Full self-consistent stationary solutions of Vlasov-Maxwell equations

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Abstract

In order to study plasmas at thermodynamic equilibrium in a cylindrical magnetic field limit, we start from the Hamiltonian of a test particle which can be completely integrable because of the symmetries of the problem. In this idealized framework of singular aspect-ratios of the torus, the problem can be formulated as a function of a single radial variable. Considering this as a problem under constraints, a particle distribution function is obtained from the maximization of the resulting entropy. This distribution can then be used to compute the source terms coming from the plasma and leading to a self-consistent problem. The exact form of this stationary Vlasov-Maxwell equations solutions end up to be solutions of a system of self-consistent non-linear differential equations arising from the differentiation of the magnetic potential in this geometry. From there, a steep density profile can be constructed, as well as an effective potential which can reveal a separatrix that is a potential source of chaos into the system. Future applications of this toy model provides for a study of the dynamics by simulating the exact trajectories of the particles for finite aspect ratios from the obtained solutions.

Keywords: Vlasov equation, Hamiltonian dynamics, collisionless plasma, magnetic confinement

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