AN EVENT-DRIVEN APPROACH TO MODELING OF PLASMAS: OVERCOMING THE COMPUTATIONAL CHALLENGES OF TRADITIONAL TIME-DRIVEN TECHNIQUES

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Computer simulation of many important complex physical systems such as the Earths magnetosphere has reached a plateau because most conventional techniques are ill equipped to deal with the multi-scale nature of such systems. The traditional approach to modeling spatially distributed physical systems has been based on time-driven (or time-stepped) simulations (TDS) where the whole state of the system is updated synchronously at discrete time intervals. This method has two inherent inefficiencies with severe consequences: (i) the well-known time step restriction imposed by a global CFL condition, (ii) uniform (and unnecessary system update) computational work independent of the level of activity in a given region. We have been working on an entirely different (asynchronous) simulation methodology based on a discrete event-driven approach. Here we report on our progress where we have developed a general parallel infrastructure based on this new technique. We demonstrate the power of this technique through a parallel hybrid simulation of a fast magnetosonic shock as well as the electrostatic simulation of spacecraft charging. We find speed up as large as a factor of 300 compared to the time-driven codes. In our technique, individual parts of the global simulation state are updated on a "need-to-be-done-only" basis and all simulation entities (individual particles/phase space elements/fluid elements, local fields) evolve on their own physically determined time scales. This has immediate implications for all types of plasma simulations. For example, one of the obstacles to the use of Vlasov codes in 2D and 3D is the fact that most of phase space is inactive but still has to be carried in the computation using standard techniques. This inefficiency makes the Vlasov codes almost unusable in 3D where the phase space (consisting of three spatial coordinates and three components of velocity) is very large. In our technique, only the active regions of phase space are updated.

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2. H - Waves in Plasma
3. (a) Numerical Simulations
4. I - Invited Paper, Program chair: Joe Huba
5. Will be showing some movies so need to be able to plug in my laptop to the projector