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Experimental Measurements and Density Functional Theory Calculations of Continuum Lowering in Strongly Coupled Plasmas

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An accurate description of the ionization potential depression (IPD) of ions in plasmas due to their interaction with the environment is a fundamental problem in plasma physics, playing a key role in determining the ionization balance, charge state distribution, opacity and plasma equation of state. Here I present the first experimental investigation of the IPD as a function of ionic charge state in a range of dense Mg, Al and Si plasmas, using the Linac Coherent Light Source X-ray free-electron laser. The measurements show significantly larger IPDs than are predicted by the most commonly used models, such as that of Stewart-Pyatt, or the ion-sphere model of Zimmerman-More. Instead, plasma simulations using finite-temperature density functional theory with excited-state projector augmented-wave potentials show excellent agreement with the experimental results and explain the stronger-than-expected continuum lowering through the electronic structure of the valence states in these strong-coupling conditions, which retain much of their atomic characteristics close to the ion core regions. These results have a profound impact on the understanding and modelling of plasmas over a wide range of warm- and hot-dense matter conditions.

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