Quantifying the Statistical Noise in Computer Simulations of Stark Broadening

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In plasma spectroscopy, the shape of an atomic line is determined by the perturbation of the energy levels due to the charged particles surrounding the emitter or absorber under consideration. This is the celebrated Stark broadening problem. It still has no solution, in the sense that no general formula has been found for a line shape relative to an arbitrary atomic species. The Dyson series, which provides a solution to the time-dependent Schrödinger equation, is only a formal relation hardly applicable to calculations in realistic conditions. The computer simulation technique has been developed in the seventies with the purpose of reproducing the exact solution as closely as possible based on a Monte Carlo technique [1]. Essentially, a simulation consists in numerically integrating the time-dependent Schrödinger equation that governs the dynamics of an atom perturbed by a fluctuating electric field, itself being generated from a numerical integration of the Newtonian equations of motion for the charged particles moving at the vicinity of the emitter. The initial conditions for the perturbers are generated randomly and, due to this, the numerical line shape exhibits a noisy behaviour, which can be reduced only by increasing the number of runs. In this work, we examine the sensitivity of the results to the statistical noise. We address the speed of convergence of the spectrum. A focus is put on hydrogen line shapes due to the simplicity of the atomic data they involve. Applications to spectra in magnetic fusion plasmas are performed as an illustration.

References

[1] R. Stamm and D. Voslamber, J. Quant. Spectrosc. Radiat. Transfer **22**, 599 (1979).