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Benchmarking Model Calculations of Fe XVII Dielectronic Recombination Satellite Line Cross Sections Using an Electron Beam Ion Trap

Dielectronic recombination (DR) is the dominant photorecombination channel for Fe XVII in hot astrophysical plasmas, producing strong satellite transitions seen in the 3s −2p and 3d −2p line formation channels of X-ray spectra from stellar coronae. Dielectronic resonances also contribute strongly to the collisional excitation of Fe XVII ions. Theoretical calculations of both DR and resonant excitation (RE) are effectively benchmarked by electron beam ion trap (EBIT) studies in which the electron beam energy is swept over the energy range of the resonances. Accurate interpretations of these DR channels are essential for accurate astrophysical plasma diagnostics. We continue the work of Shah et al. (2019) and Grilo et al. (2021) by using the Flexible Atomic Code to calculate cross sections for the DR satellite lines of Fe XVII, with configurations including principal quantum numbers and orbital angular momentum quantum numbers up to $n \leq 60$ and $l \leq 8$ respectively. Calculations of the energies for the initial, intermediate, and final atomic states as well as their transition and autoionization rates were fed into the FAC line polarization module, in order to calculate the total line emissivities. We benchmarked our theoretical predictions by converting the line emissivities to absolute cross sections, and compared these cross sections in all orders to experimental cross sections of Fe XVII resonances that were mono-energetically excited in FLASH-EBIT at the Max Planck Institute for Nuclear Physics (MPI-K) in Heidelberg, Germany. In particular, we extended the experimental benchmark of Shah et al. (2019) and Grilo et al. (2021) to all observable DR and RE channels, specifically the $n = 4 - 2$ DR resonances of Fe XVII. Our calculations show a ~20–25% overestimation of the $n = 4$ DR and RE absolute cross sections, which are consistent with the overestimation of the 3d cross sections found in previous theoretical studies.

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