Phase Space Analysis of Hybrid Kinetic-MHD Simulation

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New phase space analysis of energetic particle simulations using the hybrid kinetic-MHD option[1] in the NIMROD code[2] will be presented.

These diagnostics examine the evolution of δf in $(v_\parallel, v_\perp)$ space and convolution of the terms in the δf[3] evolution equation. By examining the contribution from each term we can see the influence of particular drive mechanisms in the evolution of the energetic particle dynamics and their influence on the MHD. We also examine the contributions from passing and trapped subpopulations and show that both subpopulations contribute significantly to energetic particle-MHD mode evolution. In particular, this phase space analysis reveals that the region near the trapped/passing boundary is a key region of activity.

The phase space diagnostic has been applied to several problems. We will first highlight the peculiar features present in idealized examples of an internal kink mode and TAE mode. We will then apply these diagnostics to some examples from experimental equilibria to look for common and characteristic features to help identify and understand the mode dynamics in these experimentally reconstructed initial value hybrid kinetic-MHD simulations.

The intent of these new δf PIC phase space diagnostics is to help elucidate the physics of energetic particle interactions with MHD modes. The analysis is in its developmental stage and primarily phenomenological, but continued development and refinement will mature these tools to quantitative and potentially predictive measurements.

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[1] C. C. Kim, *PoP*, **15** 072507 (2008)
[2] C. R. Sovinec et al., *JCP*, **195** 355 (2004)
[3] S. E. Parker and W. W. Lee, *PFB*, **5** 77 (1993)