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Modeling of the stardust reentry flows with ionization in DSMC

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Abstract

Ionized hypersonic flows for the Stardust blunt body at 80 km altitude were simulated using the direct simulation Monte Carlo (DSMC) method, at a speed of 12.8 km/s, the fastest man-made object to enter the Earth's atmosphere. The modeling of ionization processes and energy exchange between translational and internal modes in DSMC is discussed. Eleven species including 5 ions and electron and chemical reactions are considered in the flowfleld. It was found that the charge neutrality assumption held in the bow-shock region and using this assumption, ionization processes were modeled. The electron-vibration energy exchange model is important for the prediction of electron and vibrational temperature profiles, and this process was modeled by Lee's relaxation time for the first time in DSMC. DSMC results were compared with CFD(DPLR) results, with the main result that DSMC predicted lower energy exchange rates between translational and internal modes than CFD. The lower energy exchange rates resulted in lower dissociation rates and a lower degree of ionization in DSMC. Furthermore, radiation was calculated using the NEQAIR code from the CFD(DPLR) and DSMC flowfields along the stagnation line for NO, N_2^+, N, and O. The development of the DSMC models significantly affected the N radiation and O radiation in ultraviolet range.

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AB - Ionized hypersonic flows for the Stardust blunt body at 80 km altitude were simulated using the direct simulation Monte Carlo (DSMC) method, at a speed of 12.8 km/s, the fastest man-made object to enter the Earth's atmosphere. The modeling of ionization processes and energy exchange between translational and internal modes in DSMC is discussed. Eleven species including 5 ions and electron and chemical reactions are considered in the flowfleld. It was found that the charge neutrality assumption held in the bow-shock region and using this assumption, ionization processes were modeled. Modeling of Supersonic Plasma Flows in the VKI Minitorch by Means of a Collisional Radiative Model M. Panesi, A. Munafo & O. Chazot. An Experimental Investigation of Hypersonic Transverse Jet Interactions in Laminar, Transitional and Turbulent Flows G.S. Freebairn, R.R. Boyce & N. Mudford. CFD Modeling of Thermally and Chemically Nonequilibrium Flows in Discharge Channel and in Subsonic Plasmatron Jets Around of the Flat-Face Model V.I. Sakharov, A.F. Kolesnikov, A.N. Gordeev & J.-L. Verant. Session 15: Airbreathing Propulsion IV. Mathematical Interpretation of Observational Data of the Stardust SRC Re-Entry M.I. Gritsevich. The Study of Hypersonic Heat Transfer by Liquid Crystals Thermography V.N. Kovrizhina, A.M. Kharitonov, A.P. Petrov et al.