Atomic-state-dependent screening model for atomic structures of ions embedded in warm and hot dense plasma

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Warm and hot dense plasma widely exists in stars or giant planets in universe, and can be created in experiments with high power lasers and Z pinches. For atoms embedded in dense plasma, strong plasma screening effects are encountered due to complicated many-body interactions with the surrounding plasma, which significantly affects the atomic energy levels and wave functions, resulting in ionization potential depression (IPD), line shift, and remarkable changes in the photon, electron, and ion scattering cross section [1]. Accurate theoretically modeling of such kind of quantum many-body interactions is essential but very challenging.

In this work, we proposed an atomic-state-dependent screening model for treating the electron screening effects of warm and hot dense plasmas [2]. We show that the inelastic collision processes between electrons and ions are important in determining the electron density distribution around target ions embedded in dense plasma, and further contribute evidently to the IPD in warm and hot dense plasma. It is found that the electron distribution of the target ion is sensitive to the specific bound state studied, due to the quantum degeneracy effect between the recombined and initial bound electrons. These effects will further influence the atomic structures of ions embedded in dense plasmas, and the feasibility and validation of the proposed model are demonstrated by reproducing the recent experimental results of line shifts [3,4] and ionization potential depressions [5-7] of warm and hot dense plasmas. These work are expected to provide a promising tool to calculate the atomic structures and processes in dense plasma and will benefit future related studies of high-energy-density physics.

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