

Calculations of Spectral Line Broadening in Plasma

Thesis for the degree of Ph.D.

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Abstract

A new method for the calculation of the spectral line broadening in plasma has been developed and implemented. The main idea of the method is to numerically simulate the motion of the plasma particles, both ions and electrons, and use the resulting time-dependent field to evaluate the emitter oscillating function, the Fourier transform of which provides the spectral line shape. This approach enabled us to calculate shapes of spectral lines with proper accounting for dynamic contribution of ions and correct transition from the impact to quasistatic limits, covering intermediate cases. It has been verified that this method also allows for calculating correctly the shapes of forbidden lines, including satellites appearing due to the plasma waves. In addition, line shapes under the simultaneous influence of the electric and magnetic fields (which is a common problem in plasma physics) were calculated for the first time in a self-consistent manner. A special attention was paid to polarization effects caused by the collision-induced level alignment which plays an important role in devices characterized by the acceleration of charged particles, such as ion accelerators and plasma diodes. Applications to past experiments and suggestions for future experiments were made. These include, but are not limited to, pioneering works on using forbidden-line-shape diagnostics with a sub-microsecond time resolution for analysis of low-density plasmas and investigation of polarization properties of ion-excitation mechanisms in high-voltage gaps.