Formation of Multiple BGK-like Structures in the Time-asymptotic State of Collisionless Vlasov-Poisson Plasma

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Introduction

The time-asymptotic state of a finite-amplitude perturbation in a collisionless and Maxwellian plasma is typically represented as a steady-state of two non-linearly superposed [1], counter-propagating Bernstein-Greene-Kruskal (BGK) structures or modes [2 - 4] moving at speeds equal to the phase speed of the excited Langmuir waves. It has also been proposed that the time-asymptotic state of such configuration corresponds to a non-linear superposition of multiple BGK modes [5, 6]. Using high-resolution Vlasov-Poisson simulations, we show that the plasma evolves self-consistently from a finite-amplitude perturbed equilibrium state into a time-asymptotic state of multiple phase-space vortex-like structures with BGK-like features. These structures gradually fill the phase-space between the two BGK phase-velocities, resulting in the reduction of filamentation. This occurs without the need of external forcing nor the presence of an energetic plasma population. This finding suggests that the time-asymptotic regime of the plasma is rather akin to a non-linear superposition of multiple BGK-like structures. Branches of waves with nearly constant phase-speed are found to be associated with each group of BGK-like modes. Thus, the electric field and the space-averaged distribution exhibit a power-law broad spectrum, which is consistent with energy cascade, suggesting self-similarity between the multiple BGK-like structures.

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