Paper ID: 3574
student

MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Fluid and Materials Sciences (2)

Author: Mr. Ken Miura
University of Toronto, Canada, alter@idirect.com

Prof. Clinton Groth
University of Toronto Institute for Aerospace Studies, Canada, groth@utias.utoronto.ca

DEVELOPMENT OF A TWO-FLUID MAGNETOHYDRODYNAMICS MODEL FOR NON-EQUILIBRIUM ANISOTROPIC PLASMA FLOWS

Abstract

A multi-species magnetohydrodynamic (MHD) model based on an extended fluid dynamics description for each plasma species is proposed for the prediction of the transport of fully ionized non-equilibrium anisotropic plasmas. In particular, a two-fluid (ions and electrons) plasma model is described that makes use of a 10-moment or Gaussian anisotropic moment closure to model ion and electron species transport. The ion and electron moment equations are fully coupled to the complete set of Maxwell's equations which govern electromagnetic wave propagation within the plasma and a relaxation time approximation is used to model non-equilibrium Coulomb collisional processes between the ions and electrons. Unlike conventional MHD models, the proposed two-fluid model is capable of taking into account large temperature anisotropies and temperature differences between the electrons and ions, both of which can occur for low-density, high-temperature plasmas and/or strongly magnetized plasmas. The governing system of partial differential equations are well suited for solution by Godunov-type finite-volume methods provided that the disparate scales can be dealt with. A higher-order finite-volume method is developed here for the solution of the one-dimensional form of the two-fluid plasma model and dispersion analyses of the discretized equations indicates that a stable and practical scheme is possible if a fully implicit time marching scheme is adopted. Instabilities that result from large timesteps are mitigated using temporal limiting. Numerical results for several one-dimensional unsteady plasma flows are described and demonstrate the potential of the proposed multi-species plasma model for predicting non-equilibrium anisotropic plasma flows in engineering applications such as those encountered in electric space propulsion devices. The future extension of the model and numerical approach to partially ionized plasmas in two and three space dimensions is also discussed.