Particle Monte Carlo Algorithms with Small Number of Partilces in Grid Cells

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The Direct Simulation Monte Carlo (DSMC) analysis of two- and three-dimensional rarefied gas flows requires computational resources of very large proportions. One of the major causes for this is that, along with the multidimensional computational mesh, the standard DSMC approach also requires a large number of particles in each cell of the mesh in order to obtain sufficiently accurate results. In this paper we will present two modified simulation procedures which allow more accurate calculations with a smaller mean number of particles ($\langle N \rangle \sim 1$)in the grid cells. In the new algorithms, the standard DSMC collision scheme is replaced by a two-step collision procedure based on "Bernoulli trials" scheme or its simplyfied version, which is applied twice to the cells (or subcells) of a dual grid within a time step. The modified algorithms use a symmetric Strang splitting scheme that improves the accuracy of the method to $O(\tau^2)$ with respect to the time step τ making the modified DSMC method a more effective numerical tool for both steady and unsteady gas flow calculations on fine multidimensional grids. The latter is particularly important for simulation of vortical and unstable rarefied gas flows. The modified simulation schemes might be useful also for DSMC calculations within the subcell areas of a multilevel computational grid.