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Rarefied aerodynamic characteristics of aero-space-planes: a comparative study of two gas-surface interaction models

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Abstract:

Accurate computations of aerodynamic forces are very important for the design of aero-space-planes. In rarefied flow, the computation of momentum and energy transfer between the flow and the vehicle's surface occurs in two steps: incidence and re-emission of gas molecules. While incidence is well understood, the re-emission process is still today not yet completely clear, thus many models have been developed. In the present paper, the effects of the re-emission models by Maxwell and by Cercignani-Lampis-Lord have been compared by means of direct simulation Monte Carlo (DSMC) codes. Two different study cases have been considered: a complete aero-space-plane and a wing profile. Computer simulations have been carried out using two DSMC codes to investigate hypersonic flows at an altitude of 120 km where for both the wing section and the vehicle the flow is in transitional regime. The results pointed out that the influence of the interaction models, considering specular, semi-specular and full diffusive re-emission is pretty strong, while the Cercignani-Lampis-Lord and the Maxwell models are almost equivalent.

Keywords:

Gas-surface interaction models,

Direct simulation Monte Carlo method,

Aerodynamic coefficients of an aero-space-plane.

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