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Stark spectroscopy in the presence of Langmuir waves in non-equilibrium plasma

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The collective behavior of a plasma is favored by the long range of electric and magnetic fields, and is well known to be able to excite waves with an oscillating electric field. For example, Langmuir waves are ubiquitous in many types of laboratory, fusion, and astrophysical plasmas. By using a classical equipartition theorem for a plasma in equilibrium, one can attribute half of the energy of the wave to the oscillating field, and the other half to kinetic energy, and one can then estimate that the modulus of the electric field of the wave is an order of magnitude smaller than the mean plasma microfield, for example, in a plasma with a temperature T = 1 eV, and a density N = 10ˆ21 mˆ-3. In a non-thermal plasma, however, the waves can be amplified by an instability, which allows the modulus of the oscillating electric field to reach values greater than the mean plasma microfield.
We here study the spectroscopic signature of an oscillating field E ⃗_L=E ⃗_W cos(ω_p t+φ), where ω_p=√(Neˆ2/(mϵ_0)) is the electronic plasma frequency, with e and m being the charge and the mass of the electron, and ϵ_0 the permittivity of free space. We calculate the first Lyman and Balmer lines of hydrogen for densities between 10ˆ19 m-3 and 10ˆ23 mˆ-3, and a temperature of 10ˆ4 K, conditions for which the ion dynamics affect the central part of the spectral lines. Our aim is the simultaneous diagnostic of the plasma and Langmuir wave parameters. By treating the electron contribution with a constant collision operator, we calculate the simultaneous effect of ion dynamics and an oscillating electric field using a numerical simulation of ion motion, coupled with a numerical integration of the Schrödinger equation. For intense electric field calculations, we show how the dynamic fields transfer the intensity of the central part of the line to an increasing number of satellites at multiples of the plasma frequency.

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