Comment on "Large Enhancement in High-Energy Photoionization of Fe XVII and Missing Continuum Plasma Opacity"

Recent R-matrix calculations claim to produce a significant enhancement in the opacity of neonlike Fe XVII due to atomic core excitations [1] and assert that this enhancement is consistent with recent measurements of higher-than-predicted iron opacities [2]. This Comment shows that the standard opacity models [3–7] which have already been directly compared with experimental data [2,7] produce photon absorption cross sections for Fe XVII that are effectively equivalent to the R-matrix opacities reported in [1]. Thus, the new R-matrix results cannot be expected to significantly impact the existing discrepancies between theory and experiment because they produce neither a "large enhancement" nor account for "missing continuum plasma opacity" relative to standard models.

All models that satisfy the f-sum rule [7] and include the same initial and final electronic configurations can be expected to produce similar opacities (e.g.,[8]). This is demonstrated in Fig. 1, which compares calculated opacities for Fe XVII from five standard models to the R-matrix and opacity project (OP) results from [1]. The models have been restricted to the Fe XVII ion and normalized to a 0.195 abundance but are otherwise the same as those previously published [2,7]. Both R-matrix and standard models include spectral features associated with autoionizing states and inner-shell electrons that are evident in measured data but neglected in OP [1,9]. Thus the opacity enhancements of R-matrix over OP reported in [1] illustrate the deficiencies of OP rather than the merits of R-matrix.

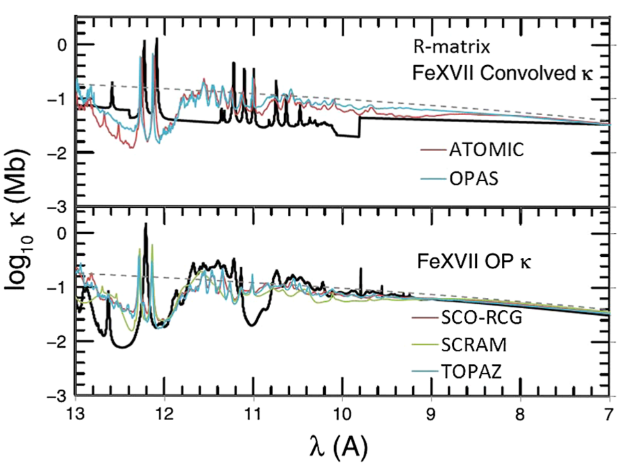

FIG. 1. (Adapted from Fig. 5 of Ref. [1].) Opacities of FeXVII at a temperature of 2.1×10^6 K, free electron number density of 3.1×10^{22} cm^{-3}, and abundance of 0.195. Dashed lines are 0.195× the cold reference opacity [10], representing a fully occupied L shell.

TABLE I. Rosseland mean opacities κ_R of Fe XVII normalized to the OP value demonstrate that both R-matrix and standard models are significantly larger than OP. Average Fe XVII opacities $\langle\kappa\rangle$ in the 7–9 Å continuum region normalized to experimental data [2] show deficits in all models.

Source	κ_R (total) relative to OP [1]	$\langle\kappa\rangle$ (7–9 Å) relative to experiment [2]
OP [1]	1.00	0.59*
R-matrix [1]	1.35	0.52*
ATOMIC [3]	1.32	0.60
OPAS [4]	1.55	0.62
SCO-RCG [5]	1.37	0.65
SCRAM [6]	1.27	0.68
TOPAZ [7]	1.21	0.62
Cold [10]		0.74
Experiment [2]		1.00

*Estimated from Fig. 5 of Ref. [1].

Table I gives relative opacities for Fe XVII to help quantify the similarities between R-matrix and standard models and their mutual differences with measurements. Both R-matrix and standard models yield larger total Rosseland mean opacities than OP, confirming the importance of transitions missing in OP. However, the Rosseland weighting function peaks near 17 Å while the most profound discrepancies between theory and experiment are in the 7–9 Å monochromatic continuum range. Here, the average opacities from all models (as well as cold reference opacities [10] representing photoionization from a fully occupied L shell) are significantly smaller than the experimental data. In this critical range, R-matrix is smaller even than OP. Thus the results reported in [1] appear unlikely to resolve this discrepancy between theory and experiments.

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[1] S. N. Nahar and A. K. Pradhan, Phys. Rev. Lett. **116**, 235003 (2016).
[2] J. E. Bailey *et al.*, Nature (London) **517**, 56 (2015).
[3] J. Colgan, D. P. Kilcrease, N. H. Magee, M. E. Sherrill, J. Abdallah Jr., P. Hakel, C. J. Fontes, J. A. Guzik, and K. A. Mussack, Astrophys. J. **817**, 116 (2016).
[4] C. Blancard, Ph. Cossé, and G. Faussurier, Astrophys. J. **745**, 10 (2012).
[5] Q. Porcherot, J.-C. Pain, F. Gilleron, and T. Blenski, High Energy Density Phys. **7**, 234 (2011).
[6] S. Hansen, J. Bauche, C. Bauche-Arnoult, and M. F. Gu, High Energy Density Phys. **3**, 109 (2007).
[7] C. A. Iglesias, High Energy Density Phys. **15**, 4 (2015).
[8] A. K. Pradhan and H. L. Zhang, J. Phys. B **30**, L571 (1997).
[9] C. A. Iglesias and F. J. Rogers, Astrophys. J. **443**, 460 (1995).
[10] B. L. Henke, P. Lee, T. J. Tanaka, R. L. Shimabukuro, and B. K. Fujikawa, At. Data Nucl. Data Tables **27**, 1 (1982).