CITA-PI Day Fall 2019 Agenda

November 1st 2019

Strongly Lensed Supernovae as a Probe of Cosmology and Astrophysics

Max Foxley-Marrable, ***Institute for Cosmology and Gravitation, University of Portsmouth***

Strongly gravitationally lensed supernovae (gLSNe) will enable us to probe cosmology and astrophysics in unique ways. Type Ia gLSNe can be used to measure the Hubble Constant (H_0) independently of the cosmological distance ladder through time delay cosmography. Additionally, the standardisable nature of Type Ia supernovae (SNe) will afford tight constraints on the mass-sheet degeneracy, arguably the largest source of systematics in lens modelling. I will outline how microlensing can impact the measurement of H0. I will then show that by being selective with our gLSNe sample in LSST, we can potentially obtain an independent measurement of H_0 with the mass-sheet degeneracy suppressed at the 0.5% level.

gLSNe could also provide insight into the astrophysics of supernovae. By detecting a gLSNe before the appearance of later multiple images, we could in principle obtain day zero spectra and photometry of the supernova, provided we accurately predict the time delay of the trailing images. I will present forecasts for the annual rates of candidate gLSNe using LSST and ZTF, and forecast peak magnitude distributions for early phase Type Ia (single-degenerate) and Type IIP SNe found in the trailing lensed images.

Magnetar outbursts from crustal failures

Xinyu Li, ***Canadian Institute for Theoretical Astrophysics/Perimeter Institute***

The ultra-strong magnetic fields of magnetars have profound implications for their radiative phenomena. We studied the dynamics of strong magnetic fields inside magnetars. We show that internal Hall waves launched from the core-crust interface can accumulate magnetic stress in the crust. The strong magnetic stress can break the crust, initiate plastic failures and lead to X-ray outbursts.

Intensity mapping: a new window into the cosmos

Hamsa Padmanabhan, ***Canadian Institute for Theoretical Astrophysics / Dunlap Institute for Astronomy and Astrophysics***

The technique of intensity mapping (IM) has emerged as a powerful tool to explore the universe at $z < 6$. IM measures the integrated emission from sources over a broad range of frequencies, unlocking significantly more information than traditional galaxy surveys. Astrophysical uncertainties, however, constitute an important systematic in our attempts to constrain cosmology with IM. I will describe an innovative approach which allows us to fully utilize our current knowledge of astrophysics in order to develop cosmological forecasts from IM. This framework can be used to exploit synergies with other complementary surveys, thereby opening up the fascinating possibility of constraining physics beyond LCDM from future IM observations.

Mass mapping with the cosmic microwave background

Mathew Madhavacheril, ***Perimeter Institute***

Gravitational lensing of the cosmic microwave background (CMB) can be used to map the total matter distribution. The clustering of matter measured this way gives us valuable information on gaps in our standard model of particle physics, including the mass of neutrinos and the particle nature of dark matter. Ongoing projects like the Atacama Cosmology Telescope and the upcoming Simons Observatory will prepare high fidelity mass maps. With data across multiple frequencies and new algorithms for reconstructing lensing, systematics from astrophysical foregrounds can be mitigated allowing for robust inference of cosmology. In addition, synergies with other CMB observables like the tSZ and kSZ effect will allow mitigation of modeling errors. I will outline recent results from these efforts, highlighting the prospects and challenges for extracting a wealth of new information from the CMB over the next decade.

Accretion in stellar-origin black hole binaries: detection, parameter estimation and electromagnetic counterparts

Laura Sberna, *Perimeter Institute*

Stellar-origin black-hole binaries detectable by the planned Laser Interferometer Space Antenna (LISA) can enter the band of ground-based gravitational-wave observatories after weeks/months. We study the impact of mass accretion on their orbital evolution. Accretion affects the gravitational-wave phase at negative (-4) post-Newtonian order, and is therefore dominant for binaries at large separations. If accretion takes place at $\sim 10\%$ of the Eddington rate, it will leave a detectable imprint on the dynamics, which should be included in waveform models to avoid biasing the estimation of the binary parameters. In optimistic astrophysical scenarios, a multiwavelength strategy with LISA and a ground-based interferometer can detect events for which the accretion rate can be measured at 50% level or better, and the sky position can be identified within less than $0.4\,\mathrm{deg}^2$ uncertainty. This would allow for targeted searches of electromagnetic counterparts to black-hole mergers in gas-rich environments with future X-ray detectors (such as Athena) and radio observatories (such as SKA).

Probing Primordial Stochastic Gravitational Wave Background with Multi-band Astrophysical Foreground Cleaning

Zhen Pan, *Perimeter Institute*

The primordial stochastic gravitational wave background (SGWB) carries first-hand messages of early-universe physics, possibly including effects from inflation, preheating, cosmic strings, electroweak symmetry breaking, and etc. However, the astrophysical foreground from compact binaries may mask the SGWB, introducing difficulties in detecting the signal and measuring it accurately. In this Letter, we propose a foreground cleaning method taking advantage of gravitational wave observations in other frequency bands. We apply this method to probing the SGWB with space-borne gravitational wave detectors, such as the Laser Interferometer Space Antenna (LISA). We find that the spectral density of the LISA-band astrophysical foreground can be predicted with percent-level accuracy assuming 10-years' observations of third-generation GW detectors, e.g., Cosmic Explorer. After the foreground cleaning, LISA's sensitivity to the primordial SGWB will be substantially improved.