Contribution ID: **41** Type: **Talk**

Discrete implicit Monte-Carlo (DIMC) scheme for simulating radiative transfer problems

Thursday 9 June 2022 11:20 (20 minutes)

We present a new algorithm for radiative transfer, based on a statistical Monte-Carlo approach, that does not suffer from teleportation effects and yields smooth results. Implicit-Monte-Carlo (IMC) techniques for modelling radiative transfer exist from the 70's. However, in optically thick problems, the basic algorithm suffers from 'teleportation'errors, where the photons propagate faster than the exact physical behavior. One possible solution is to use semi-analog Monte-Carlo (ISMC), that uses two kinds of particles, photons and discrete material particles. This algorithm yields excellent teleportation-free results, however, it also results with nosier solutions due to its discrete nature. We derive a new algorithm, Discrete implicit Monte-Carlo (DIMC) that uses the idea of the two-kind discrete particles and thus, does not suffer from teleportation errors. DIMC implements the IMC discretization and creates new radiation photons each time step. We test the new algorithm in both 1D and 2D problems, and show that it yields smooth, teleportation-free results. We finish in demonstrating the power of the new algorithm in a classic radiative hydrodynamic problem, an opaque radiative shock wave. This new MC algorithm, will enable the astrophysics community to accurately simulate radiative transfer in problems that transition from optically thick to optically thin.

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Session Classification: Accretion Disks

Track Classification: Accretion Disks