2025-26 Seminar List

RESCEU Thursday Seminar

2026-02-05 Suyog Garg

Title:
Do BBH-stellar collisions in dense stellar clusters tend to preferentially align BBH spins?
(A population-level hierarchical likelihood test)

Simpler title
Do BBH-stellar collisions in dense clusters tend to preferentially align spins?

Abstract:

Dynamical binary black hole (BBH) formation in dense stellar clusters can imprint both waveform morphology (e.g., eccentric or otherwise complicated inspirals) and population-level mass-spin signatures that differ from isolated binaries. To test this hypothesis, we are developing a hierarchical population model that links BBH-star collisions and subsequent accretion, to a selection-corrected shift towards higher total mass in the mass distribution and a preference for positive effective spin. We utilize the parameter posteriors from LIGO-Virgo-KAGRA observation data, to find quantitative evidence, for or against, this accretion-driven spin alignment. This will aid in ultimately constraining the isolated and dynamical BBH formation channels. In this seminar, I will present our idea, methods and some early preliminary insight into the results.

2026-01-29 Erika Ogata

title
Theoretical and Observational Approaches to the Formation of Supermassive Black Holes: Radiation Hydrodynamic Simulations and Line Intensity Mapping

abst
Supermassive black holes (SMBHs) are already in place at redshifts $z>6$, highlighting a long-standing challenge in understanding their formation and early growth. Radiation hydrodynamic (RHD) simulations and line intensity mapping (LIM) together provide a complementary theoretical and observational framework for investigating the origin and evolution of SMBHs. RHD simulations resolve gas accretion onto black holes within the Bondi scale, enabling a quantitative characterization of the surrounding gas dynamics and black hole growth rates. Our simulations show that radiative feedback can suppress the accretion rate to about a few per cent of the classical Bondi–Hoyle–Lyttleton rate, with the degree of suppression strongly dependent on the ambient gas conditions. In contrast, LIM statistically probes black hole activity through integrated line emission such as Hα and He II, without resolving individual sources. We found that black-hole-powered emission

significantly impacts key LIM observables, including the mean intensity, voxel statistics, and power spectrum.

2026-01-22 [canceled]

2026-01-15 Kohei Ichikawa (Tohoku University)

Title: Recent JWST insights into Little Red Dots and unresolved connections to quasars

The James Webb Space Telescope (JWST) has unveiled numerous massive black holes (BHs) in faint, broad-line active galactic nuclei (AGN), even though their survey areas are only ~10^2 arcmin^2, which were previously considered too small for significant number of AGN discoveries before the JWST launch. This discovery highlights the presence of a AGN population with "V-shape" UV-optical spectral shape, referred to as little red dots (LRDs), which are more abundant than X-ray selected AGNs that are less influenced by obscuration. In this talk, we summarize the recent observational properties of LRDs and discuss what we can learn from them about the growth of supermassive black holes (SMBHs) in the early Universe at z>=5. The large number density of LRDs indicates that the cosmic growth rate of BHs within this population does not decrease but rather increases at higher redshifts beyond z~6. The BH accretion rate density deduced from their luminosity function is significantly higher than that from other AGN surveys in X-ray and infrared bands. To align the cumulative mass density accreted by BHs with the observed BH mass density at z~4-5, as derived from the integration of the BH mass function, the radiative efficiency must be doubled from the canonical 10% value, achieving significance beyond the >2sigma confidence level.
If time allows, we will also explore the future prospects for identifying high-luminosity and/or low-redshift analogs of LRDs using upcoming and ongoing wide-area surveys such as UNIONS, PFS, Euclid, and VLA 3GHz radio surveys, and explore how LRD systems may evolve into the luminous quasars observed in the z<4 Universe.

2026-01-08 (Mock defence for M2)

2025-12-25 (Mock defense for M2)

2025-12-18 [canceled]

2025-12-11 Chinami Kato (UTAP)

Title:

Neutrinos and supernova progenitors

Abstract:
Supernovae are among the most mysterious phenomena in the universe. Although we now have a standard picture of supernova progenitors, it has not yet been firmly confirmed. In this talk, I introduce a possible new approach to constraining supernova progenitors using observations of pre-supernova neutrinos—neutrinos emitted in the final stages before the explosion. These neutrinos are much lower in energy and far fewer in number than the neutrinos observed during the supernova itself, and for decades their detection was considered extremely challenging. However, recent remarkable advances in detector technology have made such observations increasingly realistic. Although pre-supernova neutrino detection is limited to only very nearby progenitors, it nevertheless plays a crucial role in helping us unravel the long-standing mystery of supernova progenitors.

2025-12-04 Qiliang Fang (NAOJ)

Title:
From Mass Loss to Explosion: Tracing the Diversity and Commonality in Core-Collapse Supernovae

Abstract:
Massive stars are expected to end their lives as core-collapse supernova (SN) explosions. Systematic investigation of these catastrophic events offers a valuable window into both stellar evolution and the physics of core collapse. In this talk, I will introduce our recent research on Type II (hydrogen-rich) SNe. In particular, we combine late-phase (nebular) spectroscopy, which probes the innermost ejecta, with early-phase light curve modeling, which constrains the structure of the progenitor’s outer envelope. By bridging the surface and core properties of the progenitors in a large sample of well-observed SNe II, we uncover a wide range of mass-loss histories and evolutionary pathways that go beyond the standard stellar evolution models. Despite this diversity, we find a similarity in their explosion mechanisms, which closely match the expectations of modern neutrino-driven core-collapse simulations. This apparent diversity in progenitor evolution but unity in explosion mechanism offers new insights into the roles of mass loss, binary interaction, and envelope stripping in shaping the observed variety of SNe II.

2025-11-27 Daisaburo Kido

タイトル
Little Red Dotsと高赤方偏移宇宙における超大質量ブラックホール進化への示唆

アブストラクト
近年JWST の観測により、多数の Little Red Dots(LRDs) が発見されている。これらはコンパクトで非常に赤く、V字型の SED と幅広い(>1000km/s)バルマー線を示す天体である。これらの特徴は AGNの活動を示唆する一方で、X線、電波、あるいはダスト放射が著しく弱いという性質は、標準的な AGN モデルでは説明できない。ここでは、超エディントン降着とそれに伴う強力なアウトフローのフィードバックにより、観測される LRD の数密度と整合的な降着時間スケールの間、LRD 環境を維持することは困難であることを示す。

これを解決するために、我々はBHの周囲に形成される高密度で光学的に厚いガスエンベロープをLRDのモデルとして提案する。単純な静水圧平衡条件から内部構造を計算すると、このエンベロープはアウトフローを隠し、高エネルギー放射を再処理して、表面から温度 T ≈ 5000 K の黒体放射として放射することができ、観測される赤い光学連続成分を自然に再現する。また、バルマーブレイクや時間変動といった他の観測的特徴についても概説し、あわせて本モデルの限界や最近の観測で要求される、解決すべき今後の課題、についても時間があれば議論する。(I am happy to present in English if someone wants)

2025-11-20 Federico Urban (CEICO, FZU Prague)

Title: New detection techniques for spin-2 ultra-light dark matter.

Abstract: Ultra-light dark matter (ULDM) is a compelling and phenomenologically rich candidate for the cosmological dark matter. ULDM is typically considered to be a (pseudo)scalar or a vector field, but even more interesting and unique physics can be realised for spin-2 tensor fields. In this talk I will review three new ideas for how to detect spin-2 ultra-light dark matter: (a) two new methods, a bayesian method and a machine-learning method, to detect the dark-matter-induced osculations of the orbits of binary pulsars in pulsar-timing daya, (b) a new improved analysis method for LVK data and its application to spin-1 and spin-2 searches, (3) how a newly-proposed levitated superconductor detector responds to spin-2 ultra-light dark matter.

2025-11-13 Kenzaburo Kawaguchi

Title: 時間依存した宇宙の状態方程式による原始ブラックホール形成の促進

Abstract:
原始ブラックホール(PBH)は暗黒物質の有力な候補であると同時に、重力波イベントの起源としても注目されている。しかし、その存在量は観測的に強く制限されており、暗黒物質の候補として許される質量領域は限られている。PBHの形成には密度揺らぎが閾値を超える必要があるが、CMB観測から、揺らぎの振幅は強く制限されているため、小さなスケールで大きな揺らぎが必要となる。本発表では、揺らぎを大きくするのではなく、放射優勢期にスカラー場が一時的に優勢になることで閾値が低下し、それによりPBH形成が促進されるモデルについて説明する。

2025-11-06 Shinji Mukohyama

title:
Gravity and cosmology beyond general relativity

abstract:
General relativity, along with quantum theory, is the foundation of modern physics. However, it is highly likely that a theory of gravity that goes beyond general relativity will be needed to solve some of the difficult problems facing general relativity. In addition, gravity has never been directly measured at short distances of less than one micron or at long distances on the scale of cosmology, and modifying general relativity at such short or long distances is consistent with

observations and experiments. Therefore, there are growing expectations for a theory of gravity that goes beyond general relativity from both theoretical and observational/experimental perspectives. In addition, signs of gravity beyond general relativity might appear in strong gravity on astronomical scales, such as black holes. This talk is an introduction to gravity and cosmology beyond general relativity and will cover the following topics: general relativity and Lovelock's theorem; massive gravity; methods of effective field theory.

2025-10-30 Massimo Cappi (INAF)

RESCEU Colloquium [leaflet]
Title: Ultra Fast Outflows in AGNs: from X-rays to Very High Gamma-rays...to high-energy neutrinos and cosmic rays too?
Abstract: I will review the current status of high energy observations of Ultra Fast Outflows (UFOs) in AGNs. I will give particular emphasis on recent results obtained with the XRISM/Resolve X-ray microcalorimeter, and future prospects with the X-IFU microcalorimeter on-board NewAthena. These results will be discussed within a broader context, where recent observations with Pierre Auger, IceCube and Fermi observatories indicate UFOs as potential sources of photons at hundreds of GeV, of high-energy neutrinos, and how they could serve as source of ultra-high-energy cosmic rays (UHERCs).

2025-10-23 Fumihiro Naokawa

Title : Cosmic birefringence as a probe of dark sectors
Abstract : Cosmic birefringence, the rotation of polarization surfaces of photons during their propagation in the universe, has been recently reported from several works on analysis of the Cosmic Microwave Background (CMB) polarization (e.g. Minami & Komatsu 2020). This phenomenon is known to violate the parity symmetry of the universe. Therefore, the signal, if confirmed, strongly suggests something new beyond the standard frameworks of physics (Nakai et al. 2023). Especially, Axion-like particles (ALPs) attract attentions as possible origins of cosmic birefringence (e.g. Fujita et al. 2021). ALPs are also candidates of dark matter or dark energy. However, the current measurements of the cosmic birefringence with the CMB alone still have several challenges such as the difficulty of knowing the time evolution of the rotation, which is critical information to determine the origin, or the degeneracy between the real signal and systematical errors. In this seminar, I am going to introduce my works to solve theaw problems, mainly about “solving the degeneracy of multiple rotation cases” (Naokawa et al. 2024) and “establishing the method for independent tests” (Naokawa 2025).

2025-10-16 Ryoga Honjo

Title: Polarization of the aspherical shock breakout
Abstract:
The first light we can detect from a core-collapse supernova (CCSN) is called the shock breakout (SBO) emission. It occurs when the radiation

dominated shock wave, generated deep inside the star during the explosion, reaches the stellar surface and suddenly releases a burst of high-energy radiation. Several SBO candidates have been observed so far, including SN 2023ixf, one of the most recent examples.
Although many models assume a spherically symmetric explosion, SN 2023ixf showed a relatively high polarization degree, suggesting that the explosion was actually aspherical. Such asymmetry can significantly change the observed light curves and polarization signals.
In this study, we investigate how asphericity affects the bolometric light curve and polarization evolution during non-instantaneous SBOs, using a bipolar ejecta model. We focus on both plane-parallel and oblique SBO geometries to clarify the observational signatures of aspherical explosions.

2025-10-09 Seonjun Kwon

Title:
Develop and Deploy Sample Chain Based KAGRA Signal Presence Test

Abstract:
The KAGRA gravitational-wave (GW) detector in Japan currently has significantly lower sensitivity than existing detectors like LIGO and Virgo. Therefore, we propose a test method to determine the Optimal Signal-to-Noise Ratio (SNR) threshold at which KAGRA can reliably detect a signal. We hypothesize that the true parameters of any signal KAGRA might detect will lie within the parameter space derived from the LIGO-Virgo parameter estimation data. Using samples from this data space, we perform a Bayes Factor analysis to test for signal presence. Building upon this, the speaker's Master's research delves into a more specific comparison: analyzing results from both mock Gaussian noise and real detector noise. This comparison aims to test key assumptions for KAGRA's data analysis, namely whether the impact of glitches can be neglected or requires specific clean-up, and whether it is sufficient to use a Gaussian likelihood model. We detail the proposed testing methodology and present preliminary results for two specific GW events.

2025-10-02 Daiki Watarai

title:
Testing Gravity with Gravitational Waves

abstract:
Thanks to recent gravitational-wave (GW) observations, we have detected more than two hundred signals from binary black hole (BH) coalescences. These events provide an unprecedented opportunity to test general relativity (GR), the standard theory of gravity, as they encode rich information about the strong-field regime. Beyond the current ground-based detectors, space-based observatories such as LISA are planned for launch in the coming decade, with the potential to probe new physics through the collisions of supermassive BHs.

In this talk, I will begin with an overview of GW-based tests of gravity and their current status. I will then present my PhD research, which spans from data analysis to theoretical modeling, highlighting how these approaches can advance our understanding of gravity in the strong-field regime.

2025-07-31 Karim Noui (IJCLab, Orsay)

title:
Probing Black Hole Perturbations and Compact Objects in Alternative Theories of Gravity

abstract:
In this seminar, I will explore how black hole perturbations can be used as a powerful tool to study the late stages of binary systems and to probe the stability of novel compact objects predicted by alternative theories of gravity. Perturbative techniques are crucial to identify potential observational signatures of these exotic objects and to test the robustness of general relativity in strong-field regimes. I will begin with a pedagogical introduction to alternative theories of gravity, black hole physics, and their perturbations. The talk will conclude with a discussion of striking physical phenomena that emerge in these extended frameworks.

2025-07-24 Shingo Hirano (Kanagawa University)

Title: Ambient Dark Matter Around a Newborn First Star

Abst: Ambient dark matter (DM) around binary black holes can imprint characteristic signatures on gravitational waves emitted from their merger. The exact signature depends sensitively on the DM density profile around the black holes. We run high-resolution cosmological hydrodynamics simulations of the first star formation (arXiv:2505.17828). The halo undergoes a two-stage gravitational collapse, where a rotating, constant-density core is formed first, surrounded by an extended outer region. Baryonic infall toward the center continues to raise the local Keplerian velocity and promotes adiabatic contraction of DM. The resulting density profile has an approximately power-law shape. The DM density profile is typical for ordinary halos; however, our additional simulations reveal that the inner slope varies significantly with halo-to-halo scatter, as well as the effects of Lyman-Werner irradiation and supersonic baryon-DM streaming velocities, implying a wide distribution of slopes rather than a single universal curve. One has to consider the variation when calculating the predicted DM-induced dephasing of gravitational waves, which can be up to an order of magnitude relative to the classical analytic model of the DM spike.

2025-07-17 Akihiro Suzuki

title: Supernova-progenitor connection and pre-supernova evolution of massive stars

abstract:

One of the key goals in the study of core-collapse supernovae (CCSNe) is to establish the connection between massive stars and the diverse transient populations they produce.
Type IIP supernovae are among the most common CCSNe and are thought to originate from red supergiant (RSG) progenitors.
To date, progenitor identifications in pre-explosion images—including upper limits—have been made for about 20–30 Type IIP events.
These observations have revealed the so-called "RSG problem": a mismatch between the observed progenitor masses/luminosities of Type IIP SNe and the mass/luminosity distribution of RSGs in our Galaxy and nearby galaxies.
Specifically, RSGs with initial masses greater than ~16–17 solar masses appear to be underrepresented among observed Type IIP progenitors.

One possible explanation is that these massive stars initially evolve into the RSG phase but later transition to hotter, bluer states due to significant mass loss.
Among the mechanisms proposed to drive this mass loss, pulsation-induced mass loss may play a critical role.
In this presentation, I will introduce our recent work on the late-stage evolution and pulsational properties of RSGs with initial masses between 13 and 18 solar masses.
We find that more massive RSGs tend to exhibit stronger pulsations, which can lead to partial envelope ejection and alter their appearance shortly before core collapse.
This mechanism could offer a potential solution to the RSG problem.

2025-07-10 Yuta Shiraishi

Title: Search for dormant compact objects in close binaries by photometric and spectroscopic surveys

Abstract:
Binaries of a star and a compact object where mass accretion is not currently ongoing — so-called ‘dormant’ binaries — are important as they are the progenitors of various astrophysical phenomena such as type Ia supernova, gravitational wave sources and cataclysmic variables. Though dormant binaries are rarely discovered so far since they are X-ray quiet, recent progress in large scale stellar surveys made it feasible to search for them. We searched for dormant binaries by periodic flux variation in TESS light curves of the Gaia DR3 radial-velocity variables, and discovered two massive (1Msun) white dwarfs orbiting around sun-like stars in a-few-day orbit. Their future evolution is quite uncertain since they will experience poorly understood stable/unstable mass transfers, their possible final fate raging in classical novae, type Ia supernovae, accretion/merger-induced collapse and ultra-short period double degenerate binaries (AM CVn). Our method can discover ~100 similar systems, an order of magnitude more than are known at present, and their distribution of orbital elements and number densities will advance the understanding of their evolution.

2025-07-03 Reiko Harada

title: Estimation of the Hubble parameter from compact object catalogues without threshold

Gravitational waves from compact binary coalescences offer a promising avenue for inferring the Hubble parameter independently of electromagnetic distance ladders or cosmic microwave background observations. As an independent probe of cosmic expansion, it has the potential to contribute to ongoing efforts to resolve the Hubble tension. In particular, so-called dark sirens -- compact binary coalescences events without electromagnetic counterparts -- enable statistical inference using galaxy catalogs or population models. Recent studies using dark sirens have typically focused on high signal-to-noise ratio candidates, modelling the signal detection process as a step function in observed signal-to-noise ratio. While these methods have shown considerable utility, potential biases can still remain due to differences between the simulated analysis framework and real detection pipeline behavior.
In this work, we present a framework that estimates the Hubble parameter from a threshold-free catalogue of gravitational wave candidates. Our method makes direct use of detection-level information such as ranking statistic distributions and the probability of astrophysical origin, p(astro), allowing the detection process itself to be integrated into the cosmological inference. Furthermore, the approach avoids the need for individual parameter estimation for each candidate, significantly reducing computational cost and enabling the inclusion of a large number of sub-threshold candidates.

2025-06-26 Yohei Nishino (NAOJ)

Title: Entanglement-based technologies for gravitational-wave detectors

Abstract: Quantum entanglement is no longer merely a phenomenon of quantum mechanics, but is harnessed in engineering applications. In recent years, research has begun to actively explore how quantum entanglement can be applied to large-scale optical experimental systems such as gravitational-wave detectors. These efforts are based on the use of entanglement swapping. In this talk, I will provide an overview of past applications of quantum entanglement, explain the underlying principles, and discuss future prospects.

2025-06-19 Anson Chen (International Center for Theoretical Physics, University of Chinese Academy of Sciences)

Title: Gravitational Wave Probes of Cosmology and Gravity

Abstract: As one of the main components of the standard cosmology model, the nature of dark energy is still not fully understood nowadays. One of the most popular explanations of dark energy is the theories of modified gravity, for example the scalar-tensor theories of gravity. On the other hand, the violation of the isotropy principle of cosmology would result in an intrinsic cosmic dipole, which could mimic dark energy in observations. However, these dark energy theories require further tests from more observational data. Fortunately, the success in gravitational wave (GW) detections opens a new window to examine these theories. In this talk, I will present the constraints on modified gravity through GW propagation effects using the dark siren method with LIGO-Virgo-KAGRA (LVK) data. I will also forecast future constraints on modified gravity theories that predict a GW speed transition using LISA and LVK. Moreover, I will forecast the measurements of the cosmic dipole using golden dark sirens with third-generation ground-based detectors. All of these methods provide a promising picture to obtain stronger constraints on theories of cosmology and gravity with GW data in the future.

2025-06-12 Takatoshi Ko

title:
Revealing the Unique Multi-Structural Features of a Historical Type Iax Supernova Remnant with a White Dwarf Through Multi-Wavelength Observations

abst:
The historical supernova SN 1181 remained unidentified for decades. In 2021, a strong candidate for its remnant was finally discovered, revealing several unique properties not seen in other supernova remnants (SNRs). Most notably, the SNR contains a white dward (WD) and the central WD is currently emitting a fast stellar wind at 15,000 km/s. This high-velocity wind is likely colliding with the ejecta of SN 1181, forming a termination shock. Consequently, the remnant exhibits a multi-layered X-ray structure: thermal X-ray emission is observed from both the shocked SNR and an inner emission region, as revealed by XMM-Newton.

We analyzed Chandra X-ray data of this central emission and developed a theoretical model that reproduces the observed X-ray structure. Our analysis suggests that the fast wind from the WD began relatively recently, around 1990. To investigate this delayed wind onset, we performed WD evolution calculations using the stellar evolution code MESA, demonstrating that a delay of approximately 1,000 years is feasible. Furthermore, our calculations constrain the properties of the central WD, allowing us to constrain the progenitor system of SN 1181, which remains poorly understood.

Additionally, we have conducted VLA observations targeting the termination shock region, which are expected to provide further constraints on the interaction between the fast wind and the surrounding medium. In this presentation, we will discuss our Chandra/VLA data analysis, theoretical modeling, and the potential implications of our findings for understanding SN 1181 and its central WD.

2025-06-05 [canceled]

Intensive lecture by Kotaro Kyutoku (at Komaba)

2025-05-29 [canceled]

Intensive lecture by Dan Kasen

2025-05-22 [canceled]

Intensive lecture by Jim Fuller

2025-05-15 Toshikazu Shigeyama

Title: Model-Observation inconsistency in the late evolution of massive stars

Abstract:
I will introduce observations of massive stars suddenly becoming brighter before the supernova explosions and what current models of massive stars predicted at this stage.

Then I will discuss the possibility that the so-called shell burning is responsible for the observed brightening and why the current models do not show the observed features.

2025-05-08 Levi Berg

Title: Kilonovae and Ionization Rates

Abstract: Humans have always wondered where they come from, and to explain this we need the origin of elements. A particular proposed source of heavy elements found in nature are collisions of neutron stars, where heavy elements are synthesized in the so-called r-process. In this talk, we will go over the basic concepts encountered in modeling kilonovae and then move on to ionization rates for the thermalization of alpha particles and fission fragments, which has major implications on the kilonova spectrum.

2025-05-01 Takuya Takahashi

Title: Probing axions through gravitational waves from binary black hole mergers

Abstract:
Ultralight bosons, such as axions, are among the most well-motivated candidates for physics beyond the Standard Model. Around rotating black holes (BHs), superradiance can trigger the spontaneous formation of the cloud of axions. When a BH with a cloud belongs to a binary system, energy transfer from the cloud can modify the orbital evolution and resulting gravitational wave emissions. In this talk, we present the latest results on the evolution of such systems and their observational signatures, taking into account the effects of axion self-interactions. We will also briefly outline our future research directions.

2025-04-21 [canceled]

2025-04-17 Nanae Domoto

Speaker: Nanae Domoto

Title: Signatures of heavy elements in optical and near-infrared spectra of neutron star mergers

Abstract:
Binary neutron star (NS) merger is a promising site for the rapid neutron capture nucleosynthesis (r-process). The radioactive decay of synthesized elements powers electromagnetic emission called a kilonova. The detection of gravitational waves from an NS merger GW170817 and the observations of the associated kilonova AT2017gfo have provided us with evidence that r-process occurs in the NS merger. However, the abundance pattern synthesized in this event, which is important to reveal the origin of the r-process elements, is not yet fully understood. In the talk, I will present our recent results for identification of elements in the kilonva spectra a few days after the merger. We found that only several elements are important for absorption features, and Sr, La, and Ce can explain

the observed features in the spectra. We also confirmed our results of identification by utilizing stellar spectra. The direct identification of elements allows us to constrain amounts of synthesized elements.

Other seminars

2026-04-02 Peony Lai (The Chinese University of HongKong)

(move to 2026-27 seminar list)
title: tbd
abstract: tbd

2026-02-18 14:00 Daniel Pauli (KU Lueven)

Title: Unraveling massive star and binary physics in the nearby low-metallicity galaxy, the Small Magellanic Cloud, as a proxy for high-redshift galaxies

Abstract: Typically, massive stars are formed in binary systems, where they can interact with their companions, which significantly alters their evolution as well as their feedback. However, binary evolution, particularly at low metallicity, remains poorly understood. In this talk, I will present the recent discoveries of post-interaction binaries in the low-metallicity Small Magellanic Cloud galaxy. I will illustrate how the detailed multi-epoch and multi-wavelength spectral analysis, impacts our understanding of binary evolution and stellar winds. Finally, I will discuss the implications for our interpretation of the rest-frame UV spectra of high-redshift galaxies.

2026-02-12 13:00 Neha Parma (International Centre for Theoretical Sciences, Bengaluru)

Title: Rapid inference of gravitational-wave signals in the time domain using a heterodyned likelihood

Abstract: Parameter estimation of gravitational wave signals is computationally intensive and typically requires millions of likelihood evaluations to construct posterior probability distributions. This computational cost increases significantly in the time domain, which requires non-diagonal covariance matrices to compute the likelihood. Consequently, parameter estimation of long-duration gravitational wave signals, such as binary neutron star mergers, becomes computationally infeasible in time domain. In this work, we detail a framework for the heterodyned likelihood that enables rapid inference in the time domain. Our method is applicable to signals with arbitrary mode content, and leverages the smoothness of the ratio of complex-valued waveform modes, approximating the ratio as a linear function within appropriately chosen time bins. This allows downsampling of the waveform modes and a reformulation of the likelihood, such that it depends only on the bin edges. We demonstrate that this likelihood recovers posteriors that are indistinguishable from those obtained using the standard likelihood in the time domain. We also observe dramatic improvement in speed—for a 128 seconds-long gravitational wave signal, our method is at least ~400 times faster than the standard time-domain analysis, reducing the wall-clock time to just a few hours. We also demonstrate the reliability and unbiasedness of the likelihood using percentile-percentile tests for binary black hole and binary neutron star injections. We use the Gohberg–Semencul representation of the inverse of Toeplitz covariance matrix to accelerate matrix–vector products, which has potential applications even in non-heterodyned time-domain inference.

2026-01-27 Cailin Plunkett (MIT)

Title:
Black Hole Populations with Gravitational Waves: Then, Now, and the Future

Abstract:
The Fourth Gravitational-Wave Transient Catalog by the LIGO–Virgo–KAGRA collaboration now contains over 150 binary black hole (BBH) candidates. This growing dataset allows us to probe increasingly fine details of the BBH population, including the still-open question of formation channels. We present recent evidence for hierarchical mergers: black holes that have merged repeatedly in dense stellar environments. This represents the strongest observational evidence to date for any specific formation channel. These mergers offer a plausible mechanism to populate the predicted mass gap due to pair-instability in massive stars, and can sharpen bounds on nuclear physics processes.

Looking ahead, next-generation gravitational-wave observatories like the Einstein Telescope and Cosmic Explorer will reach deeper into the universe, unveiling previously hidden stellar populations. Population III stars—formed in the low-metallicity early universe and never observationally confirmed—are one key target. We discuss a method to infer the initial properties of Pop III stars directly from the collection of gravitational-wave sources, calibrated to astrophysical and cosmological simulations. We highlight the broad scientific importance of next-generation observatories, including how they can reveal the details of high-redshift stellar progenitors.

2025-06-20 Shang-Jie Jin

Date and venue: 2025 June 20, 15:00, at 1723, 7th floor of Sci Bldg No. 4

Title: Standard siren cosmology in the era of the next-generation gravitational wave detectors

Speaker: Shang-Jie Jin (University of Western Australia)

Abstract: Gravitational-wave (GW) standard siren observations have opened a new window for cosmological studies. By analyzing the GW waveform, one can directly determine the absolute luminosity distance to the source—an approach known as the "standard siren" method. When combined with redshift measurements, this allows for the establishment of the luminosity distance–redshift relation, offering a powerful probe of the universe's expansion history. In this talk, I will present our recent work on cosmological parameter estimation using standard siren observations from next-generation GW detectors. In particular, I will highlight the potential of this method to constrain the Hubble constant and the dark energy equation-of-state parameter.

2025-04-22 Harry Ng Ho Yin

Title: Accurate muonic interactions in neutron-star mergers and impact on heavy-element nucleosynthesis
Speaker: Harry Ng Ho Yin (current PhD student, Institute for Theoretical Physics, Goethe University Frankfurt)
Date and time: Tuesday, April 22, starting at 13:00 and expected to last for about an hour
Venue: the RESCEU seminar room on the ground floor of Sci Blg 4
Abstract:
The abundances resulting from r-process nucleosynthesis as predicted by simulations of binary neutron-star (BNS) mergers remain an open question as the current state-of-the-art is still restricted to three-species neutrino transport. We present the first BNS merger simulations employing a moment-based general-relativistic neutrino transport with five neutrino species, thus including (anti)muons and advanced muonic β-processes, and contrast them with traditional three neutrino-species simulations. Our results show that a muonic trapped-neutrino equilibrium is established, forming a different trapped-neutrino hierarchy akin to the electronic equilibrium. The formation of (anti)muons and the muonization via muonic β-processes enhance the neutrino luminosity, leading to rapid cooling in the early post-merger phase. Since muonic processes redirect part of the energy otherwise used for protonization by electronic processes, they yield a cooler remnant and disk, together with neutrinodriven winds that are more neutron-rich. Importantly, the unbound ejected mass is smaller than three-species simulations and, because of its comparatively smaller temperature and proton fraction, it can enhance lanthanide production and reduce the overproduction of light r-process elements for softer equations of state. This finding underlines the importance of muonic interactions and five neutrino species in long-lived BNS remnants.

RESCEU Colloquium is summarized here.