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Calculation of electron impact excitation cross-sections and collision strengths for non-LTE modelling

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The production of heavy elements beyond iron in the expanding ejecta of binary neutron star mergers (NSMs) provided evidence for the synthesis of lanthanides and possibly actinides through rapid neutron capture (r-process) nucleosynthesis. However, identifying specific atomic absorption and emission features in kilonova spectra to associate them with individual elements remains a significant challenge [1,2].
One of the primary obstacles is the lack of comprehensive atomic data for modeling the late nebular epochs (> 4 days post-merger). While it is a reasonable approximation to assume that the ejecta is in local thermodynamic equilibrium (LTE) and that atomic absorption processes dominate in the early hours (< 1 day after the NSM), it is not possible to assume LTE for nebular epochs (non-LTE). During these late stages, relevant processes include photoionization, ionization and excitation by electron impact, and electronic recombination, for which the data is very scarce [3].
In this work, we address this gap by benchmarking electron-impact excitation (EIE) cross sections and collision strengths (CS) for selected elements, including Y, Pt, and Au [4], using the Flexible Atomic Code [5] and AUTOSTRUCTURE [6]. Our results show that the approximations by van Regemorter and Axelrod underestimate collision strengths by orders of magnitude, particularly for forbidden transitions. Preliminary calculations of EIE cross-sections and CS for selected lanthanides will be also presented, providing new atomic parameters essential for advancing non-LTE spectral modeling.

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