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Determination of Trajectory Parameters and Some Parameters of Planetary Atmospheres by Means of Spectral Heat Radiation Generated by Entering Space Vehicle

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The possibility of determining trajectory parameters of an entering space vehicle and some characteristics of Martian atmosphere (the element composition and density) by measuring spectrum of heat radiation from high-temperature gas around the space vehicle is discussed.
For development of experimental investigations into the atmospheres of planets by means of space probes, there is possibility to the use of remote methods similar to those used in meteor astronomy (for spectral analysis of meteor burst) with the aim of determining the density of the Earth's atmosphere at altitudes 70-150 km. These methods are based on measurement and analysis of the spectral, energy, and time characteristics of the meteor burst electromagnetic radiation, which accompanies the deceleration and ablation of meteorite bodies in the atmosphere. In principle, such methods may be used to determine the density and composition of the planet's atmosphere at altitudes above the point at which the brake parachute of the lander is opened.

In the present paper, an attempt is made to analyze the possibility of using such remote methods for Martian atmosphere. The case is considered when the burst of radiation is generated by MSRO-like space vehicle (the Mars Sample Return Orbiter), entering Martian atmosphere along a typical trajectory, and the spectral radiation emissive (spectral signature) of which is detected by an Orbiter with an optical electronic device operating as a spectroradiometer.

 ...FIGURE....see pdf abstract

The computational radiative fluid dynamic (CRFD) model is presented, which can be used to solve the problem under consideration. This model is based on the Navier- Stokes equations for prediction parameters of flowfield around entering space vehicle, on the kinetic equations of chemically reacting gases, and on the radiation heat transfer equation. The character of the computational model consists in the necessity to calculate directional radiation emissivity from whole disturbed gas area in direction to Orbiter (see Figure).
Two physical models are discussed in the paper. The first one is the chemically nonequilibrium model of Martian gases heated by entering space vehicle. The Boltzmann distribution of molecular and atomic particles over internal energy levels is supposed in this model. The second model takes into account non-equilibrium physical-chemical processes, because of the small number of collisions in shock layer and wake the gas passing through the bow shock does not achieve the Boltzmann equilibrium.
Analysis of the existing information about the absorbing components of Martian atmosphere indicates that the radiation burst generated by the space vehicle may escape out of the atmosphere and be detected by Orbiter.