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Atomic Physics Inputs for Kilonova Modelling

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With the recent detection of multiple neutron star merger events, the necessity for a more comprehensive understanding of nuclear and atomic properties, as well as radiative transfer processes, has become increasingly critical. Despite advancements in our knowledge, significant uncertainties persist in opacity calculations, leading to variations in the strength and location of spectral features in radiative transfer models. These uncertainties hinder the definitive identification of r-process nucleosynthesis products.

Additionally, observations with the James Webb Space Telescope (JWST) yielded numerous spectral features at infrared wavelengths, with proposed explanations ranging from a cool continuum to forbidden line emission. Due to their intricate atomic structures, Lanthanide ions are promising candidates among these forbidden emission lines, which dominate the cooling processes from approximately one week post-merger in the kilonova evolution and which are essential for non-local thermodynamic equilibrium (NLTE) radiative transfer. However, this is only the first step towards full NLTE-radiative transfer, which will be required to model future kilonova observations.

In my presentation, I will discuss both the current and future needs from atomic physics for radiative transfer modeling of kilonovae. In particular, I will reflect on the required accuracy of atomic properties, large-scale atomic structure calculations, and key challenges associated with the non-local thermodynamic equilibrium (NLTE) radiative transfer necessary for connecting neutron star merger models with astronomical observations.

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