Introduction

The reliable prediction of radiative and convective thermal loads on a spacecraft’s thermal protection system during high-speed entry into a planetary atmosphere requires adequate consideration of the non-equilibrium character of the flow, taking into account the elementary processes of ionization, excitation and ionization of heavy particles and electronic collision. In particular, electronic excitation is strongly connected to the instantaneous electron energy distribution function at a given point, since the latter dictates the actual rates of electron impact processes, while at the same time the instantaneous population distributions on the internal electronic and vibrational quantum states reflect on the shape of the EEDF through a complex interplay between inelastic and superelastic collisions, often leading to non-Maxwellian EEDFs and corresponding non-Arrhenius impact rate coefficients.

The spectral intensity in the post-shock is described in the present work by solving the radiative transfer equation (RTE).

Dedicated tools have been implemented extending the chemical kinetic scheme with the ATOMIC MODEL in order to enable a corresponding method for the calculation of the absorption coefficient, and the composition of the species, chemical composition and the distribution of excited states. Electron-impact rate coefficients are directly calculated integrating the chemical composition and the distribution of atomic and molecular excited states. The model has been described. The model solves the steady state shock wave problem. An one-dimensional steady shock wave model coupling a comprehensive chemical kinetic scheme with a Boltzmann solver for the EEDF and an RTE. The results have been shown in the case of a pure hydrogen plasma and a 7-species mixture: H, He, H, H, H, H, H. The chemical kinetic scheme contains a total of 71 reactions and 14 species. The model solves the steady state shock wave problem. The problem has been solved using the mole fractions of the species, chemical composition and the distribution of excited states. The model solves the steady state shock wave problem, taking into account the non-equilibrium character of the flow.

Shock Wave Solver

For the purpose of this work, a reliable description of the fluid flow is obtained solving the following set of four continuity equations for the mass density, momentum, internal energy and entropy.

Collisional-Radiative Model

Jupiter’s atmosphere is mostly composed by molecular hydrogen and atomic helium and for this work we have assumed a pure hydrogen plasma. The chemical kinetic scheme contains a total of 71 reactions and 14 species. The model solves the steady state shock wave problem. The problem has been solved using the mole fractions of the species, chemical composition and the distribution of excited states. The model solves the steady state shock wave problem, taking into account the non-equilibrium character of the flow.

Electron energy distribution function

Electron impact rate coefficients are calculated by integrating the relevant cross section over the EEDF determined by solving the following Electron-impact Cross Section. Inelastic collisions depopulate the high energy tail of the EEDF and correspond to excitation and ionization by electron-impact processes. Superelastic collisions correspond to de-excitation and recombination and tend to enhance the tail of the EEDF.

Radiation modeling

The spectral intensity in the post-shock is described in the present work by solving the radiative transfer equation (RTE).

References