Canadian Institute for Theoretical Astrophysics
L'institut Canadien d'astrophysique théorique

JAMBOREE 2021

Introduction - Thursday : 12:00 - 12:15

Juna Kollmeier jak@cita.utoronto.ca	**Introduction to CITA** Introduction to CITA

Cosmology and Extragalactic I - Thursday : 12:15 - 13:00

Jose Tomas Galvez Ghersi jgalvezg@cita.utoronto.ca	**Beyond perturbative methods for early universe cosmology and strong gravity** In this short talk, I will briefly cover the topics of my research which dedicates to the development of computational techniques applied to dynamical systems. In particular, to study inflationary cosmology (and alternatives) and the generation of GW waveforms for beyond-GR theories.
Lukas Hergt lthergt@phas.ubc.ca	**LiteBIRD – Anesthetic – Gambit** Just a quick introduction about me and what I work on. I am a new postdoc at UBC working on cosmic inflation and beyond LCDM cosmology using nested sampling to perform Bayesian model comparisons, which I visualise with Anesthetic (check it out, also useful for MCMC visualisations and highly intuitive for matplotlib users). I am also a member of the LiteBIRD and Gambit collaborations.
Dick Bond	**TBA** TBA
Thomas Morrison morrison@physics.utoronto.ca	**Early Universe Simulations and Non-Gaussianity** My work focuses on generating novel forms of non-Gaussianity in the early universe using lattice simulations as a computational tool. I am particularly interested in non-Gaussianity generated by phase transitions during inflation.

Zack Li zack@cita.utoronto.ca	**CMB data analysis and theory for SO/S4** Upcoming millimeter-wave surveys like SO/S4 will yield lots of interesting cosmology, as long as we can understand our instruments, foregrounds, and cosmological models. I'm interested in developing methods and tools for analyzing data from these surveys! In particular, I think about power spectra pipelines, forward models of foregrounds, and using gradients to accelerate model exploration.
Nathan Carlson njcarlson@physics.utoronto.ca	**Looking for signatures of novel physics in the cosmic web with semi-analytic simulations** The Peak Patch simulations very rapidly model the approximate development of large-scale cosmological structure from a primordial random density field without requiring the full physical treatment of an N-body simulation. My research involves updating the code's ability to model relatively small scales in the interiors of galaxy clusters and on the largest scales the future trajectories clusters and the structures they will produce at Great Attractors. Our objective in this effort is to reconstructing cosmic fields and study various models of cosmology beyond ΛCDM.
Matthew Johnson	**Fundamental Physics in Cosmology**
Pavel Motloch motloch@cita.utoronto.ca	**What I have been up to** Galaxy spins, CMB, CIB
James Taylor taylor@uwaterloo.ca	**Cosmological Constraints using Halo Structure** For a broad range of group and cluster mass at low redshift, halo "age" or mean assembly time varies almost orthognoally to halo abundance in the omega_m-sigma_8 plane. Thus, estimates of age based on structural proxies such as concentration can significantly reduce the error contours in cluster abundance studies. This provides an interesting path to explore the recent tension between CMB and cluster results.
Adrian Liu adrian.liu2@mcgill.ca	**First Constraints on Reionization from HERA** In this talk, I will briefly showcase recent science results from the Hydrogen Epoch of Reionization Array (HERA), which rule out adiabatic heating of the IGM at $z \sim 7.92$.

Planets - Thursday : 13:00-14:00

Eve Lee eve.lee@mcgill.ca	**Linking solar and extra-solar systems** Solar system planets are at the extreme ends of the overall exoplanetary population. Observationally, however, we do not yet have technical capabilities to detect true solar system analogs and so robustly determining whether we live in an unusual system or not is challenging. At the rocky and gassy ends of exoplanets, there are populations that bridge the more common mini-Neptunes with the more extreme solar system counterparts, namely rocky super-Earths and gas giants. I will talk about these two populations.
Sam Hadden shadden1107@gmail.com	**Instabilities In Planetary Systems** A lightning introduction to simulating planetary systems and understanding their potential for dynamical instabilities.
Scott Tremaine tremaine@cita.utoronto.ca	**Stellar and planetary dynamics** I will give a brief overview of my research interests.
Fergus Horrobin horrobin@astro.utoronto.ca	**Planet Disk Interactions with Luminous Planets** Protoplanetary disks are the environment from which all planets, including our own Earth form. Composed initially of gas and dust, which, over hundreds of thousands of years, comes together to form the planets we observe today. The structure of these disks, such as the density and temperature profiles play an important role in influencing how planets can form. And these structures are in turn strongly influenced by the dynamical evolution of the disk. Over the past couple decades, many works both numerical and analytic have aimed to describe how perturbations to the disk from embedded forming planets influence the formation and evolution of planetary systems. Here I will briefly show how applying explicit radiative hydrodynamics and including the accretion luminosity of the planet as a source can greatly change the torque a planet feels from the disk, and consequently have significant influence over its migration pathway.
J. J. Zanazzi jzanazzi@cita.utoronto.ca	**Teasing-Out Tilts within Planet-Forming Disks** I will briefly discuss recent and ongoing work on theoretical and observational work on constraining tilts within planet-forming disks.
Brett Gladman gladman@phas.ubc.ca	**Planetary Dynamics via small-body orbits** In this lightening talk I will summarize various insights into planetary dynamics available via the study of small-body orbits, both observationally and numerically.

High Energy / FRB I - Thursday : 14:20 - 15:20

Xinyu Li xli@cita.utoronto.ca	**Negative Dynamical Friction** We study the case where a star moving inside ambient gas. When outflow is launched from the star, a bow shock is formed ahead leading to a net acceleration from the ambient gas. With a new GPU-based code, we can study this effect in realistic astrophysical systems.
Jonathan Zhang jzhang@physics.utoronto.ca	**Investigating sources of fast radio bursts** Two of the more commonly proposed sources of fast radio bursts (FRBs) are heavy dark matter particles, and magnetar bursts. If FRBs are caused by dark matter, the signal distribution would correlate with dark matter structure, and therefore allows us to calculate the signal distribution from halo structure simulations. I also intend to study how FRBs could be caused by magnetars. By calculating the plasma distribution in the magnetosphere, we can make more precise predictions about the processes that could lead to FRBs.
Ashley Stock stock@astro.utoronto.ca	**Pulsar Scintillation with CHIME** Pulsars scintillate as a result of scattering by the interstellar medium (ISM). Measurement of the scintillation properties of a pulsar, especially the annual variation of these properties, can be used to determine the distance and orientation of the scattering structures. Knowing the distances to the scattering structures can allow for 3D co-location with features in the ISM. I use the CHIME telescope to measure scintillation properties of pulsars on several sight-lines with high cadence to better understand the ISM structures that cause scintillation.
Fang Xi Lin flin@cita.utoronto.ca	**Lensing predictions from dispersion measure** Dispersion Measure (DM) is a commonly measured quantity in pulsar astronomy: it is the column density of electrons along the line of sight from Earth to the pulsar. It is well known that changing electron densities will change the index of refraction of the ISM and environments surrounding binary pulsars, which should lead to focusing and de-focusing effects. However, this link hasn't been clearly demonstrated in current literature. I present some results showing such lensing effects in eclipsing binary pulsars.
Chris Thompson thompson@cita.utoronto.ca	**Topics in High Energy Astrophysics** Much of my research over the last year has focused on the electrodynamics of neutron stars and various quantum electrodynamic and plasma effects that appear to be involved in the bizarre and spectacular behavior of magnetars. Some progress may have also been made untying the longstanding question of how and why radio pulsars produce radio waves. I'm also actively interested in the rotation of stars and the formation of planets, which still provide much fresh theoretical territory to be explored.

Galaxies I - Thursday : 15:20-16:20

Marta Reina-Campos reinacampos@mcmaster.ca	**Modelling stellar cluster populations alongside their host galaxies: the EMP-Pathfinder view** Stellar cluster populations in the Local Universe show a wide range in properties, suggesting that these objects form via a unique physical channel, and that their demographics are shaped by their formation and evolution in an evolving cosmic environment. This scenario links the current cluster formation sites in the disks of the the Antennae galaxies to the old GC population that mostly populates the halo of the Milky Way, implying that their evolution is tightly coupled to that of their host galaxy. To understand the observed cluster populations, it has become necessary the use of numerical simulations that can model the co-formation and evolution of stellar clusters alongside their galactic environments over a Hubble time. In this talk, I will introduce the EMP-Pathfinder simulations (Reina-Campos+ in prep.), and I will show that GC populations emerge self-consistently in this scenario after 10 Gyr of co-evolution with their host galaxy. Lastly, I will briefly discuss how cluster demographics can be used as diagnosis tools for baryonic models in galaxy formation simulations, and I will set up the floor for a discussion regarding upcoming challenges in numerical simulations of galaxy formation and evolution.
Seunghwan Lim	**High-z star formation from protoclusters and CIB-optical cross-correlation** I will present a summary of comparisons of protoclusters from observation and current simulations, as well as of CIB-optical cross-correlation using the CFIS r-band and SPIRE images.
Rainer Weinberger rainer@cita.utoronto.ca	**Rainer Weinberger** main interests: - Galaxy formation and evolution from cosmological initial conditions - Numerical modeling and code accessibility - Idealized simulations - connections to fundamental physics

Denis Leahy leahy@ucalgary.ca	**Modelling the Star Formation History of M31 Using FUV Through IR Data** M31 has being surveyed at far and near ultraviolet (FUV and NUV) with the UVIT telescope on AstroSat. We carry out photometry in 5 FUV and NUV bands, and also analyze archival data, including SDSS data in optical, Spitzer data in near infrared and Herschel data in mid and far infrared. The resulting multiband photometry is modeled using the public CIGALE code and with our own code for modeling multiple Simple Stellar Populations (SSP) code. We confirm recently published star formation history (SFH) studies, and find improved results for the youngest populations. The latter is enabled by the inclusion of the FUV and NUV data.
Neige Frankel frankel@cita.utoronto.ca	**What Sets the Orbits of Stars in the Milky Way?** Disk galaxies are very regular in their stellar bodies but reveal complex structures in their stars and gas. The Milky Way is an ideal model organism to study the connection between the structured birth conditions and the subsequent dynamical evolution of its disk, as much 6D phase space information is available for its individual stars. At the same time, cosmological simulations are reaching resolutions high enough to start making quantitative comparisons with observations. I will briefly present my work using the Milky Way at the interface between cosmological simulations and external disk galaxies.

Lichen Liang lliang@cita.utoronto.ca	**CII 158 micron line emission as star formation rate indicator of galaxies** CII (singly ionized carbon) 158 micron emission line, the brightest FIR line of galaxies (1e-2∼ 1e-3 L_IR), is adopted as a powerful tool for measuring SFR of galaxies at extremely high redshifts ($z > 5$). It is motivated by the observed linear correlation between SFR and CII luminosity (L_CII) of normal star-forming galaxies by several different groups recently. However, other studies also show that CII luminosity of different types of galaxies, such as local ULIRGs and high-z SMGs, exhibit a "CII-deficit" with respect to their L_IR. In addition, recent ALMA programs (e.g. ALMA-ALPINE survey) have also revealed a large population of UV-selected galaxies that have no [CII] line detection, casting doubts on the empirical, locally calibrated SFR vs. CII luminosity scaling relation. In this talk, I will introduce our recent study on the CII line emission of galaxies using the FIREBox cosmological simulation, the first-ever cosmological-volume simulation that has the resolution of typical galaxy zoom-in simulations. I will show that the FIREBox simulation can successfully reproduce the local SFR vs. CII luminosity scaling relation at 0.1-10 M_sun/yr, as well as the observed deficiency of CII emission at higher SFR regime and at high redshifts. I will discuss the physical drivers of the variation in the L_CII / SFR ratio, and their relative importance at different regimes of physical parameter spaces of galaxies. Finally, I will also pinpoint several important sources of observational uncertainties that could bias our SFR calibration by CII line emission at high redshifts.

Multimessenger and "Multitopic" - Friday : 12:00 - 1:00

Sarah Gossan gossan@cita.utoronto.ca	**The Multi-Messenger Milky Way** The era of multi-messenger astronomy is well and truly upon us, with over 50 compact binaries observed since the Advanced LIGO detectors saw first light in 2015. Despite our very own cosmic backyard, the Milky Way, being ripe with prospective sources for ground-based gravitational wave detectors, the closest source detected thus far was at a distance of 40 Mpc. In this talk, I will outline several potential Galactic multi-messenger sources, and discuss several ways in which their detection prospects over the next twenty years can be improved through both experimental and analytical techniques.

Phil Landry pgjlandry@gmail.com	**Gravitational Waves, Neutron Stars, and Strong Gravity** In this lightning talk, I will introduce myself and describe my research interests in gravitational wave astronomy, neutron star astrophysics and general relativity.
Jose Miguel Jauregui jgarcia@cita.utoronto.ca	**A hardware side of CITA** Quarantine times ask for new ways of work. Benchwork needs lab equipment (expensive) or a bunch of orders from online orders and coffee.
Janosz Dewberry jdewberry@cita.utoronto.ca	**Tides and oscillations in stars and gaseous planets** In this lightning talk, I will describe my efforts over the last year to understand the fluid dynamics of rapidly rotating, centrifugally distorted gas giants like Saturn and Jupiter. In particular, I will describe projects related to i) wave excitation in Saturn's rings by the planet's internal oscillations, ii) the computation of tidal Love numbers for rapidly rotating planets and stars, and iii) the tidal response of rotating fluid bodies with stably stratified interiors.
Omar Contigiani contigiani@cita.utoronto.ca	**Propagation of gravitational waves on arbitrary backgrounds** In General Relativity and beyond, the propagation of gravitational waves (GWs) on top of a background metric is studied under one of two assumptions: either the background is fixed to a specific form, or a well-behaved separation between wave and arbitrary background must be imposed. This is traditionally done by requiring that the wavelength of the first is smaller than the typical length scale of the second. However, this naturally limits us to the geometric optics limit, where the ratio between the two is ¡¡1. In this talk, I will introduce a second way to achieve this separation for arbitrary GW wavelengths in the presence of a spontaneously broken symmetry. I will discuss what a well-behaved separation implies and introduce a simple application of this formalism in the context of scalar waves present in modified theories of gravity.

High Energy / FRB II - TBD

Dylan Jow djow@physics.utoronto.ca	**Wave Optics in Lensing** The abundance of lensing data for coherent sources (e.g. FRBs and pulsars) that is set to be obtained has made the study of wave effects in lensing extremely relevant to the current observational climate. New advancements in numerical techniques for evaluating highly oscillatory integrals has made a more sophisticated study of wave effects possible. In this work, we hope to systematically study the theory of wave optics in lensing using these new techniques in order to identify and categorize novel effects in the wave regime.
Almog Yalinewich almog.yalin@gmail.com	**Violent Astrophysical Transients** I will present my research on violent astrophysical transients, such as gamma ray bursts, supernova explosions, tidal disruption events and planetary collisions
Daniel Baker	**Pulsar Scintillometry $\theta - \theta$ Methods** Pulsar scintillometry can provide an excellent tool for studying both the properties of pulsars and the Interstellar Medium (ISM). Unfortunately, much of this information is hidden behind a convolution. $\theta - \theta$ methods allow us to undo the convolution to make order of magnitude improvements to measurements of pulsar velocities and details of the the structures in the ISM responsible for scintillation.
Simon Blouin sblouin@uvic.ca	**Towards precision white dwarf cosmochronology** The predictable cooling of white dwarfs is routinely exploited to measure the ages of stellar systems. With the ongoing data revolution in stellar astronomy, the accuracy of this age-dating technique is increasing and may soon provide useful constraints in cosmology. For the moment, modeling uncertainties of white dwarf cooling prevent us from unlocking the full potential of white dwarf cosmochronology. During the last few years, I have been working on improving the microphysics (equation of state, opacities, phase diagrams) of white dwarf cooling models to increase their accuracy. I have worked on characterizing the chemical fractionation undergone by white dwarfs as their interiors freeze, a process that can delay their cooling by as much as 8 Gyrs. During the next few years, I will be investigating convective boundary mixing during the previous evolutionary phases to better constrain the chemical profile at the start of the white dwarf phase, a quantity that my previous work has revealed to be critical for cooling models.
Jing Santiago Luo luojing1211@gmail.com	**VLBI FRB Localization** The Fast Radio Bursts are short duration, 10ms, strong radio flash from the deep universe. The accurate localization of FRBs helps us understand the physics of their origin and propagation. In this presentation, we present the concept of VLBI localizing the CHIME FRBs to sub-arcsecond precision.

Evan McDonough e.mcdonough@uwinnipeg.ca	**STrongly-Interacting Ultralight Millicharged Particles (STUMPs)** We consider the implications of an ultra-light fermionic dark matter candidate that carries baryon number. This naturally arises if dark matter has a small charge under standard model baryon number whilst having an asymmetry equal and opposite to that in the visible universe. A prototypical model is a theory of dark baryons charged under a non-Abelian gauge group, i.e., a dark Quantum Chromo-Dynamics (QCD). For sub-eV dark baryon masses, the inner region of dark matter halos is naturally at 'nuclear density', allowing for the formation of exotic states of matter, akin to neutron stars. The Tremaine-Gunn lower bound on the mass of fermionic dark matter, i.e., the dark baryons, is violated by the strong short-range self-interactions, cooling via emission of light dark pions, and the Cooper pairing of dark quarks that occurs at densities that are high relative to the (ultra-low) dark QCD scale. We develop the astrophysics of these STrongly-interacting Ultra-light Millicharged Particles (STUMPs) utilizing the equation of state of dense quark matter, and find halo cores consistent with observations of dwarf galaxies. These cores are prevented from core-collapse by pressure of the 'neutron star', which suggests ultra-light dark QCD as a resolution to core-cusp problem of collisionless cold dark matter. The model is distinguished from ultra-light bosonic dark matter through direct detection and collider signatures, as well as by phenomena associated with superconductivity, such as Andreev reflection and superconducting vortices. Talk based on arXiv:2011.06589.

Galaxies II - Friday : 14:20 - 15:20

Aris Tritsis atritsis@uwo.ca	**Halo's Magnetic field as Evident from stRiated Interstellar Clouds (HOMERIC)** From the propagation of cosmic rays and the removal of CMB foregrounds to the formation of molecular clouds and star formation, the Galactic magnetic field (GMF) plays a paramount role. Despite the importance of the GMF, unveiling its properties has proven to be, like the journey of Ulysses to Ithaca in Homer's epic poem, a real Odyssey. This is not because of lack of effort but rather because the magnetic field is hard to observe. The majority of the diagnostics we have been using to probe the GMF cannot provide 3-dimensional information about its strength or structure. In this talk, I will present HOMERIC (HalO's Magnetic field as Evident from stRiated Interstellar Clouds), an ambitious project that aims to perform a bona-fide tomographic measurement of the strength and orientation of the plane-of-sky component of the GMF. To this end, HOMERIC makes use of a novel method that utilizes the imprint of hydromagnetic waves on interstellar clouds to trace back the strength of the magnetic field.
Antoine Marchal amarchal@cita.utoronto.ca	**Exploring the multiphase and multiscale nature of the (neutral) ISM**
James McKee jmckee@cita.utoronto.ca	**Studying the Insterstellar Medium with Pulsars** Pulsars allow sensitive measurements of different aspects of the interstellar medium. I will talk about work I am doing to understand the variable nature of the ISM.
Ted Mackereth tedmackereth@cita.utoronto.ca	**Galactic astrophysics using the Milky Way and its connection(s) with the galaxy population** I will present a brief overview of the various projects I'm working on or interested in within the broad area of 'using the Milky Way as a tool for developing our understanding of galactic astrophysics'. I'll show results examining how alpha-element abundances can be tracers of galactic assembly, new results from modelling the density of the Milky Way bar, a look at the 'resolved' assembly of the Milky Way and some smaller results on dark matter substructure and interstellar objects.
Peter Martin pgmartin@cita.utoronto.ca	**The turbulent dusty magnetized ISM** At lightning speed I will illustrate analyses by me and my colleagues of new probes for modeling the ISM in 3D. These involve: Exploiting the complementarity of Herschel/Planck thermal dust emission, NIR/optical extinction, and Dragonfly scattered light; Exploiting H I gas kinematics; and Exploiting Gaia.

Jiayi Sun sun208@mcmaster.ca	**Molecular Cloud Populations and Their Star Formation Efficiencies in Nearby Galaxies** I will showcase my latest research in the context of the PHANGS-ALMA project, a CO(2-1) survey mapping the molecular cloud populations in 90 nearby, massive, star-forming galaxies. Taking advantage of the rich multiwavelength data available for these galaxies, we measure physical properties of the molecular clouds and put them in the context of their local, kpc-scale galactic environment. We observe clear correlations between molecular cloud characteristics (such as surface density and velocity dispersion) and galactic environmental properties (such as kpc-scale surface densities of gas, star, and SFR). We further calculate a number of characteristic timescales relevant to molecular cloud formation and evolution, including cloud free-fall time, turbulence crossing time, and gas depletion time. The combination of these timescales allow us to constrain the star formation efficiency per free-fall time (0.9%) and test theoretical predictions from turbulence-regulated star formation models.

Cosmology and Extragalactic II - Friday : 15:20 - 16:20

Jennifer Y. H. Chan jyhchan@cita.utoronto.ca	**Understanding the evolving Universe** My research focuses on understanding two main aspects of the Universe: cosmological reionization and cosmic magnetism. To understand how the Universe acquires its magnetization on the large scales and how reionization proceeded, proper theoretical tools in modeling and analysis of radiation we receive are needed, in addition to collecting more data through observations and experiments. I develop covariant formalisms of cosmological radiative transfer (CRT) of (i) 21-cm line of neutral hydrogen and (ii) polarized continuum radiation to study these two key sciences, respectively. These CRT formalisms can take the advantage of the vast resources in sophisticated cosmological (magneto-)hydrodynamic simulations and make unambiguous predictions of the observables to compare with observation.

Dongwoo Chung dongwooc@cita.utoronto.ca	**Line-intensity mapping: enabling new lines of enquiry into the high-redshift universe** Line-intensity mapping promises to capture large-scale structure at high redshift through a three-dimensional measurement of the intensity field of a given spectral line species. Surveys of rest-frame cm- to mm-wave lines associated with CO and [C II] will strongly complement 21 cm surveys at high redshift by tracing dense star-forming environments. While CO and [C II] intensity mapping experiments are still in early stages, modellers must lay the groundwork for more advanced analyses with future data to enable both astrophysical and cosmological inferences. My programme of research looks to work towards this goal through better forward models of the connection between halo properties and emission in different spectral lines, more complete accounting of astrophysical effects, and novel methods of revealing cross-correlations between observations of overlapping cosmic volumes.
Jonathan Braden jbraden@cita.utoronto.ca	**The Nonlinear and NonGaussian Early Universe** I work on various aspects of nonlinear dynamics in the early Universe, such as phase transitions, preheating, and production of novel forms of nonGaussianity. I also work on analog table top models for cosmology.
Renee Hlozek	**TBA** TBA
Alex Lague lague@astro.utoronto.ca	**Efficient Modelling of Ultralight Axions** Many models of high energy physics predict the existence of ultralight scalar bosons. It has been shown that such particles make ideal dark matter candidates which may help alleviate some observational discrepancies in cosmology such as the missing satellite problem and the Hubble-S_8 tensions. However, due to their mass range spanning many orders of magnitude and their wave-like nature, accurately modelling the impact of ultralight bosons on large-scale structure has proven to be a computational challenge. I will discuss the use of a combination of BOSS and Planck CMB data to reach the strongest constraints on the relic density of axions with mass lower than 10^{-26} eV (arXiv:2104.07802).
Hongming Zhu hmzhu@cita.utoronto.ca	**Physics with the Nonlinear Universe** I will talk about how to optimally extract information from the nonlinear structures of the Universe and present some recent results for reconstructing the large-scale density field from the small-scale matter distribution. I have also proposed new estimators for CMB lensing and robust probes of cosmic neutrinos.
Martine Lokken	**TBA** TBA

Levon Pogosian levon@sfu.ca	**The Hubble tension and the magnetic universe** Magnetic fields, if present in the plasma prior to last scattering, would induce baryon inhomogeneities and speed up the recombination process. As a consequence, the sound horizon at last scattering would be smaller, which would help relieve the Hubble tension. Intriguingly, the strength of the magnetic field required to alleviate the Hubble tension happens to be of the right order to also explain the observed magnetic fields in galaxies, clusters of galaxies and the intergalactic space. I will review this proposal and provide an update on its status in the context of the latest data.