the structure of disk galaxies inferred from their rotation curves and predictions from cosmological simulations. I will then describe how the WALLABY widefield HI survey now underway on the Australian SKA Pathfinder (ASKAP) will deliver population statistics to address these issues, and our progress on that front so far. This work paves the way for probing HI disks across cosmic time using the SKA telescope when it comes online towards the end of this decade.

X-ray emission mechanisms in Active Galactic Nuclei and galaxy evolution

Rozenn Boissay-Malaquin
(NASA Goddard/UMBC)
Date: Friday 4 November 2022

The supermassive black holes (SMBHs) at the center of massive galaxies are fed by accretion of surrounding matter, forming compact regions called Active Galactic Nuclei (AGN), which are amongst the most luminous objects in the Universe. The SMBH at the center of an AGN is thought to play a major role in the evolution of the host galaxy, quenching star formation and explaining some close relationships observed between black holes and galaxies. The strong X- ray emission of AGN is produced very close to SMBH, and is responsible for the ionization of the surrounding medium. Therefore, X-ray observations are powerful tools to study what happens in the strongest gravitational fields in the Universe, probing the inner regions of AGN, and to determine how they affect their surroundings, in particular when combined with observations at different wavelengths (from radio to gamma-rays). I will talk about the structure and emission mechanisms of AGN, focusing in particular on an excess of soft X-ray emission (whose origin is debated) and on multi-components and multi-velocities winds (especially Ultra- Fast Outflows which can have an impact on galaxy evolution). I will present studies performed on AGN observed with several X-ray satellites, such as Chandra, XMM-Newton, Swift, and NuSTAR. In a second phase, I will talk about how the X-Ray Imaging and Spectroscopy Mission (XRISM), scheduled to be launched in early 2023, will revolutionize how we understand accreting SMBHs.

What stops a galaxy forming stars?

Exploring possible links between colliding galaxies, super massive black holes and galaxy wide shut down in star formation.

Vivienne Wild
(University of St Andrews)
Date: Friday 28 October 2022

It has been known since the first half of the 20th century that massive galaxies in the local Universe tend to fall into two classes, either smooth elliptical shapes with little ongoing star formation, or spiral disk structures which continue to form stars. Over the past 100 years we have gathered more and more data that demonstrates this bimodality in the galaxy population, but the exact cause(s) of it remains something of a mystery. While the latest generation of cosmological simulations obtain approximately correct fractions of non-star forming galaxies, they do so in many different ways. I will take a look at this question from the perspective of a rare population of "post-starburst" galaxies, which are easily detectable in large spectroscopic or multiwavelength galaxy surveys out to large distances and early in cosmic time. I will demonstrate how difficult it can be to recover causal connection between events which can be
separated by 100's of millions of years or more, but how we have started to make progress through analysis of large populations of galaxies with exquisite data, combined with forward- modelling of hydrodynamic simulations to create directly comparable observables.

Photometric redshifts in the context of the Euclid mission

Guillaume Desprez
(Saint Mary's University)
Date: Friday 21 October 2022

Photometric redshift became a major tool of modern cosmological and extragalactic surveys due to the continuous increase of the probed areas. With billions of galaxies observed in a survey such as Euclid, it is unrealistic to expect a spectroscopic redshift to carry out all the different science goal. However, to reach these goals, photometric redshift need to be reliable and of high quality. To tackle this challenge, a variety of methods to derive photometric redshifts have been developed, all with their advantages and downsides. In this talk, I will present the efforts conducted by the Euclid photometric redshift team to produce the mission redshift pipeline. I will present the main tool developed to handle this task: Phosphoros. I will also review the Euclid photometric redshift challenge, a test of the main photometric redshift codes, which aims to assess the ability of the different codes to provide sensible measurements to carry out the weak-lensing tomography science planned by the Euclid mission.

Widowed Massive Stars

Mathieu Renzo
(Flatiron Institute)
Date: Friday 7 October 2022

Massive stars live predominantly in multiple systems, where mass-transfer can modify their appearance and final fate. Even apparently single stars can be binary products, e.g., mergers or accreting secondary stars ejected from binaries at the companion's explosive death. These ejected "widowed" stars might constitute a significant fraction of the field population of O-type stars (up to ~10%) -- however they are typically slow-moving walkaways hard to find kinematically only. Understanding the structural and evolutionary impact of binary mass transfer onto a mid- mainsequence massive star is important not only to help distinguish binary products from genuine single stars, but also to characterize potential long-GRB progenitors (at low Z) as well as up to ~15% of H-rich supernovae. I will present self-consistent binary evolution models of the accretor star pinned onto the nearest O-type star on Earth, zeta Ophiuchi. This fast runaway star has long been recognized as a binary product, and indeed our models match observational constraints more easily than single stars. Our accretors have important structural differences compared to single (rotating) massive stars, in terms of angular momentum profile, surface chemistry, and density profile above the helium core. In cases when the binary is not broken at the donor's explosion, these differences might have implication on isolated binary evolution paths towards a GWmerger.

Revealing how Star Formation and Quenching proceed in High Redshift Galaxies with Spatially Resolved Space-based Slitless Spectroscopy

Jasleen Matharu
(University of Copenhagen)
Date: Friday 23 September 2022

Space-based slitless spectroscopy capabilities on-board the Hubble Space Telescope have made it possible for us to conduct spatially-resolved studies of star formation in high redshift galaxies for the first time. The future is truly slitless, with the James Webb Space Telescope, Euclid and the Nancy Grace Roman Space Telescope pushing these studies to higher redshifts and increased number statistics. I will unveil the first spatially resolved HAlpha emission line maps of cluster galaxies at z~1 from the GCLASS survey, made possible with the Wide Field Camera 3 G141 grism on-board the Hubble Space Telescope, revealing what they have taught us about the shutdown of star formation in galaxy clusters at this crucial epoch in the history of cosmic star formation. Then I will present deep spatially resolved HAlpha emission line maps of CANDELS galaxies at z~0.5 from the CLEAR survey, made possible with the Wide Field Camera 3 G102 grismon-board the Hubble Space Telescope, and what these have unveiled on galaxy size growth via star formation at intermediate redshifts. By synthesizing the few existing spatially-resolved studies of High-Redshift Galaxies between 0.5<z<1.7 we now have, I will provide some of the first direct observations on how star formation and its quenching propagates spatially in galaxies over time.

More Data + More Parameters = More Fun with Galaxy Evolution

Josh Speagle
(University of Toronto)
Date: Friday 16 September 2022

We observe an incredible diversity of galaxies both today and in the past, across almost all axes we can measure, which means that galaxies can provide a window into a complex, interconnected set of physical processes across a huge range of scales. Likewise, it also means we need to gather and model data from a large number of galaxies to really get a handle on things. In this talk, I'll go over a small segment of what we've learned about galaxy evolution by studying similar types of star-forming galaxies across cosmic time. In particular, I'll focus on how improved models and statistical methods to fit them have allowed us to go from more "closer-to-data" quantities (such as half-light radii) to "closer-to-theory" quantities (such as star formation histories), highlight some of the apparent disagreements between theory and data that have arisen as a result, and then discuss how (and why) state-of-the-art approaches have helped to resolve these apparent tensions. I'll then describe new work that bridges physical theory with statistical modelling to help further constrain galaxy star formation timescales. If time permits, I will also discuss ongoing work to model galaxies in a flexible, spatially resolved manner. Plus other possible exciting things that might now be possible with new incoming data from the James Webb Space Telescope (JWST)!