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Editorial

Special Issue on Spectral Line Shapes in Plasmas

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1. Foreword

Line-shape analysis is one of the most important tools for diagnostics of both laboratory and space plasmas. Its reliable implementation requires sufficiently accurate calculations, which imply the use of analytic methods and computer codes of varying complexity, and, necessarily, varying limits of applicability and accuracy. However, studies comparing different computational and analytic methods are almost non-existent. The Spectral Line Shapes in Plasma (SLSP) code comparison workshop series [1] was established to fill this gap.

Numerous computational cases considered in the two workshops organized to date (in April 2012 and August 2013 in Vienna, Austria) not only serve the purpose of code comparison, but also have applications in research of magnetic fusion, astrophysical, laser-produced plasmas, and so on. Therefore, although the first workshop was briefly reviewed elsewhere [2], and will likely be followed by a review of the second one, it was unanimously decided by the participants that a volume devoted to results of the workshops was desired. It is the main purpose of this special issue.

2. Hydrogen-Like Transitions

Many calculation cases suggested for the first two SLSP workshops are for simple atomic systems: the hydrogen atom or hydrogen-like one-electron ions. Of these, the Ly-α transition is truly the simplest; the atomic model was further reduced by neglecting the fine structure and interactions between states with different principal quantum numbers. Interestingly, this simplest system caused the largest discrepancies between results of various models presented at the first workshop [2] due to, apparently, different treatments of the ion dynamics effect. Now, Ferri *et al.* [3] discuss this, extending the analysis to more complex transitions with forbidden components. The ion dynamics effect is intimately related to the microfield directionality, as studied in depth by Calisti *et al.* [4]. Notably, the effects of the directionality of the microfield fluctuations were first researched within the framework of the "standard theory" of the plasma line broadening almost four decades ago, but have largely been forgotten. This approach is recalled and comparisons with computer simulations are made in the paper by Demura and Stambulchik [5].

Results of computer simulations will indeed be found in a majority of studies in this volume. By many scholars, such calculations are considered *ab initio* and their results regarded as benchmarks—at least for hydrogen-like transitions. However, Rosato *et al.* [6] argue that caution should be exercised in the case of very weakly coupled plasmas; in the extreme limit of the ideal plasma model, even the largest supercomputers available today might not be able to achieve convergence.

3. Isolated Lines

Isolated lines are often contradistinguished from radiative transitions in hydrogen-like species with degenerate energy levels. Alexiou *et al.* [7] briefly summarize the theoretical aspects of isolated-line broadening and then delve into a detailed comparison of Stark widths and shifts of Li-like 2s–2p transitions as calculated by various approaches. One of these approaches is the semiclassical perturbation (SCP) method, the work horse behind the STARK-B database. A complete up-to-date description of SCP is presented by Sahal-Bréchot *et al.* [8]. Another approach, also included in the comparison [7], is based on the relativistic Dirac R-matrix method, and is described by Duan *et al.* [9] with a focus on the B III 2s–2p doublet.

Koubiti *et al.* [10] present a comparison of various line-shape computational methods applied to the case of a plasma-broadened isolated line subjected to magnetic field. Furthermore, this study covers one of the two challenges introduced at the second SLSP workshop, where participants were asked to explain previously unpublished experimental data based on best-fit spectra of their models.

4. Applications

One can hardly overestimate the significance of line-shape calculations for diagnostics of laboratory, space, and industrial plasmas. Dimitrijević and Sahal-Bréchot [11] show and discuss numerous examples of such studies, where the SCP approach [8] was used. In the article of Omar *et al.* [12], the authors use a few theoretical methods and computer simulations to calculate the shapes of a He I line and compare them to experimental line profiles, allowing inference of the plasma parameters. Lisitsa *et al.* [13] introduce a new method able to describe penetration of a neutral atomic beam into low-density inhomogeneous fusion plasmas, and provide sample calculations suitable for ITER diagnostics. Spectral line features caused by Langmuir waves and charge-exchange processes are discussed by Dalimier *et al.* [14], who also suggest several spectral lines for prospective studies of laser-produced plasmas.

5. Conclusions

For the first two SLSP workshops, participants submitted in total over 1,500 line-shape calculations. The studies collected in this Special Issue explore only a part of this immense work. Research is ongoing, and we expect more publications soon.

The next workshop is scheduled for March 2015 in Marseille, France [1].

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Conflicts of Interest

The authors declare no conflict of interest.

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