# COMBINING KINETIC VLASOV AND DISSIPATIVE MOMENT CLOSURE METHODS IN SPACE PLASMA SIMULATIONS

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Because of their low noise, kinetic simulations based on direct integration of the Vlasov equations are a valuable tool in the numerical modeling of space plasmas. However, in $D > 1$ spatial dimensions, the computational demand of simulations with a $2 \times D$ (or greater) dimensional phase-space grid of sufficient resolution can be prohibitive. Therefore, alternative simulation schemes in which one or more spatial dimensions can be treated using less than a fully-kinetic approach are always worth pursuing.

One such complementary approach to treating basic plasma kinetic behavior with greater numerical simplicity is know as *dissipative moment closure.* The essence of this method (G. W. Hammett and F. W. Perkins, *Phys. Rev. Lett.*, **64**, 3019-3022, 1990) is to find complex closure coefficients coupling low-order velocity moments of a distribution function that yield a linear susceptibility that approximates the true kinetic susceptibility. Whereas Hammett and Perkins found three and four moment closures that *approximate* the kinetic susceptibility of a *Maxwellian* distribution, we show here that that there are closures yielding *exact* agreement with the kinetic susceptibility of a *kappa* distribution [$f(v) \propto (v^2 + w^2)^{-\kappa}$, with $w \propto v_{\text{th}}$] for integer values of the parameter $\kappa$, provided $\kappa + 1$ moments are retained in the closure. Kappa distributions are of particular interest in the space-physics community because observed distribution typically have power-law rather than Gaussian tails. Although the dissipative closure is linear, dominant nonlinearities such as the ponderomotive force can be incorporated into the numerical algorithms.

We have developed a 2-D simulation code in which the dynamics along the dominant, $z$, direction (e.g., parallel to a current or external electric field) is modeled using full-Vlasov methods, while the perpendicular, $y$, dynamics are modeled using a five-moment dissipative closure (corresponding to a distribution with $v^{-8}$ tails). It is important to recognize that this approach goes beyond that of simple fluid closures because a separate set of moments is evolved for each point in $z$–$v_z$–$y$ phase space. Simulation results will be presented from a study of the formation and evolution of *double layers* in the auroral ionosphere. In these simulations, electrons were evolved in the strong-magnetization limit, with ions treated as unmagnetized using the five-moment dissipative closure.

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2. H - Waves in Plasma

3. (a) Numerical Simulations

4. I - Invited Paper, Program chair: Joe Huba and Wayne Scales

5. No special instructions