Numerical simulation of 3D flow around sounding rocket by DSMC method

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In order to study the dynamics and the thermal energy budget in the lower thermosphere, simultaneous temperature and density measurements between 100 - 150 km were carried out in situ by a sounding rocket at Kagoshima, Japan on February 6, 2002. The observed data are strongly disturbed by aerodynamic effects caused by the supersonic motion of the rocket vehicle, since the experimental method is based on the Electron Beam Fluorescence (EBF) technique and the measurement volume of the instrument is located in the vicinity of the payload. From the information on the attitude and the spin phase of the rocket, the disturbance on the measured density shows clear ram/wake modulation originating from compression/rarefaction in the density field around the payload.

For typical rocket experiments at 80 - 120 km, aerodynamic condition is generally called 'transition regime' from continuum flow to free molecular flow, it is very difficult to solve theoretically. We applied the Direct Simulation Monte Carlo (DSMC) method to the demonstration of the three-dimensional flow around the payload. The numerical simulation is performed by providing a simplified shape of the rocket vehicle and under atmospheric conditions of the actual flight. The comparison of density modulation derived from the DSMC results with the relative density perturbation of the original measurements shows good agreement, and undisturbed atmospheric density profile is successfully obtained by correcting the measured disturbance.

This is the first fully three-dimensional treatment of the DSMC application for the sounding rocket observation, and similar quantitative analysis is required for the complete reproduction of the ram/wake modulation.