Internal energy relaxation processes of nitrogen plasmas at different electronic states in an entry flight condition

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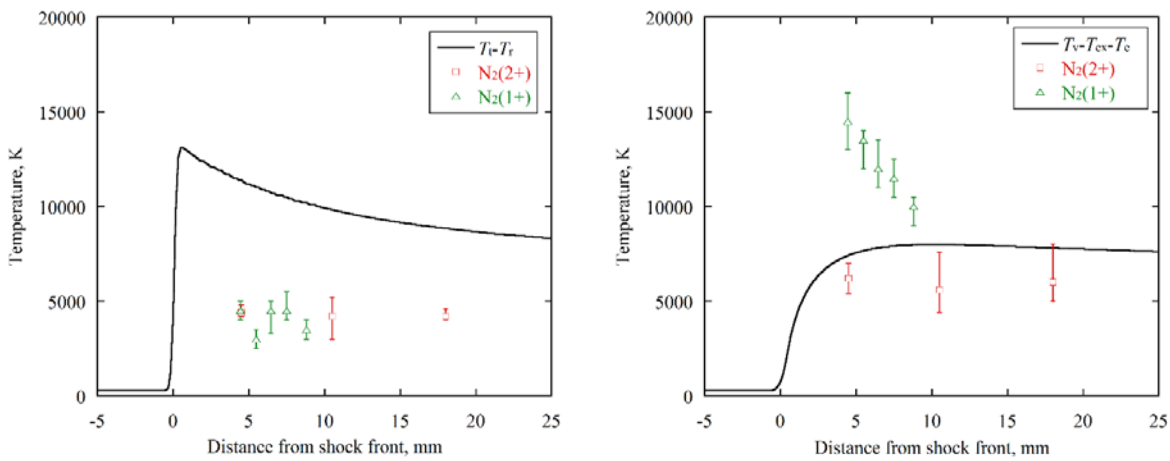
Entry flight is a technical issue on the development of space vehicles used for planetary exploration. Particularly, characteristics of plasma flows around the space vehicles should be clarified for the better prediction of aerodynamic forces and heating rates on the body during entry flight. In the present study, to investigate the internal energy relaxation process of nitrogen plasma behind a shock wave, spectroscopic measurements are conducted using a shock tube facility in an entry flight condition. The shock velocity and the spectrum position from the shock front are determined by the double laser schliren measurement system. Emission spectra of N_2(1+), and N_2^+(1-) are obtained by means of the spatially- resolved imaging spectroscopy. The rotational and vibrational temperatures are derived from the measured spectra by a spectrum fitting method and finally temperature distributions correlated to the shock front are obtained as shown in Figs.1(a) and (b). In these figures, the calculated temperatures are plotted as solid lines for comparison. From Fig.1(a), it is found that the measured rotational temperatures of N_2(1+) and N_2(2+) are almost same behind the shock wave and much lower than the calculated rotational temperatures, showing the notational nonequilibrium process. On the other hand, from Fig.1(b), the measured vibrational temperature of N_2(1+) is much higher than that of N_2(2+) . This is considered to be due to the difference of internal energy relaxation process depending on the electronic energy state. The present result has indicated that the electronic state has great influence on the relaxation process behind the shock wave.



(a) Rotational temperature (b) Vibrational temperature

Fig. 1 The spatial distribution of temperatures correlated to the distance from shock front