Self-Consistent Hybrid Model: Applications to the Polar and Solar Winds

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We discuss a self-consistent hybrid modeling technique that combines kinetic and fluid calculations. The model is particularly suitable for describing plasma outflow phenomena. The kinetic calculations are in the form of Monte Carlo simulations, which follow the global evolution of the ion velocity distributions along the outflow while taking into consideration the influence due to physical mechanisms of microscopic scales. The fluid equations are used to describe the ambipolar electric field and the properties of the thermal electrons. In the case where there are non-thermal electron features, the evolution of the suprathermal electron velocity distribution is considered as well, based on a Monte Carlo simulation similar to those for the ions. The model utilizes an iterative scheme between the results of the fluid and kinetic calculations, generating self-consistent solution upon convergence. The self-consistent hybrid model has been applied to the ionospheric polar wind and the solar wind. For the polar wind, the model takes into account the global kinetic collisional effects of the photoelectrons and shows that these suprathermal electron effects may drive the polar outflow. For the solar wind, the kinetic effects due to the resonance between ion cyclotron waves and the protons and alpha particles are considered. The wave-particle interaction is found to lead to the preferential acceleration of the heavier ions and the formation of double-peaked proton velocity distributions, two of the features that have been frequently observed in the high-speed solar wind.