An Effort to Reconcile Electron-Broadening Theories

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Calculations of line broadening are important for many different applications including plasma diagnostics and opacity calculations. One concern is that line-shape models employ many approximations that are not experimentally validated for most element conditions due to challenges with high-fidelity line-shape benchmark experiments. Until such experiments become available, we need to test approximations with ab-initio line-shape calculations.
There are three primary formalisms to derive an electron-broadening operator: the impact theory (Baranger, Griem), relaxation theory (Fano), and kinetic theories (Zwanzig, Hussey), all of which give different expressions for electron broadening. The impact and relaxation theories approximate the density matrix as factorizeable while the kinetic theory has a more general density matrix. The impact and kinetic theories relate the electron broadening operator to collision amplitudes, while the relaxation theory has a more complicated formula using projection operators. Each theory has a different prediction for the width and shift of spectral lines, which will become apparent in strongly-coupled plasmas.
We have made an effort to better understand the approximations and limitations of all of these approaches and to try to reconcile the differences between them. Here, we present the current status of our understanding of the electron-broadening theories and our preliminary attempt to unify the various formulae. Currently, we have found the projection operator to be necessary part of line broadening. We will be showing (for the first time) how the projection operator broadens spectral lines.

Acknowledgements
+Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.This work was supported by the U.S. Department of Energy, Office of Science Early Career Research Program, Office of Fusion Energy Sciences under FWP-14-017426.

^The work of C.F. and D.K. was carried out under the auspices of the US Department of Energy by Los Alamos National Laboratory under contract No. DE-AC52-06NA25396.

*M.H.M. and D.E.W. acknowledge support from the US Department of Energy under Grant No. DE-SC0010623, the Wooton Center for Astrophysical Plasma Properties under the US Department of Energy under Grant No. DE-FOA-0001634, and the National Science Foundation Grant No. NSF-AST 1707419