

Free-Electron Degeneracy Effects for Collisional-Radiative Codes

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Collisional-radiative (CR) codes are increasingly being called upon to model conditions at high densities and low temperatures where electron degeneracy becomes important. Experiments at large laser facilities and X-ray free electron lasers routinely produce such conditions and an accurate treatment of degeneracy effects is important to their simulation and interpretation.

Degeneracy affects all processes involving one or more free electrons, including collisional excitations and ionizations, radiative recombination, Auger processes and bremsstrahlung. We review the modifications necessary for a CR code to incorporate these effects. For thermal electron distributions, we present simple analytical expressions which capture or approximate the additional factors required for transition rates and radiative properties. The expressions for collisional excitation and ionization factors correct results previously published by the authors. For cases of strong degeneracy, the analytical expressions for collisional ionization and three-body recombination lose accuracy and numerical integrations require careful evaluation. For these, we present robust numerical formulations and provide a simple modification to the analytical expressions which restores accuracy.

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