Center for Scientific Computation
And Mathematical Modeling
University of Maryland, College Park

CSCAMM

PICSciE Princeton Institute for Computational Science and Engineering

A Program on

"Numerical Methods for Plasma Astrophysics: From Particle Kinetics to MHD"

A Joint CSCAMM - PICSciE Program Spring 2004

March 22-25, 2004

Organizers: William Dorland, James Drake, Björn Engquist, James Stone, Eitan Tadmor, William Tang

Invited Participants

Jorge Balbas, UCLA
Steven Cowley, UCLA
Pierre Degond, Universite Paul Sabatier
William Dorland, University of Maryland
James Drake, University of Maryland
Björn Engquist, Princeton University
Charles Gammie, University of Illinois
Tom Gardiner, Princeton University
Greg Hammett, Princeton University
John Hawley, University of Virginia
Michael Hesse, NASA
Yannis Kevrekidis, Princeton University
Jean-Noel Leboeuf, UCLA
C. David Levermore, University of Maryland
Angus MacNab, University of Maryland
Eve Ostriker, University of Maryland
Eliot Quataert, UC-Berkeley
Prateek Sharma, Princeton University
Mike Shay, University of Maryland
James Stone, Princeton University
Eitan Tadmor, University of Maryland
William Tang, Princeton University
George Vahala, College of William and Mary
George Zaslavsky, New York University

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SCIENTIFIC BACKGROUND. Most of the visible matter in the Universe is a plasma, that is a dilute gas of electrons, ions, and neutral particles. Numerical methods are the only viable way of studying the dynamics of astrophysical plasmas. Using numerical simulations, much progress has been made in recent years in understanding a variety of important problems, including the structure and evolution of accretion flows around compact objects such as neutron stars and black holes, and the decay rate and fluctuation statistics of compressible MHD turbulence. Almost without exception, such advances have used multidimensional MHD codes. However, for many astrophysical problems, the MHD approximation may not be valid. Examples include the dynamics of very dilute accretion flows, the dynamics of turbulent plasmas near the energy dissipation scale, or magnetic reconnection. In order to address fundamental problems in these areas, it will be necessary to move beyond the MHD approximation, and consider particle kinetics. However, a full time-dependent and multidimensional numerical solution to the Boltzmann equation is intractable in most circumstances, thus novel methods will be required.

GOALS. To bring together astrophysicists, plasma physicists, and applied mathematicians to discuss future developments in numerical methods for astrophysical plasmas. Topics to be covered include:

I. reviews of the astrophysical problems that motivate future developments, including what we have learned from current techniques, and why we need new methods,

II. reviews of modern methods for MHD, including adaptive mesh techniques for multiscale problems, and methods for non-ideal MHD, and

III. reviews of modern methods for collisionless plasma dynamics that result from various approximations to the full collisionless Boltzmann equation. A key ingredient of the workshop is to engage plasma physicists and applied mathematicians with experience in plasma kinetics in the development of methods suitable for astrophysical plasmas.

The format of the program calls for a limited number of formal presentations, and ample time for informal interaction (and hopefully even some coding).

The Center for Scientific Computation
And Mathematical Modeling (CSCAMM)
CSIC Building #406, Paint Branch Drive
University of Maryland, College Park

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