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Development of the Martian upper thermosphere and exosphere DSMC model

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Although the exosphere is traditionally modeled by Chamberlain approach, recently they are often calculated by using the direct simulation Monte Carlo (DSMC) method. Chamberlain theory, which is based on the Liouville theory, calculates the exospheric densities and velocity distributions using exobase ($Kn \sim 1$) conditions as boundary conditions on the assumption that collisions are negligible above the exobase, collisions maintain a complete Maxwellian distribution below the exobase, exobase parameters are uniform over a spherical exobase, and the exosphere is spherically symmetric. Around the exobase, however, there exists a transitional domain (between collision and collisionless domains) where the collision frequency is not high enough to maintain equilibrium in the flow but the momentum exchange in a collision between atmospheric molecules is still important. Moreover the exosphere is not spherical symmetric due to non-uniform exobase parameters.

In the transitional regime, where the Knudsen number region between 0.01 and 10, neither a continuum nor a free molecule assumption would be appropriate. The DSMC method is a standard numerical method for solving such a rarefied gas flow. In the DSMC method, the flow is represented by the positions and velocity component of many simulated particles, which obey the underlying physical law governing real flow. Its solutions converge to Boltzmann equation solutions in the limit of infinite number of simulated particles, and vanishing cell size and t . Chemical reacting and polyatomic gases, which are hard to deal with by the direct solution of the Boltzmann equation, can be analyzed by the method.

We have been developing a model for the Martian upper thermosphere and exosphere using the multi-species DSMC method. In this paper, we will show the initial results.