Contribution ID: **67** Type: **Oral Talk**

Calibrated Atomic Data and 3D Radiative Transfer Modelling of Kilonova

Monday, 9 September 2024 15:05 (15 minutes)

With the detection of multiple neutron-star merger events in the last few years, the need for a more comprehensive understanding of nuclear and atomic properties as well as radiative transfer has become increasingly important. Despite our current understanding, there are still large discrepancies in the opacities obtained from different codes and methods. These discrepancies lead to variations in the location and strength or absorption and emission features in radiative transfer models and prevent a firm identification of r-process products. We report on converged large-scale atomic structure calculations of all singly and doubly ionised lanthanides with greatly improved transition wavelength accuracy compared to previous works. We present three-dimensional radiative transfer calculations for the ejecta from a neutron star merger that include line-by-line opacities for tens of millions of bound-bound transitions, composition from an r-process nuclear network, and time-dependent thermalization of decay products from individual and decay reactions. We demonstrate the importance of wavelength-calibration of atomic data using a model with calibrated Sr, Y, and Zr data, and find major differences in the resulting spectra, including a better agreement with AT2017gfo. We also show that 1D models obtained by spherically averaging the 3D ejecta lead to dramatically different direction-integrated luminosities and spectra compared to full 3D calculations.

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Session Classification: Explosive Stellar Objects and Nuclear Physics

Track Classification: Explosive Stellar Objects and Nuclear Physics