



Multi-Extrema Electron And Ion Phase Space Structures in a 1-D Vlasov Plasma

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For a wide range of astrophysical and laboratory plasma phenomena, collisions are negligible. Then, the evolution of the particle distribution in phase space is usually described by Vlasov system. Collisionless plasmas admit a large number of wave phenomena and kinetic effects such as wave-particle resonant interactions, provide efficient mechanisms that transfer energy from fluctuations to the plasma (and vice versa), which can lead to damping effects, instabilities, nonlinear particle trapping and several interesting nonlinear coherent phase space structures. Such structures may form as a final state of an initial value problem or as a consequence of an external drive. Thus the formation and dynamics of phase space structures or phase space vortices (PSVs) in a collisionless, unbounded, one-dimensional plasma is of fundamental interest. For example, for Maxwellian distributions of electrons and stationary background ions, which are typical of extensive systems, characterized by additivity of energy, a small amplitude external drive, when chirped, has been recently shown to couple effectively to the plasma and increase both streaming of “untrapped” and “trapped” particle fraction, eventually leading to large, multi-extrema phase space vortices [1].

The generality of this mechanism has been shown to be effective in producing multi-extrema PSV with novel features such as “shark”-like structures and transient “honeycomb”-like structures in non-Maxwellian systems as well [2]. For long drawn chirps or when chirp rate is reduced, it may be expected that the ion dynamics would become relevant and may effectively participate in the formation of multiple PSVs. Also, on ion time scales, the dynamics of vortices can change significantly if there is a characteristic length scale which would interfere with the inverse cascade of these vortices. In the present work, using a numerical Vlasov-Poisson solver with dynamics of electrons and ions included, we bring out several interesting features of multi-extrema phase space structures and the possible role of ions, in both Maxwellian and as well as non-Maxwellian plasma, the details of which will be presented.

References

- [1] Pallavi Trivedi, R. Ganesh, *Physics of Plasmas*, 23, 062112 (2016).
- [2] Pallavi Trivedi, R. Ganesh, *Physics of Plasmas*, 24, 032107 (2017).