Revised Water Hot-band Emission Model in Comets

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While the fundamental vibrational bands of water are significantly hamphered by the telluric atmosphere from the ground-based observatories, vibrational hot-band emission lines of water near 2.9 microns are readily observable and provide us with precious information about cometary water (gas production rate, rotational excitation temperature and etc.). Water production rate, Q(H_2O), is important as a base-line for chemistry in cometary ices, so the precise determination of Q(H_2O) is one of the most important issues in comet science. Although Q(H_2O) could be estimated from the observations of OH (in UV or radio domains) or the forbidden oxygen lines in optical region, these estimates are affected by uncertainties in the used parameters (e.g., a photo-dissociation rate of H_2O by solar UV). Thus, the modeling of the hot-band emission lines for direct detection of H_2O in comets are considered important. A basic model of water hot-band emission in comets was developed by Dello Russo et al.[1]. This model can basically reproduce the water hot-band emission lines in comets around 2.9 microns. However, there are a few cases where observed cometary line intensities diverge from model predictions. Here, we propose some improvements to the water fluorescence model in order to derive more accurate Q(H_2O), rotational excitation temperature and an ortho-to-para abundance ratio in H_2O.

In the basic model described by Dello Russo et al.[1], the vibrational ground state is assumed to follow the Boltzmann distribution at a given rotational excitation temperature (T_{rot}). For example, in the case of (2,0,0)—(1.0,0) vibrational hot-band (sometimes described as $2v_1 - v_1$), H_2O molecules in the ground state (0,0,0) are excited into upper vibrational state (2,0,0) by the solar radiation field (cascade from higher vibrational levels are also considered), and then the molecules go down to the lower state (1,0,0) followed by the transition into (0,0,0). The solar radiation field is modeled as the blackbody at ~5800 K in the previous model.

However, treatment of the solar radiation field as a blackbody may produce significant errors for some transitions. There are no significant absorption lines in the solar spectrum near 3 micron regions. However, in the case of water hot-bands, the molecules were excited by the solar radiation field in the shorter wavelength regions. Figure 1 shows the situation of the water. The solar radiation field near 1.4 microns (~7000 /cm) is important to the excitation into upper vibrational states. Furthermore, the actual solar spectrum near 1.4 microns is different from a blackbody (5770 K) by about 10 %.

Therefore, we used the high-resolution modeled solar spectrum in our revised H_2O hot-band model. Furthermore, we checked the vibrational transitions that contribute to the hot-band near 2.9 micron [3]. Based on this, some vibrational transitions were added into the model. We will present our revised H_2O hot-band model and demonstrate the difference in modeled H_2O spectra between previous and revised models.

References: [1] Dello Russo, N. et al. (2004) *Icarus,168,* 186–200. [2] Dello Russo, N. et al. (2005), *ApJ, 621,* 537–544. [3] Barber, B. et al. (2006), *MNRAS, 368,* 1087–1094.

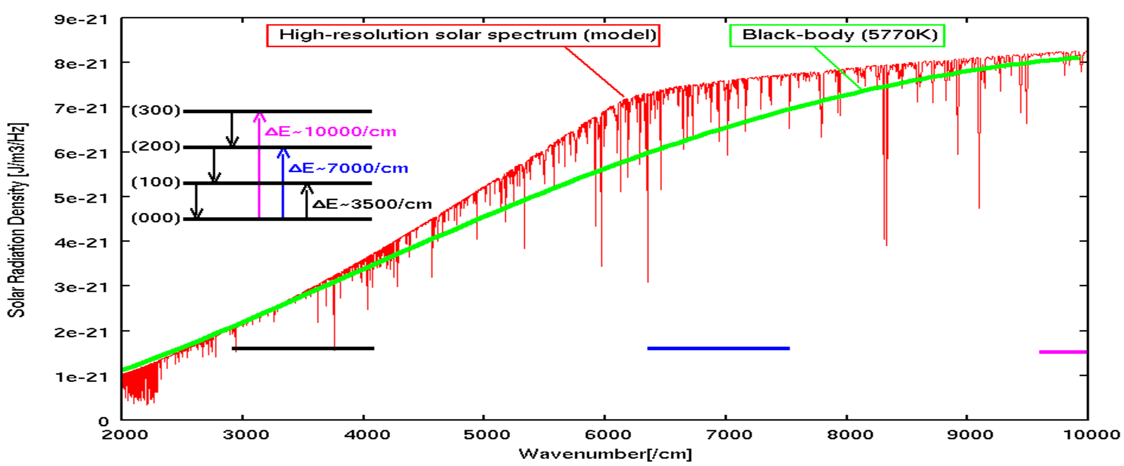

Figure 1: Solar spectrum in near-infrared region (from 1 to 5 microns).