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P4.3009 Precursor phenomena ahead of a re-entry vehicle into Earth atmosphere

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Thermochemical and radiative transfer processes in a shock layer should be clarified to develop a future space vehicle because of their affecting the aerodynamic forces and heating rates. Although the two-temperature model has been utilized widely for a long time, the accuracy of the reaction rate coefficients might be not enough due to its being deduced from the limited experimental data which is different from those of an actual vehicle flight. In this study the chemical reaction process in the shock layer is investigated by observing not time-frozen but temporal radiation profiles in a re-entry flight condition and comparing with the calculated ones with the two-temperature model. We predict that these profiles will not coincide and the reason for the discrepancy would come from the precursor phenomena, which is photochemical and excitation reactions ahead of the shock wave and re-absorption of radiation emitted from a shock layer.
The shock tube facility is shown in Fig.1, which can generate the normal shock speed of 6.0 km/s under the pure N_2 gas pressures of 50 and 100 Pa. Time-resolved emission spectroscopy is applied to measure the temporal profile of radiation emitted from the shock layer through the test section. Radiations of N_2 (2+) (1, 0) band head, N2+ (1-) (0, 0) band head and N 3p 4S0 - 3s 4P triplet are targeted in the study. The calculated flow with the two-temperature model is one-dimensional, and the species considered here are N2, N, N2+, N+ and e-. Therefore, a thermal nonequilibrium is considered.
The experimental and numerical results are shown in Fig.2. The precursor radiation of N_2^+ ahead of the shock front indicates photoionization reaction occurs far from the shock front. The fast decline of the measured radiation intensity means the precursor phenomena has a great influence on chemical reactions

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