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○ **Deflection & Disruption Modeling and Testing**

An Overview of Numerical Radiation Transport Techniques in Asteroid Deflection Modeling

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Detailed modeling of asteroid deflection via thermal radiation requires simulation of photon transport and photon matter interactions. We will provide an overview of the three most common photon transport methods used in radiation hydrodynamics simulations: Flux Limited Diffusion (FLD), discrete ordinates (S_N), and Implicit Monte Carlo (IMC) [1]. These three methods are frequently used in Inertial Confinement Fusion (ICF) simulations, which, despite the difference in length scales, present similar simulation challenges to asteroid modeling with regard to the large range of density, temperature, opacity, and velocity required. Both kinds of simulations stress both the accuracy of radiation hydrodynamics models and computational resources.

Each radiation transport method has strengths and weaknesses for asteroid deflection modeling; these relate trade-offs between the accuracy of various approximations and simulation run time. Diffusion throws away all angular information about the radiation intensity, making it particularly inaccurate in regions with low opacity, but very fast compared to the other two methods. S_N, which integrates the transport equation along a series of discrete angles, is more accurate, but consumes more simulation time. The presence of discrete ray directions produces artifacts in low opacity regions called "ray effects", and can also limit the accuracy of modeling anisotropic scattering such as Compton scattering. IMC models radiation transport by simulating computational particles that undergo emission, scattering, and absorption events that stochastically model photon behavior. IMC can in principle simulate radiation transport very accurately; for example, anisotropic scattering events can be directly modeled, and Doppler shifts allow for accurate modeling of material motion effects. However, the expense of simulating many particles often makes IMC very expensive compared to the other two methods, and the stochastic nature of the method adds statistical noise to output quantities such as temperature [1], [2].

We will also discuss two other aspects of radiation hydrodynamics simulations. One is the multigroup approximation, which models opacities in frequency space as constant over ranges of ν called groups. This approximation is used to limit the amount of opacity data. The other concerns approximate material motion corrections to radiation transport. Certain common approximations (for example, modeling radiation momentum deposition as a radiation pressure) are not accurate in asteroid deflection scenarios because of the presence of vacuum regions [2].

We will show simulation results illustrating the behavior of transport methods, and the results of one- 1 and two-dimensional 2 asteroid deflection simulations performed with the Kull ICF code [3].

Comments:

(Oral session preferred; not a student paper)

References

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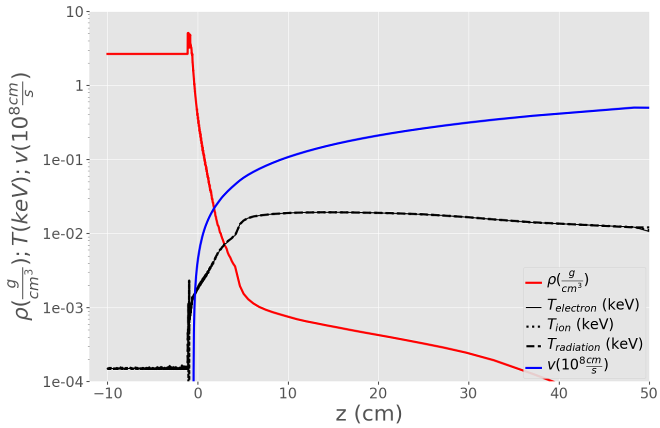

Figure 1: Density, temperature, and velocity vs. z in a 1D asteroid simulation using IMC in Kull, $10^{-6}s$ after illumination from a photon source with fluence of $10^{14}\frac{erg}{cm^2}$ and a 1 keV blackbody spectrum.

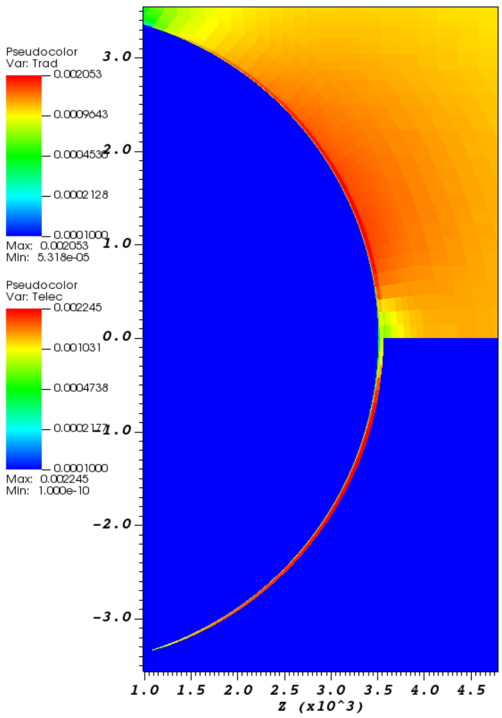

Figure 2: Radiation temperature (top) and electron temperature (bottom) in keV for a 2D Kull IMC simulation of a 35 m radius S_iO_2 asteroid, $6.7^{-6}s$ after illumination from a 1 kiloton photon source with a 1 keV blackbody spectrum.

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