Modeling Nonlinear Nonstationary Kinetic Self-Organized States and Their Cascading Interactions Using Fast, Adaptive, Physically Motivated, Hybrid Particle-Continuum Algorithms

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We will discuss new algorithms for the adaptive and (presumably) efficient numerical simulation of the evolution of phase space (charge, probability) densities, $f_e(\mathbf{x}, \mathbf{v}, t)$ and $f_i(\mathbf{x}, \mathbf{v}, t)$, together with their self-consistent electromagnetic fields $E(\mathbf{x}, t)$ and $B(\mathbf{x}, t)$ or their equivalent scalar and vector potentials. Our focus will be the refinable resolution of intricate regions of phase space where trapping, untrapping and retrapping oscillations occur. The main big picture focus will be to track the evolution of KEEN waves, Kinetic, Electrostatic, Electron Nonlinear Waves (1-5) and stimulated scattering of laser radiation off KEEN waves, or SKEENS (6). The interactions, mutual dependencies and co-evolutions of Stimulated Raman Backscattering SRBS, Stimulated Raman Forward Scattering (SRFS) and SKEENS will also be highlighted (6).

Promoting reversibility of particle orbits by adaptively refining the field resolution in regions where escaping particles are retrapped within a trapping period is one such novel feature. Separate estimates of the smooth part of the distribution function considered as a continuum, with refinements executed by the use of particles in multiscale structured and thinning regions of phase space is another. We will also show the results of detailed diagnostics which have been developed to ascertain the degree of complexity of the dynamics in different partitions of phase space and various cases of KEEN waves and their mutual interactions as well as interactions with electron plasma waves (EPW). In depth simulation diagnostics are just as indispensible to decipher the nonlinear, kinetic physics of nonstationary self-organized structures such as KEEN waves, as good algorithms of simulation are, in our experience, and this will inform this presentation.

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