Thoughts about the Iron Opacity Controversy

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The controversy concerning the opacity of iron, arising from a discrepancy between helioseismology [1] and revised solar elemental abundances [2], continues to defy explanation. Experiments at the Sandia Z-facility have produced iron, nickel and chromium spectra [3, 4, 5] that have yielded both good and poor agreement with theoretical calculations, adding to the mystery. For example, the bound-free contribution to the opacity agrees well between theory and experiment for nickel and chromium at all measured conditions, while the iron comparisons display good agreement at lower temperatures/densities, but not at higher temperatures/densities. Continuing with a previous study that was presented at the 2023 Atomic Processes in Plasma (APiP) Conference in Vienna, we compare photoionization cross sections generated with the distorted-wave (DW) and R-matrix (RM) methods. At the APiP Conference, good agreement was demonstrated between the DW and RM methods for the case of He-like iron, Fe^{24+}. In this talk, we focus on the Ne-like ion stage, Fe^{16+}, which is predicted to dominate the charge state distribution for iron under the conditions that are present in the Sandia experiments. The DW results are calculated with the Los Alamos Suite of Atomic Physics Codes [6] and the RM results are calculated with the Dirac Atomic R-matrix Codes (DARC) [7]. We consider both the background and resonance contributions to various photoionization cross sections produced with each method, highlighting similarities, differences, and consequences for the corresponding opacities.

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