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Atomic and Molecular Phases of Persistent Train by Spectroscopic Observation

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Bright fireballs sometimes leave a long-lasting glow that is called a persistent train which lasts long after the disappearance of its parent meteor. Although persistent trains has been an object of study for a long time, the knowledge of physical process of trains is still far from satisfactory. The main reason is that a number of spectra of persistent train with high quality are still lacking and spectra in a wide wavelength range are also still absent.

We report here slitless spectroscopic observations of persistent trains performed with an image intensified video camera during the 2001 Leonid meteor storm over Japan. Video observation was carried out using two co-aligned GEN II image intensifiers in the spectral range of 400–930 nm; spectroscopic camera had an objective grating of 150 grooves/mm, while imaging camera recorded train images simultaneously. The MEteor TRain Observation(METRO) campaign has been widely announced to amateur observers in Japan since the 1998 Leonids and resulted in great success for triangulation observations. These triangulation data provided from METRO campaign enabled us to calculate three-dimensional structure of trains with its precise height information.

From our previous study(Earth, Moon, & Planets 2005, in press), an extensive combined spectrum of one persistent train was investigated from simultaneous observation in UV and visible regions(300–930 nm). The emission energy contributions in the persistent train from UV to near-IR wavelength region are (300–400 nm) / (400–600 nm) = 2.5 and (300–600 nm) / (600–900 nm) = 1.0. It is also important to note that at the lower altitude of 88.0 km, Na I(589 nm) was stronger than Mg I(518 nm) and was almost comparable to O_2(0,1)($\sim$ 865 nm), on the contrary, Mg I and O_2(0,1) were stronger than Na I in the upper altitude of 90.0 km. Temperatures in persistent trains have been measured by atmospheric O_2 A(0,1) band at the wavelength near 864.5 nm and rotational temperatures were estimated with a function of time at the appropriate altitude. We can say that at least for the Leonid meteoroids the cooling time scale of train strongly depends on the initial mass of its fireball. Based on cooling constant calculated from our previous results, we estimated a temperature of $\sim$ 130 K as a final exothermic temperature at early stage of persistent trains.

According to the analysis of 5 cases of persistent trains, we recognized that continuum dominated emission, so called $the\ molecular\ phase$, begins between 30 and 40 seconds after meteor disappearance. We shall focus on an early stage of persistent trains, named $the\ atomic\ phase$, and $the\ molecular\ phase$ separately. In this paper, we will discuss atomic and molecular phases of 5 excellent persistent spectra and its images.