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A new tool on the workbench: the rapid population synthesis code SEVN for gravitational wave astronomy

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LISA will play a crucial role in unveiling the universe of gravitational wave sources, particularly by probing the inspirals and mergers of binary compact objects (BCOs) such as black holes, neutron stars, and white dwarfs over cosmological distances. To fully exploit the wealth of data that LISA will provide, we need accurate predictions for the properties and rates of these binary mergers across cosmic time. This requires state-of-the-art binary population synthesis tools that can evolve large stellar populations, track complex binary interactions, and account for diverse stellar environments. In this talk, I present SEVN (Stellar EVolution for N-body codes), a new state-of-the-art population synthesis code specifically designed to model the formation and evolution of BCOs. Unlike many traditional population synthesis codes, which rely on outdated stellar evolution models and offer limited flexibility, SEVN uses a fully modular approach. The code interpolates stellar evolution from pre-computed look-up tables, allowing users to dynamically switch between different sets of stellar models without modifying or recompiling the code. The code's adaptive time-stepping method ensures both high-resolution modeling of critical phases (e.g., Roche Lobe overflow) and a significant reduction in computational time. In this presentation, I will showcase the first scientific applications of SEVN, particularly focusing on the formation and properties of BCOs from Population I, II, and III stars. I will discuss how the choice of stellar evolution models can dramatically affect predictions for BCO merger rates and properties, providing valuable insight for future gravitational wave observations with LISA. This modular and scalable approach makes SEVN a powerful tool for studying the binary systems that LISA is poised to detect, offering a versatile framework that scales seamlessly from personal computers to large clusters.

Presenter(s) : IORIO, Giuliano (ICCUB, Universitat de Barcelona)

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