Contribution ID: **6** Type: **Presentation**

# Title: Classification of the nuclear equation of state using the reconstructed core-collapse supernova gravitational wave high-frequency feature in real interferometric data

*Monday 21 July 2025 16:10 (20 minutes)*

Galactic (or near Galactic) core-collapse supernova (CCSN) is currently one of the most anticipated astrophysical events of the century. CCSN are multimessenger astronomy events that work as exceptional laboratories enclosing different carriers of physical information, neutrinos, photons, and gravitational waves (GWs) all coexisting in a single event. The CCSN GW signals are characterized by a non-deterministic nature in their GW emission, as is revealed by the CCSN numerical simulations available to date. LIGO, Virgo and KAGRA (LVK) interferometric data has opened a window for exploration of mechanisms to estimate physical parameters from the GW source, decoding the information incorporated in the CCSN GW burst signals. We present a methodology, following Casallas-Lagos et al. 2023 (PRD.108.084027), Murphy et al. 2024 (PRD.110.083006) and Casallas-Lagos et al. 2024 (MDPI.15010065), based on a convolutional neural network (CNN) to distinguish and classify the nuclear equation of state (EOS) in isolation, for E series, CCSN GW signals from Mezzacappa et al. 2023 (PRD.107.043008) using the estimated slopes of the temporal evolution of the high-frequency feature GW emission for a CCSN at three Galactic distances of 1 kpc, 5 kpc and 10 kpc using LIGO interferometric noise of the third observing run of LVK. The accuracy of this classification algorithm is evaluated by the implementation of the Receiver Operating Characteristic curve, classification accuracy, and the confusion matrix. Our CNN model demonstrates robust discriminative ability in classifying the EOS, achieving 98% accuracy classifying correctly the EOS classes within 1 kpc, with sustained performance at 92% (5 kpc) and 87% (10 kpc). The high micro-average area under the curve AUC (0.93) confirms strong overall classification reliability, while the macro-average AUC (0.87) indicates consistent performance across all EOS categories, even for subtle or rare features. These findings highlight the significant potential of our methodology for effectively discerning EOS within GW detector noise.

**Primary authors:** CASALLAS LAGOS, Alejandro (Faculty of Physics, Warsaw University); Prof. ANTELIS, Javier. M (Tecnologico de Monterrey); Prof. SZCZEPAŃCZYK, Marek (Faculty of Physics, Warsaw University); Prof. ZANOLIN, Michele (ERAU)

**Presenter:** CASALLAS LAGOS, Alejandro (Faculty of Physics, Warsaw University)

**Session Classification:** Detection