Revisiting the microfield formulation of Stark broadening using stochastic processes

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About four decades ago, Frisch and Brissaud [1] proposed conspicuous Stark broadening calculations by replacing the true microfield with a simpler stochastic process for which the mean evolution operator could be calculated exactly. This approach was the starting point for the microfield formulation of Stark broadening which allowed extensive calculations of line shapes which are currently used for plasma diagnostics [2], and motivated the development of other approaches for which the properties of the electric microfield determine the line profile [3]. There is a new interest today for the use of stochastic processes such as the Poisson-step and the Kangaroo process, since those may provide computationally efficient solutions for the investigation of radiative and transport properties of media submitted to fluctuations of the plasmas parameters. In this work we first revisit such approaches for calculating the ion dynamics effect on the Lyman alpha line in weakly coupled plasmas, and we then further explore possible improvements of the stochastic process. This may be done by using the Continuous Time Random Walk theory (CTRW), an approach first proposed by Montroll and Weiss [4]. Indeed, the standard Kangaroo process where the waiting time distribution between electric field jumps follows a Poisson distribution can be extended to various waiting time distribution including Lvy distributions. The standard Kangaroo process for the microfield uses a Markov approximation for the microfield [1], and we will show that using the CTRW allows to retain non-Markovian effects. We will tentatively compare the previous and new results obtained with these models with profiles obtained by a plasma computer simulation coupled to a numerical integration of the Schrödinger equation.

Acknowledgements This work is part of a collaboration (LRC DSM 99-14) between the Laboratory of Physique des Interactions Ioniques et Molculaires and the Fdration de recherche en fusion par confinement magntique. It has also been supported by the Agence Nationale de la Recherche (ANR-07-BLAN-0187-01), project PHOTONITER.

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