Effect of Interatomic Interactions on Opacity in Hot Dense Plasmas

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Recent opacity experiments at Sandia's Z machine and the National Ignition Facility (NIF) at Livermore have seen disagreement with theory. Of particular note is the iron experiment, which seeks to replicate the conditions present in the solar interior [1]. Although a variety of possible modifications to opacity models have already been examined, none have provided a good explanation to resolve the conflict [2]. In this work we examine the possible role of interatomic interactions between the iron and magnesium ions. If iron and magnesium interact differently than do the analogous chromium–magnesium and nickel–magnesium systems, this could shed light on the discrepancy. Calculations using multiple scattering theory [3] are used to calculate the opacity of mixed metal–magnesium systems generated from snapshots of pseudo-atom molecular dynamics [4] run at the experimental densities and temperatures. While the interatomic interactions included in these calculations do change the positions and intensities of some of the lines, the effect is small and does not meaningfully impact the opacity enough to account for the differences in theory and experiment. This is not particularly surprising at these densities where the average interatomic distance is approximately 3× that of solid density where chemical bonding and interatomic interaction is significant.

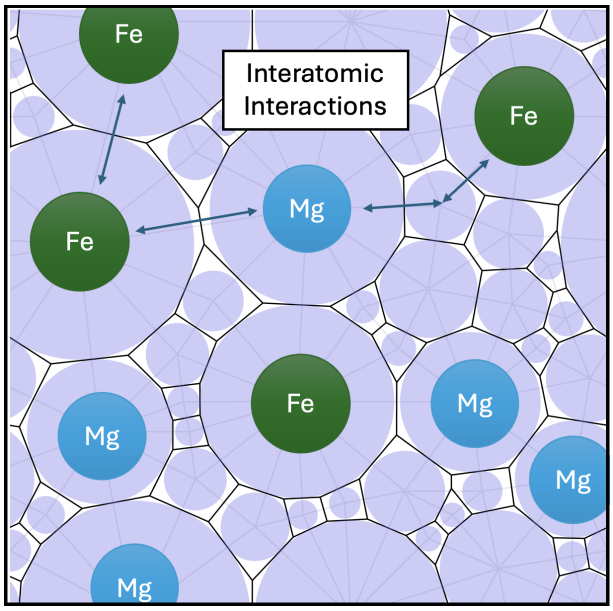

Figure 1. Multiple scattering includes self-consistent corrections to the potential in each cell from its neighbors, capturing interatomic interactions in the electronic structure of each ion.

References

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