Sensitivity of Tokamak Transport Modeling to Atomic Physics Data: Some Examples

D. P. Stotler[1], S. Baek[2], J. D. Elder[3], M. L. Reinke[4], F. Scotti[5], J. L. Terry[2], and S. J. Zweben[1]

[1]*Princeton Plasma Physics Laboratory, Princeton, NJ, USA*
[2]*MIT Plasma Science and Fusion Center, Cambridge, MA, USA*
[3]*University of Toronto Institute for Aerospace Studies, Toronto, ON, Canada*
[4]*Oak Ridge National Laboratory, Oak Ridge, TN, USA*
[5]*Lawrence Livermore National Laboratory, Livermore, CA, USA*

A central concern in the design of burning plasma devices, such as ITER or DEMO, is that they represent extrapolations in dimensionless parameters from existing devices. The only means by which one can confidently predict their operation is via a well validated simulation based upon a first principles, or as close as possible, model. Accurate atomic physics data are essential to this task, not only for these predictive applications, but also for the validation of the model against the available data. In this talk, we present examples illustrating the sensitivity of such simulations to uncertainties in atomic physics data.

The Gas Puff Imaging (GPI) diagnostic [1] provides spatially and temporally resolved data ideal for validating plasma turbulence simulations. To date, those validation tests have been based on statistical characterizations of the turbulence, such as correlation lengths and times. In using those data, one must account for the spatial extent of the neutral gas cloud that is being "lit" by the plasma turbulence. Neutral transport simulations of that gas cloud have essentially no free parameters and are themselves amenable to quantitative validation tests [2]. We will describe a couple of these, utilizing deuterium or helium gas puffs, and examine the sensitivity of the results to the atomic physics data for those systems.

The use of tungsten in ITER as a principal plasma facing material has led to its introduction in a growing number of existing devices. Experiments conducted on those surfaces are frequently targeted at assessing tungsten erosion and its transport into the tokamak core. We will highlight two such recent investigations. In both cases, factor-of-a-few variations in the tungsten atomic physics data result in order of magnitude, or more, changes in the analysis results [3].

Finally, the drive towards truly first principles simulations entails, at least in some regimes, a shift from fluid descriptions of the plasma to ones that are fully kinetic [4]. The development of ever more capable computers and simulation algorithms has been steadily relaxing restrictions on the dimensionality and spatial coverage of such simulations. As they become more detailed and practical, additional atomic physics data will be required, e.g., doubly differential ionization cross sections.

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