Prediction of UV Radiation for Soyuz Descent Vehicle Reentry

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For reentry into the Earth atmosphere at the escape velocity and higher, radiation flux may give a significant contribution to the total heat flux to the vehicle surface. At lower velocities, the radiation contribution to heat flux is insignificant; however, the investigation of characteristics of radiation is important for better understanding of diverse physico-chemical processes occurring in the shock layer and affecting the aerodynamic characteristics and heat transfer.

The present study is a continuation of [1], where a method was described of calculation of nonequilibrium ultraviolet (UV) radiation in systems of electron molecular bands from plasma formations under conditions of hypersonic flow. The method was based on numerical solution of three-dimensional Euler equations for a nonequilibrium mixture of chemically reacting gases complemented with conservation equations for electron-excited states of molecules. A locally equilibrium approximation was also used in [1], where populations of molecular electron states are assumed to be Boltzmannian. The nonequilibrium UV radiation from the shock layer near the Soyuz-TMA descent vehicle upon reentry into the Earth atmosphere in the altitude range 45 - 70 km was calculated in [1] as an example, and comparison was made with experimental data in the spectral range 230-280 nm obtained aboard the International Space Station (ISS).

In the present study calculations were made of UV radiation from the Soyuz-TMA descent vehicle reentry for higher altitudes (70-100 km) where viscous effects become significant. Simulation was performed on the basis of numerical solution of the Navier–Stokes equations for thermo-chemical nonequilibrium air flow. Using the Treanor and Marrone CVDV model the effect of vibration-dissociation coupling on UV radiation is studied. Molecular bands most contributing to radiation in the near UV spectral range are identified. Satisfactory agreement was observed with full-scale radiation observation during the Soyuz-TMA descent from aboard the ISS.

1. Plastinin, Yu.A., Zemliansky, B.A., Karabadzhak, G.F. et al., Measurements and Analysis of UV_Radiation Intensity of Plasma Structure Along Orbital Re_Entry Trajectory of Space Vehicle “Soyuz_TM” Based on Observation Data Obtained on Board ISS, *European Conference for Aerospace Sciences* (EUCASS). Moscow, 2005 (CD_ROM Publication).