Comparison between ab initio and semi-empirical calculated bound-bound opacities of Tm ions

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Heavy element ions such as lanthanides and actinides are formed in neutron star mergers through neutron capture r-process and greatly contribute to the opacities of the ejecta [1]. The bound-bound part of opacity can be derived from the calculations of transition probabilities of radiative transitions of an ion, taking into account typical conditions in a kilonova.

Here we present the case of triply ionized thulium Tm^{3+} (Tm IV). A recent extended analysis [2] of the high-resolution ultraviolet emission spectrum of the ion increased by ~150 the number of known energy levels previously reported for the four lowest configurations [3]. Based on these energy levels, a semi-empirical approach was adopted by performing parametric calculations using the Cowan codes [4, 5]. Then the Tm IV contribution to opacity is derived from reliable transition probabilities. It is compared to the one derived from calculations applying a fully relativistic ab initio multiconfiguration Dirac-Hartree-Fock (MCDHF) method using the code GRASP2018 [6].

The bound-bound opacity of Tm V from parametric calculations, based on newly determined energy levels will also be presented.

References

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