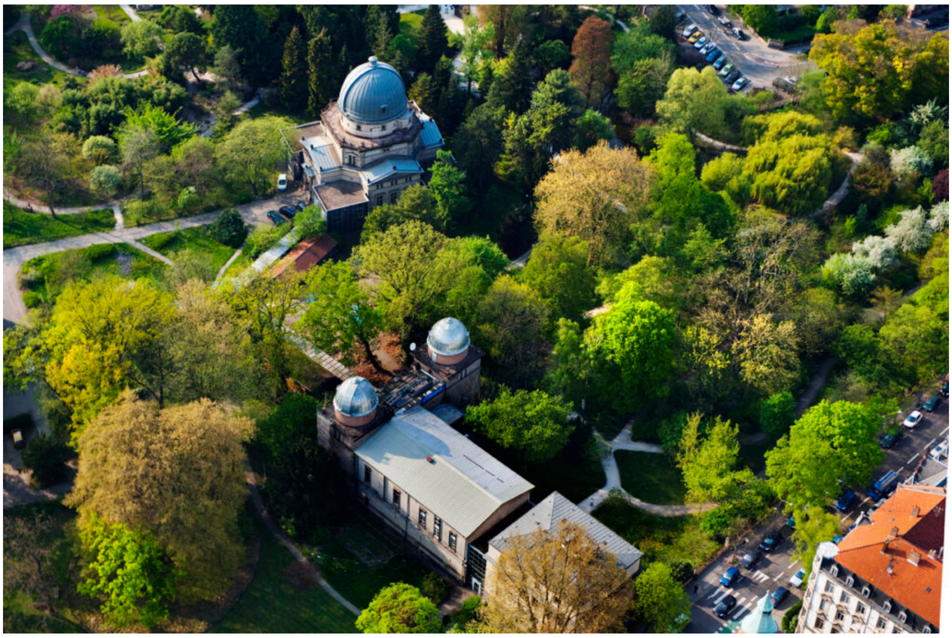
CoCoNuT meeting 2025



Report of Contributions

Contribution ID: **1** Type: **Talk**

Probing equation of state from supernova gravitational waves

Tuesday 28 October 2025 16:15 (25 minutes)

Core-collapse supernovae are sources of strong gravitational waves (GWs). We explore whether GW signals from rapidly rotating supernovae can be used to infer the equation of state (EOS) of high density matter. Focusing on the bounce and early post-bounce phases, we generate a large set of waveforms using general-relativistic hydrodynamics simulations with different EOS models. These are used to train machine learning algorithms to classify the EOS from the GW signal. We assess classification accuracy under various conditions, including detector noise.

Presenter: ABDIKAMALOV, Ernazar

Contribution ID: **3** Type: **Talk**

Machine Learning applications to gravitational wave data analysis

Wednesday 29 October 2025 09:00 (1 hour)

Presenter: BEJGER, Michał

Contribution ID: **4** Type: **Talk**

Modeling Neutron Star under Extreme Conditions Using the LOCV Approach

Monday 27 October 2025 17:30 (25 minutes)

In this work, we briefly discuss the equation of state (EOS) for the different layers of a neutron star, from the inner core to the crust, employing the Lowest Order Constrained Variational (LOCV) approach. To this end, we investigate the EOS of quark clusters, kaon-condensed matter, and nuclear matter, as well as the equilibrium composition and energy of the Wigner-Seitz cell in the crust. We also study the influence of strong external magnetic fields on the EOS of nuclear matter. Finally, the excluded volume effect for nucleons is taken into account.

Presenter: BIGDELI, Mohsen

Contribution ID: **6** Type: **Talk**

Unravelling the interior of Neutron Stars with Gravitational Waves

Monday 27 October 2025 09:00 (1 hour)

One of the most exciting scientific discoveries in recent times has been the detection of Gravitational Waves from massive compact objects such as Neutron Stars, opening a new window to astronomy beyond multiwavelength telescopes. The ultra-high densities in the interior of Neutron Stars surpass those of terrestrial nuclear and heavy-ion laboratories and provide an ideal environment to study fundamental Physics under extreme conditions. It is conjectured that strangeness containing matter such as hyperons or deconfined quarks, or even dark matter could exist in the core of neutron stars. Their presence in the stellar interior could affect observable properties of neutron stars, and their understanding is crucial for the correct interpretation of multi-messenger data. In this talk, I will highlight some of our recent works that demonstrate how gravitational waves can be used as a unique tool to probe the neutron star interior and provide insights into the behaviour of dense matter.

Presenter: CHATTERJEE, Debarati

Contribution ID: **7** Type: **Talk**

ComPyTools: A new package for CompOSE equation-of-state tables

Monday 27 October 2025 11:20 (25 minutes)

We introduce a Python package called ComPyTools, currently under development, that allows the user to work with CompOSE equation-of-state tables. ComPyTools uses an object-oriented approach to provide a user-friendly interface to not only read in tables for analysis workflows, but also to create them in the CompOSE format. Additionally, we have implemented an interface that allows the user to run the CompOSE software to create interpolated tables for cold and general-purpose equations of state. We conclude with future development plans.

Presenter: DAVIS, Philip

Contribution ID: **8** Type: **Talk**

Black Hole Supernova Outcomes Across a Progenitor Range of 19–75 Solar Masses in 2D and 3D

Monday 27 October 2025 11:45 (25 minutes)

Recent advancements in core-collapse supernova modeling are revealing a new black hole (BH) formation channel in which a BH forms within about a second of shock revival yet still results in a successful supernova. The limited body of literature on these black hole supernovae (BHSNe) has mostly focused on highly massive, compact progenitors. I will present a sample of ~40 stars between 19 and 75 solar masses, evolved in two dimensions from core-collapse to hours after BH formation. We find a remarkably wide occurrence of BHSN outcomes and characterize the properties of their explosions and BH remnants. We demonstrate the impact of uncertainty in the nuclear equation of state on these properties as well as on the composition of the ejecta that escape the BH. Building on these 2D results, I will present a 3D BHSN simulation of a 39 solar mass progenitor.

Presenter: EGGENBERGER ANDERSEN, Oliver

Contribution ID: **9** Type: **Talk**

Classification of proto-neutron star oscillation modes

Wednesday 29 October 2025 12:10 (25 minutes)

The gravitational radiation from core-collapse supernovae (CCSNe) is dominated by the oscillation modes of the proto-neutron star associated and the stalled accretion shock, and can be detectable in the case of galactic distances. These modes have been computed by several methods [1, 2, 3]. In this talk, we present the first steps of a potential alternative method to classify the different eigenmodes, based on linear similarity among the different modes, as well as other techniques, starting from some simplified cases and taking into account more realistic CCSNe scenarios. This work aims at providing information for asteroseismology of CCSNe from gravitational-wave future observations data. [1] MNRAS 474, 5272–5286 (2018). [2] MNRAS 482, 3967–3988 (2019). [3] arXiv:2504.12183 (2025).

Presenter: FERNÁNDEZ RODRÍGUEZ, Guillem

Contribution ID: **10** Type: **Talk**

Nonradial oscillations of stratified neutron stars with solid crusts: Mode characterization and tidal resonances in coalescing binaries

Wednesday 29 October 2025 10:55 (25 minutes)

Dynamical tides of neutron stars in the late stages of binary inspirals provide a viable probe into dense matter through gravitational waves, and potentially trigger electromagnetic precursors. We model the tidal response as a set of driven harmonic oscillators, where the natural frequencies are given by the quasinormal modes of a nonrotating neutron star. These modes are calculated in general relativity by applying linear perturbation theory to stellar models that include a solid crust and compositional stratification. For the mode spectrum, we find that the canonical interface mode associated with crust-core boundary vanishes in stratified neutron stars and is replaced by compositional gravity modes with mixed gravity–interfacial character, driven primarily by strong buoyancy in the outer core. We also find that fluid modes such as the core gravity mode and the fundamental mode can penetrate the crust, and we establish a criterion for such penetration. Regarding the tidal interaction, we find that transfer of binding energy to oscillations is dominated by the fundamental mode despite its frequency being too high to resonate with the tidal forcing. In general, we find that lower-frequency modes induce gravitational-wave phase shifts smaller than $\sim 10^{-3}\,\mathrm{rad}$ for the equation of state we consider. We discover that nonresonant fundamental and crustal shear modes can trigger crust failure already near the first gravity-mode resonance, while gravity-mode resonance concentrates strain at the base of the crust and may marginally crack it. These results suggest that both resonant and nonresonant excitations can overstress the crust and may channel energy into the magnetosphere prior to merger, potentially powering electromagnetic precursors. Our work represents an important step toward realistic modeling of dynamical tides of neutron stars in multimessenger observations.

Presenter: GAO, Yong

Contribution ID: **11** Type: **Talk**

The mode-sum approach to dynamical neutron-star tides: The impact of dissipation

Monday 27 October 2025 14:55 (25 minutes)

Next-generation gravitational-wave detectors are expected to constrain the unknown neutron star equation-of-state from static and dynamical tides in binary inspirals. The impact of dissipation on the tides is generally considered negligible, but recent work suggests that the bulk viscosity of exotic phases (e.g. hyperons and deconfined quark matter) can be significant enough to be detectable using the future instruments. As a step towards developing realistic waveform models, we incorporate dissipation from both gravitational radiation reaction and fluid viscosity in the tidal response of a neutron star expressed as a sum of contributions associated with the star's free oscillation modes. We compute the effective Love number incorporating dissipation along with the expected 'tidal lag'between the induced quadrupole and the external tidal field. We also determine the expected energy loss to heat from fluid dissipation and quantify its impact on the orbital evolution. Finally, based on scaling relations of fluid viscosity with orbital frequency we discuss whether fluid dissipation can dominate over gravitational radiation reaction and thus have detectable impact on the gravitational waveform.

Presenter: GHOSH, Suprovo

Contribution ID: **12** Type: **Talk**

Gravitational-Wave Asteroseismology: Illuminating Dense Nuclear Matter through Dynamical Tides

Tuesday 28 October 2025 09:00 (1 hour)

Presenter: GITTINS, Fabian

Contribution ID: **13** Type: **Talk**

Bulk Viscosity of Two-Flavor Color Superconducting Quark Matter in Neutron Star Mergers

Wednesday 29 October 2025 11:45 (25 minutes)

This work investigates the bulk viscosity of warm, dense, neutrino-transparent, color-superconducting quark matter, where damping of density oscillations in the kHz frequency range arises from weak-interaction-driven direct Urca processes involving quarks. We study the two-flavor red-green paired color-superconducting (2SC) phase, while allowing for the presence of unpaired strange quarks and blue color light quarks of all flavors. Our calculations are based on the SU(3) Nambu-Jona-Lasinio (NJL) model, extended to include both vector interactions and the 't Hooft determinant term. The primary focus is on how variations in the NJL Lagrangian parameters - specifically, the diquark and vector coupling strengths - affect both the static properties of quark matter, such as its equation of state and composition, and its dynamical behavior, including bulk viscosity and associated damping timescales. We find that the bulk viscosity and corresponding damping timescale can change by more than an order of magnitude upon varying the vector coupling by a factor of two at high densities and by a lesser degree at lower densities. This sensitivity primarily arises from the susceptibility of 2SC matter, with a smaller contribution from modifications to the weak interaction rates. In comparison, changes in the diquark coupling have a more limited impact. The damping of density oscillations in 2SC matter is similar quantitatively to nucleonic matter and can be a leading mechanism of dissipation in merging hybrid stars containing color superconducting cores.

Presenter: HARUTYUNYAN, Arus

Contribution ID: **14** Type: **Talk**

Binary Neutron Star Merger Simulations with Microphysical Equation of State using Spritz

Wednesday 29 October 2025 15:20 (25 minutes)

We present new simulations performed with Spritz, a general-relativistic magnetohydrodynamics (GRMHD) code designed for high-precision studies of binary neutron star (BNS) mergers with realistic nuclear equations of state (EOS). We evolve both magnetized and non-magnetized equal-mass binaries, employing two tabulated EOS modeled after the GW170817 event. Our analysis focuses on the gravitational-wave (GW) signals emitted during the inspiral and merger, as well as the post-merger in the case of a long-lived remnant. In addition, we explore the possible formation of relativistic jets and massive neutron-rich outflows. These results contribute to bridging GW observations with electromagnetic counterparts, and provide insight into the role of the EOS and magnetic fields in shaping multimessenger signatures of BNS mergers.

Presenter: HOSSEIN NOURI, Fatemeh

Contribution ID: **15** Type: **Talk**

Impact of the Si/O interface on supernova explosion

Tuesday 28 October 2025 15:20 (25 minutes)

Predicting whether a core-collapse supernova (CCSN) will successfully explode remains a central challenge in astrophysics. While many physical parameters influence the explosion outcome, recent studies have highlighted the structure of the silicon-oxygen (Si/O) interface as a potentially decisive factor in shock revival. In this work, I investigate the role of the Si/O interface by systematically modifying a set of progenitor models to produce a broad range of density gradients at the interface, while keeping all other physical properties fixed. This controlled approach allows us to isolate and better understand the influence of the interface's steepness and structure on the explosion dynamics. By analyzing the outcomes of these modified progenitors in numerical simulations, we aim to determine whether the Si/O interface is indeed a critical ingredient in triggering successful CCSN explosions.

Presenter: HOURY, Nicolas

Contribution ID: **16** Type: **Talk**

Numerical simulations of oscillations in differentially rotating neutron stars

Tuesday 28 October 2025 10:30 (25 minutes)

The accurate modelling of neutron star oscillations is essential as we prepare for the next generation of gravitational-wave detectors, which will be able to probe the rich astrophysical content of post-merger signals. In this talk, I will present recent results obtained with ROXAS, a spectral code that numerically simulates the dynamical evolution of perturbed rotating neutron stars, extracting their emitted gravitational waves. In particular, I will show how the introduction of differential rotation alters the frequencies of axisymmetric and non-axisymmetric modes, comparing them with the values reported in the literature where available, and highlighting the new results.

Presenter: JARABA, Santiago

Contribution ID: **17** Type: **Talk**

Quasinormal g-modes of twin neutron stars

Tuesday 28 October 2025 17:05 (25 minutes)

We investigate the non-radial gravity-pulsation discontinuity mode (g-mode) in neutron stars with a strong 1st-order phase transition, dubbed twin stars. For this, we consider the standard four categories and employ the constant-speed-of-sound parametrization which accounts for the QCD transition. We find that depending on the category, the relations between g-mode frequencies and gravitational masses as well as tidal deformabilities display a highly distinct behavior across the twin star categories that appear within the slow hadron-quark conversion regime. This distinct phenomenology provides smoking-gun evidence to clearly distinguish and further classify twin stars using upcoming gravitational-wave data. Finally, we derive two types of unifying oscillatory relations: a) g-mode frequencies versus the normalized energy density jump for each category and b) a novel universal one encompassing the four categories.

Presenter: JIMÉNEZ APAZA, José Carlos

Contribution ID: **18** Type: **Talk**

3D numerical study of magnetorotational effects on extreme core-collapse supernovae

Wednesday 29 October 2025 11:20 (25 minutes)

Core-collapse supernovae are among the most energetic explosions in the universe. Their evolution is shaped by the hydrodynamics, neutrino transport, and magnetic fields at work in the first seconds after the collapse. We investigate these processes through 3D simulations of an extremely compact 39-Msun progenitor using the FLASH M1 magnetohydrodynamics code. Our study explores three models –a nonmagnetized nonrotating baseline model, a nonmagnetized rotating model, and a magnetized rotating model –to highlight the roles of rotation and magnetic fields in shaping the explosion mechanism and multi-messenger signals. We evolve each model from core collapse through bounce and into the early post-bounce phase (~0.7s post-bounce). We employ a three-species, energy-dependent M1 moment scheme for neutrino transport, incorporating a state-of-the-art nuclear equation of state and advanced treatments of deleptonization and neutrino heating/cooling. All three simulations undergo similar gravitational collapse and bounces. During the post-bounce phase, rotation and magnetic fields significantly impact the shock dynamics, explosion morphology, protoneutron star development, and angular variations in neutrino distributions. We will present these findings, highlighting how rotation and magnetization influence neutrino and GW signatures. We will discuss potential observational signatures that could help distinguish magnetorotationally influenced explosions from more spherical cases. Future work will refine our treatment of neutrino microphysics and magnetic fields while extending simulations to longer time scales and a broader range of progenitor conditions.

Presenter: KOVALENKO, Liubov

Contribution ID: **20** Type: **Talk**

Dynamical simulations of quark stars in general relativity

Wednesday 29 October 2025 14:30 (25 minutes)

Numerical simulation of strange quark stars is challenging due to the strong density discontinuity at the stellar surface. In this talk, we shall present our successful simulations of rapidly rotating quark stars and study their oscillation modes in full general relativity.

Presenter: LIN, Lap-Ming

Contribution ID: **21** Type: **Talk**

An effective model for magnetic field amplification by the magnetorotational and parasitic instabilities

Monday 27 October 2025 15:20 (25 minutes)

The magnetorotational instability (MRI) is considered a leading mechanism for driving angular momentum transport in differentially rotating astrophysical flows, including accretion disks and protoneutron stars. This process is mediated by the exponential amplification of the magnetic field whose final amplitude is envisioned to be limited by secondary (parasitic) instabilities. By relaxing previous approximations, we carried out the first systematic analysis of the evolution of parasitic modes as they feed off the exponentially growing MRI while being advected by the background shear flow. In this talk, I will provide the most accurate calculation of the amplification factor to which the MRI can grow before the fastest parasitic modes reach a comparable amplitude. Based on these insights, and guided by numerical simulations, I will also present a simple analytical expression for the amplification of magnetic fields responsible for MRI-driven angular momentum transport.

Presenter: MIRAVET-TENÉS, Miquel

Contribution ID: **22** Type: **Talk**

Causal representation of the equation of state for neutron star applications

Tuesday 28 October 2025 14:30 (25 minutes)

Meta-modeling frameworks have emerged as tools for exploring the nuclear equation of state (EoS) in a flexible way. However, current implementations often violate causality at supranuclear densities, resulting in a significant fraction of otherwise viable models being discarded for failing to support the observed maximum neutron star mass with a subluminal sound speed. I will present a refined meta-model that enforces causality by construction for a large fraction of the parameter choices, ensuring a subluminal speed of sound across all densities while maintaining flexibility and consistency with low-density nuclear physics. The robustness of the model is demonstrated by accurately reconstructing known EoSs from the COMPOSE database and by evaluating NS oscillation mode frequencies with possible deviations from beta equilibrium. With analytical expressions for thermodynamic quantities, the model may also benefit for hydrodynamic simulations, avoiding reliance on tabulated EoS with composition.

Presenter: MONTEFUSCO, Gabriele

Contribution ID: **23** Type: **Talk**

Neutron stars collapsing to black holes in massive scalar tensor theories

In this talk we discuss a fully 3D numerical evolution code to study neutron stars within the framework of massive-scalar-tensor (MST) theories. Our focus is to study the gravitational collapse of rapidly rotating neutron stars by exploring the parameter space defined by the scalar field couplings and the mass. We investigate how these parameters influence both the dynamical characteristics of the process and the emitted gravitational waveform. We also examine different criteria for stability and how the massive field influences the oscillation modes of the neutron stars.

Presenter: OLVERA MENESES, José Carlos

Contribution ID: **24** Type: **not specified**

General relativistic M1 scheme in CoCoNuT

Tuesday 28 October 2025 14:55 (25 minutes)

The M1 scheme aimed at neutrino treatment in core collapse supernovae codes has numerous advantages. It is a good tradeoff between computational cost and accuracy. The M1 equations are hyperbolic, making it perfectly suitable for GR, and a part of the equations can be treated explicitely. I will show an implementation of the M1 in the CoCoNuT code, along with possibilities of future works in CoCoNuT.

Presenter: PERES, Bruno

Contribution ID: **25** Type: **Talk**

Oscillation Modes in Binary Neutron Star Systems: Implications for Nuclear Physics and tidal corrections

Tuesday 28 October 2025 12:10 (25 minutes)

Gravitational waves (GWs) from binary neutron star (BNS) mergers offer crucial insights into the Neutron Star (NS) interiors and nuclear physics. The inference of NS properties hinges on the GW waveform, and achieving an accurate description of BNS GWs is a key focus of current research. The leading tidal contribution arises from the f-mode oscillation of the NS, for which the mode frequency is typically much higher than the orbital frequency, and thus adiabatic tidal corrections are considered. However, recent studies indicate that dynamic f-mode corrections during the late inspiral phase can significantly influence the inferred NS properties. In our work, we examine the bias in nuclear physics due to the ignorance of dynamical f-mode tides in GW waveform models, using data from GW170817 and an ensemble of future detectable BNS events. We discuss precision measurements of the NS equation of state (EOS) and nuclear parameters, utilizing data from BNS events detectable by the upgraded LIGO-VIRGO detectors and next-generation detectors. Furthermore, we explore the viscous dissipation of the f-mode in binaries and the tidal heating involving strange matter in the NS interior. This heating in the presence of the strange matter could raise the temperature of the star higher than that of purely nucleonic NSs, potentially making it observable by future GW detectors. We also investigate the impact of compositional g-modes on the BNS signal.

Presenter: PRADHAN, Bikram Keshari

Contribution ID: **26** Type: **Talk**

Thermal response of ab initio constrained extended Skyrme equations of state

Monday 27 October 2025 10:30 (25 minutes)

Numerical simulations of core-collapse supernovae, mergers of binary neutron stars and formation of stellar black holes, which employed standard Skyrme interactions, established clear correlations between the evolution of these processes, characteristics of the hot compact objects as well as neutrino and gravitational wave signals and the value of effective nucleon mass at the saturation density. Unfortunately, the density dependence of the effective mass of nucleons in these models does not align with the predictions of ab initio models with three body forces. In this talk, I shall discuss the thermal response for a set of extended Skyrme interactions that feature widely different density dependencies of the effective mass of the nucleons. Thermal contributions to the energy density and pressure are studied along with a few thermal coefficients over wide domains of density, temperature and isospin asymmetry, relevant for the physics of hot compact objects. For some of the effective interactions, the thermal pressure is negative at high densities. In a failed core-collapse supernova simulation, these models will favor an early collapse into a stellar black hole, while in a simulation of binary neutron star merger, the remnant appears to live long.

Presenter: RADUTA, Adriana R

Contribution ID: **27** Type: **Talk**

Tidal resonances of non-linear gravito-inertial modes in binary neutron stars

Tuesday 28 October 2025 11:45 (25 minutes)

For some short gamma-ray bursts, a non-thermal precursor flare can be observed a few seconds before mergers. The luminosity and energy of these precursors can be explained by a surface magnetic dipole of 10^13 G and the release of magnetoelastic energy when the crust breaks. A recently-proposed scenario to explain this magnetic field is that during the last seconds of a binary neutron-star merger, the tidal force can excite gravity (and inertial) modes to large amplitudes. However, existing estimates for their impact employ linear schemes which may be inaccurate for large amplitudes, as achieved by tidal resonances. In this talk, I will present the first non-linear simulations of excited gravito-inertial modes by the tidal force in a simplified rotating model. These simulations show that the axisymmetric differential rotation induced by nonlinear 2g and 1g modes may theoretically be large enough to amplify a magnetic field to ~ 10^14 G. We also find that, even without initial rotation, the neutron star would be spin-up, extending the resonance window, which might lead to higher mode amplitudes than linear predictions. Overall, these results support that resonant g-modes are able to amplify the magnetic field of a premerger neutron star, and it further suggests that g-mode resonances might have a stronger impact on gravitational-wave signals than previously estimated.

Presenter: REBOUL-SALZE, Alexis

Contribution ID: **28** Type: **Talk**

The thermal index of neutron-star matter in the virial approximation

Tuesday 28 October 2025 16:40 (25 minutes)

We study the thermal index of low-density, high-temperature dense matter, using the virial expansion to account for nuclear interaction effects (G.R. et al 2025 ApJ 987 67). We focus on the region of validity of the expansion, which reaches 10^{-3} fm^{-3} at $T = 5$ MeV up to almost saturation density at $T = 50$ MeV.
In pure neutron matter, we find an analytical expression for the thermal index, and show that it is nearly density- and temperature-independent, within a fraction of a percent of the non-interacting, non-relativistic value of $\Gamma_{\text{th}} \approx 5/3$.
When we incorporate protons, electrons and photons, we find that the density and temperature dependence of the thermal index changes significantly.
We predict a smooth transition between an electron-dominated regime with $\Gamma_{\text{th}} \approx 4/3$ at low densities to a neutron-dominated region with $\Gamma_{\text{th}} \approx 5/3$ at high densities. This behavior is by and large independent of proton fraction and is not affected by nuclear interactions in the region where the virial expansion converges. We model this smooth transition analytically and provide a simple but accurate parametrization of the inflection point between these regimes. When compared to tabulated realistic models of the thermal index, we find an agreement that is of the order of 2% at high temperatures but remains commensurate, at the 5-10% level, for colder matter. The discrepancies can be attributed to the missing contributions of nuclear clusters. The virial approximation provides a clear and physically intuitive framework for understanding the thermal properties of dense matter, offering a computationally efficient solution that makes it particularly well-suited for the regimes relevant to neutron star binary remnants.

Presenter: RIVIECCIO, Giuseppe

Contribution ID: **29** Type: **Talk**

Influence of rotation on magnetic field stability and orientation in isolated neutron star

Neutron stars are the most compact horizonless objects in the Universe, exhibiting the strongest known magnetic fields. They are potential sources of coincident gravitational waves and electromagnetic radiation across the entire spectrum. However, the internal configuration of their magnetic fields and the mechanisms that stabilize them remain open questions. As a stepforward understanding the timescale for the emergence of magnetic instabilities that disrupt the stellar field configuration, we study the impact of stellar rotation using three-dimensional general relativistic numerical simulations of uniformly rotating neutron stars threaded by strong, poloidal, pulsar-like magnetic fields. The initial stellar configurations assume perfect conductivity and are stationary and axisymmetric. We explore a range of angular velocities, from non-rotating stars to those near the mass-shedding limit. We find that non-rotating neutron stars are unstable to the Tayler and Parker instabili- ties, which significantly change the magnetic field geometry. These instabilities lead to a rapid reduction of the initial magnetic energy by ~ 99% within ~ 4 Alfv´en times from their onset. In contrast, rotation significantly delays the development of these instabilities and, in some cases, mitigates their effects. Highly rotating models retain up to ~ 30% of their magnetic energy for at least ~ 10 Alfv´en times. Additionally, our simulations show that neutron stars spontaneously develop differential rotation in their cores. At larger distances from the star, the magnetic field strength becomes misaligned with the angular velocity, with the degree of misalignment increasing for higher angular velocities. Our results suggest that rotation plays a crucial role in stabilizing the magnetic field of neutron stars, regardless of its initial configuration.

Presenter: RUIZ, Milton

Contribution ID: **30** Type: **Talk**

Superconducting magnetars: Microphysics and potential gravitational-wave signatures

Wednesday 29 October 2025 10:30 (25 minutes)

We present a general-relativistic study of strongly magnetized neutron stars (NSs), using the XNS code to solve the coupled Einstein–Maxwell equations, focusing on (i) examining equilibrium configurations with both toroidal and poloidal magnetic field geometries, (ii) incorporating complex many-body effects through microscopically derived pairing gaps for proton superconductor, and (iii) employing equations of state (EoSs) derived from microscopic nuclear many-body theory with realistic two- and three-body forces, as well as from relativistic mean-field models. Across these EoSs, we compare superconducting topologies and analyze the influence of magnetic field geometry in models parameterized by central density. We further compute m ellipticities for several millisecond pulsars (MSPs), estimating their continuous gravitational-wave (CGW) emission. Although the predicted strains lie below the sensitivity of current detectors, next-generation observatories such as the Einstein Telescope and Cosmic Explorer may be able to detect these signals, providing an observational probe of superconductivity, magnetic field structure, and dense-matter microphysics in neutron stars.

Presenter: SEDRAKIAN, Armen

Contribution ID: **31** Type: **Talk**

A General Overview of LISA Data Analysis: The Global Fit Approach

Wednesday 29 October 2025 14:55 (25 minutes)

The spatial gravitational waves observatory LISA has been officially adopted by ESA in January 2024 and its launch is currently planned for 2035, leaving a decade to face all the data analysis challenges posed by the expected data. In this presentation I will present the various sources of LISA with their associated science cases and how this leads to new challenges in gravitational data analysis. The current approach, the so-called global-fit, and its associated costs, will be presented. I will finally briefly focus on time-frequency approaches that are foreseen as a promising tool to enhance computational speed and save computation resources in the analysis.

Presenter: SERVIGNAT, Gaël

Contribution ID: **32** Type: **Talk**

Mode-induced magnetic field amplification in binary mergers

Tuesday 28 October 2025 10:55 (25 minutes)

In the moments leading up to a binary merger, tides can excite a variety of modes inside neutron stars. I will describe how g-modes, and gravitoinertial modes more generally, excite differential rotations inside the stars in such a manner that dynamo activity can amplify an existing magnetic field there. This has implications for precursor flares, tidal dephasing, and various other phenomena in binary mergers, in a manner that is supported by both linear and non-linear simulations of tidally-forced modes.

Presenter: SUVOROV, Arthur

Contribution ID: **33** Type: **Talk**

Autoencoder based surrogate model for gravitational waves from BBH mergers

Monday 27 October 2025 12:10 (25 minutes)

Gravitational wave approximants are widely used in the analysis of Gravitational wave signals. They are highly accurate but they still lack speed. We present an autoencoder based surrogate model for BBH gravitational wave signals. We train our autoencoder on a NR informed surrogate model, we modify it so it can produce waveforms from the initial binary system parameters and then we fine tune it using the NR waveforms in the SXS dataset. We achieve an accurate approximant, having mismatches of the order of 10-4 with the NR waveforms, while being able to produce 106 waveforms in under a second.

Presenter: THEODOROPOULOS, Anastasios

Contribution ID: **34** Type: **Talk**

Asteroseismology of a proto-neutron star including accretion flows

Monday 27 October 2025 14:30 (25 minutes)

Core-collapse supernovae (CCSNe) are one of the most anticipated future gravitational wave (GW) sources. The GW emission is dominated by the oscillation modes of the newly born proto-neutron star (PNS) and the stalled accretion shock. I am going to present a new general relativistic framework for computing the oscillation modes of a PNS, including, for the first time, an accretion flow and a surrounding stalled accretion shock. The oscillations can be described by a system of partial differential equations, which can be solved as an eigenvalue problem. In that frame, the eigenvalues are the characteristic frequencies of the oscillation modes. In this work, I have implemented spectral methods as the eigenvalue solver. By doing so, we can explore the PNS oscillation modes and especially those related to the standing-accretion-shock instability (SASI). In that way, we include some of the missing ingredients towards a more realistic PNS asteroseismology.

Presenter: TSENEKLIDOU, Dimitra

Contribution ID: **35** Type: **Talk**

Asteroseismology of a proto-neutron star including accretion flows

Core-collapse supernovae (CCSNe) are one of the most anticipated future gravitational wave (GW) sources. The GW emission is dominated by the oscillation modes of the newly born proto-neutron star (PNS) and the stalled accretion shock. I am going to present a new general relativistic framework for computing the oscillation modes of a PNS, including, for the first time, an accretion flow and a surrounding stalled accretion shock. The oscillations can be described by a system of partial differential equations, which can be solved as an eigenvalue problem. In that frame, the eigenvalues are the characteristic frequencies of the oscillation modes. In this work, I have implemented spectral methods as the eigenvalue solver. By doing so, we can explore the PNS oscillation modes and especially those related to the standing-accretion-shock instability (SASI). In that way, we include some of the missing ingredients towards a more realistic PNS asteroseismology.

Presenter: TSENEKLIDOU, Dimitra

Contribution ID: **36** Type: **Talk**

Finite-temperature hypernuclear EoS and universal relations of isentropic, rapidly rotating compact stars

Tuesday 28 October 2025 11:20 (25 minutes)

The equation of state (EoS) for dense, strongly interacting matter serves as the central input in an array of astrophysical simulations involving isolated compact objects and binary systems across various scenarios. While numerous models exist to describe the composition of cold neutron stars, the range narrows considerably when considering the so-called general-purpose EoS, which encompass varying temperature, density, and electron fraction. Moreover, several EoS models that include hyperonic degrees of freedom in dense matter have been rendered incompatible with the recently imposed constraints from observational astrophysics. This talk will discuss the generation of finite temperature EoS of hypernuclear matter in the range of densities, temperatures, and electron fractions that are needed for numerical simulations of supernovas, protoneutron stars, and binary neutron star mergers, along with the variation of their generic features and composition depending on the parametrization of the baryon-meson couplings. In addition, it will address the properties of hot, isentropic compact stars constructed from those EoS, in the limiting cases of static and maximally rotating configurations. Finally, it will test the validity of universal relations between global properties of such stars for various combinations of fixed entropy and electron fraction, representative of astrophysical scenarios.

Presenter: TSIOPELAS, Stefanos

Contribution ID: **39** Type: **Talk**

Dynamical Stability of Hypermassive Neutron Stars against Quasi-radial Perturbations

Monday 27 October 2025 16:15 (25 minutes)

The dynamical stability of differentially rotating neutron stars, including hypermassive neutron stars, is of paramount importance in understanding the fate of the postmerger remnant of binary neutron stars mergers and the formation of a black hole during core-collapse supernovae. We study systematically the dynamical stability of differentially rotating neutron stars within a broad range of masses, rotation rates, and degrees of differential rotation, modeled as polytropes with $\Gamma = 2$. We pay particular attention to quasi-toroidal configurations that are outside the parameter space region explored in previous works. We estimate the limits of the region of stability against quasi-radial perturbations by performing an extensive set of numerical simulations. We find that some of the stability criteria proposed in the past are not sufficient or necessary to determine stability if differential rotation is present, and propose a new, more general criterion. We show that there is a large parameter space that allows for quasi-toroidal configurations that will not collapse immediately to a black hole and that can sustain masses up to ~2.5 times the maximum mass of a nonrotating neutron star.

Presenter: ROSINSKA, Dorota (University of Warsaw)

Contribution ID: **40** Type: **Talk**

Neutron stars collapsing to black holes in massive scalar tensor theories

Monday 27 October 2025 17:05 (25 minutes)

In this talk we discuss a fully 3D numerical evolution code to study neutron stars within the framework of massive-scalar-tensor (MST) theories. Our focus is to study the gravitational collapse of rapidly rotating neutron stars by exploring the parameter space defined by the scalar field couplings and the mass. We investigate how these parameters influence both the dynamical characteristics of the process and the emitted gravitational waveform. We also examine different criteria for stability and how the massive field influences the oscillation modes of the neutron stars.

Presenter: OLVERA MENESES, José Carlos

Contribution ID: **41** Type: **Talk**

Well-balanced central WENO Finite Differences and ADER Discontinuous Galerkin schemes for a first-order hyperbolic generalized harmonic formulation of the Einstein-Euler equations

Monday 27 October 2025 16:40 (25 minutes)

We present a study on the application of two high-order numerical methods for solving the first-order hyperbolic generalized harmonic (GH) formulation of the vacuum Einstein equations of general relativity, introduced in [1], coupled with the Euler equations for matter variables. More precisely, we consider the central WENO Finite Differences method on 3D Cartesian grids, and the ADER discontinuous Galerkin (DG) method on 2D unstructured polygonal meshes [2]. Both schemes are designed to be well-balanced with respect to arbitrary but a priori known equilibria. The numerical tests successfully reproduce standard vacuum test cases of numerical relativity, such as the robust stability test and the gauge wave (even at large amplitudes), as well as long-term stable evolutions of stationary black holes, including Kerr black holes with extreme spin. We validate the well-balancing property of the schemes by introducing a perturbation to the initial data and verifying that the system relaxes back to the equilibrium configuration with accuracy up to machine precision. Concerning the coupling with matter, besides performing the Michel spherical accretion test, we are able to evolve a perturbed Tolman-Oppenheimer-Volkoff (TOV) star in pure vacuum without introducing any artificial atmosphere, thanks to the filter in the conversion from the conserved to the primitive variables proposed in [3]. These results provide a solid foundation for addressing more complex and challenging simulations, including those of binary systems. References [1] L. Lindblom, M. A. Scheel, L. E. Kidder, R. Owen, and O. Rinne, "A new generalized harmonic evolution system,"Classical and Quantum Gravity, vol. 23, no. 16, S447, 2006. [2] E. Gaburro, W. Boscheri, S. Chiocchetti, C. Klingenberg, V. Springel, and M. Dumbser, "High order direct arbitrary-lagrangian-eulerian schemes on moving voronoi meshes with topology changes," Journal of Computational Physics, vol. 407, p. 109 167, 2020. [3] M. Dumbser, O. Zanotti, E. Gaburro, and I. Peshkov, "A well-balanced discontinuous galerkin method for the first–order z4 formulation of the einstein–euler system,"Journal of Computational Physics, vol. 504,p. 112 875, 2024.

Presenter: MUZZOLON, Stefano

Contribution ID: **42** Type: **Talk**

Probing Strange Dark Matter through f-mode Oscillations of Neutron Stars with Hyperons and Quark Matter

Wednesday 29 October 2025 15:45 (25 minutes)

We investigate the impact of a hypothetical bosonic dark matter (DM) candidate, the sexaquark, on the fundamental (f-mode) oscillations of neutron stars (NSs). By varying the DM particle mass and considering different core compositions including hypernuclear matter, sexaquark DM, and deconfined quark matter (QM), we construct hybrid equations of state (EOS) with a smooth hadron-quark crossover that remain consistent with current astrophysical constraints on mass, radius, and tidal deformability. Our analysis shows that the presence of these exotic components systematically alters quasi-universal f-mode relations. Within this extended framework, the relations remain tight and effectively composition independent. These results suggest that precise f-mode measurements with future gravitational-wave detectors could provide clear signatures of DM and other exotic matter in NS interiors.

Presenter: RAFIEI KARKEVANDI, Davood

Contribution ID: **43** Type: **Talk**

Hyperons in Neutron Stars across the observed mass range: Insights from realistic Λ-N and Λ-Λ interactions within a Microscopic Framework

Monday 27 October 2025 10:55 (25 minutes)

We investigate the equation of state (EOS) and macroscopic properties of neutron stars (NSs) and hyperonic stars within the framework of the lowest order constrained variational (LOCV) method, extended to include interacting Λ hyperons. The ΛN and ΛΛ interactions are described by realistic spin- and parity-dependent potentials fitted to hypernuclear data. Cold, charge-neutral, and β-equilibrated matter composed of neutrons, protons, electrons, muons, and Λ hyperons is considered. We compute particle fractions, chemical potentials, the EOS, speed of sound, tidal deformability, and stellar structure by solving the Tolman-Oppenheimer-Volkoff equations, and compare our results with recent NICER and gravitational-wave observations. The inclusion of Λ hyperons leads to EOS softening, reducing the maximum NS mass while keeping it consistent with the 2 solar mass constraint. At 1.4 solar mass, the model satisfies observational limits on radius and tidal deformability, with the Λ onset occurring below this mass permitting even canonical-mass NSs to accommodate hyperons. These results suggest that hyperons can appear in NSs across the observed mass range without violating current astrophysical constraints, and that the extended LOCV method provides a consistent, microscopic approach to modeling dense hypernuclear matter.

Presenter: SHAHRBAF, Mahboubeh

Contribution ID: **44** Type: **Talk**

Power gap dependance on equation of state and other microphysics

Tuesday 28 October 2025 17:30 (25 minutes)

Gravitational waves are an important messenger to observe the first milliseconds of a core-collapse supernova, as radiations are still trapped and cannot convey any signal from the deeper part of the explosion. As such detections are only possible in the context of a galactic supernova, we have not yet been able to observe GWs from CCSN, and thus need to rely on simulations to decipher the potential signature of physical events. The so-called power gap is one of these signatures. In this talk, I will present an analysis of a set of 14 2D simulations varying the neutrino interactions formalism, transport, inclusion of axions, and EOS. These differences will help us determine if the power gap can be a clear signature of the internal microphysics of the CCSN.

Presenter: BETRANHANDY, Aurore

Contribution ID: **45** Type: **not specified**

Group Picture

Wednesday 29 October 2025 10:00 (5 minutes)