Gyrokinetic and Gyrofluid Modeling of Low-Frequency Phenomena in Well-Magnetized Space Plasmas

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Often, one is interested in frequencies much lower than either the electron or ion cyclotron frequency in well-magnetized regions of the magnetosphere and ionosphere. In such cases, a gyrokinetic (or drift-kinetic) model may be a very useful approximation. There are existing three-dimensional electromagnetic δf gyrokinetic turbulence simulations that model both ions and electrons as kinetic using realistic mass ratios. These codes can be used for studying collisionless inner magnetosphere plasmas where β is low. Both the benefits of using gyrokinetic simulation methods as well as the approximations and appropriate limits involved will be discussed. We will also discuss both the benefits and limitations of the δf method. In addition, a linear one-dimensional gyrofluid model of Alfvén wave propagation in the auroral ionosphere will be discussed. Alfvénic wave packets have dramatic acceleration in phase velocity when entering the auroral acceleration region and resonant electrons can be "picked up" and accelerated to 1-10 keV energies. Finally, we will discuss how these kinetic methods can be used to close macroscopic MHD (or so-called "extended-MHD" models).