The Opacity Project: R-Matrix Opacities for Laboratory and Astrophysical Plasma Sources

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The Opacity Project (OP) was initiated in 1983 and aimed to employ the state-of-the-art atomic physics based on the powerful R-matrix method to compute stellar opacities[1, 2]. However, hitherto computational and theoretical issues related to its implementation have proved to be intractable. Simpler approximations based on atomic structure and distorted wave methods were used in the OP work, akin to other existing opacity models. The primary difference is that the R-matrix method accounts more precisely for electron correlation, configuration interaction, and channel coupling effects. That, for example, gives rise to autoionization resonances in bound-free photoionization cross sections in an *ab initio* manner [2, 3]. This presentation describes recent developments reported in a series of papers on R-matrix calculations for opacities (RMOP I-IV: [4, 5, 6, 7]), including (i) large-scale atomic calculations for iron ions of heretofore unprecedented complexity, and (ii) a new treatment of plasma effects on resonances in photoionization cross sections with collisional electron impact, Stark ion microfield, and thermal Doppler broadening mechanisms. Generally, these physical effects are likely to manifest themselves for atomic processes in high-energy-density (HED) environments such as stellar interiors. In addition to atomic-plasma issues, the OP-RMOP works employ the Mihalas-Hummer-Däppen equation-of-state (EOS), and it is important to ascertain its precise behavior which may also affect opacities via atomic ionization states and level populations as function of temperature and density [8]. An exemplar of astrophysical applications is the "solar problem" which depends on an accurate determination of opacities. Similarly, laboratory measurements of opacities (viz. [9]) are also addressed. The interface of EOS, atomic data, and opacities is important for HED plasmas [8], and might constitute a topic of detailed discussion for the RPHDM workshop.

References

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