THE FORMATION MECHANISMS OF D$_3$: AN INFRARED SPECTROSCOPIC INVESTIGATION

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In 1993, we reported observations of the infrared absorption spectra of D$_3$ with a difference frequency laser system in the frequency ranges around 3600 cm$^{-1}$ ($3d^2A_1^1 \leftarrow 3p^2E'$) and 3900 cm$^{-1}$ ($3d \leftarrow 3p^2E'$). The observed line shapes exhibited a broad non-Maxwellian velocity distribution, and the line shapes depended on the rotational states. At that time, the line shapes and the widths were not completely understood. Here we present a more detailed and consistent analysis.

Most lines of the 3600 cm$^{-1}$ band appear to be a superposition of two components, broader and narrower features, for some transitions with an opposite phase. From a broader flat-topped line profile, it is concluded that D$_3$ carries excess translational energy of 0.4 eV and is formed through the dissociative recombination reaction of D$_3^+$ with electrons. The rotational dependence of the line shapes of the 3600 cm$^{-1}$ band is brought about by a competition between the predissociation in the $3s^2A_1^1$ state and the radiative decay in the $3p^2E'$ state. The shorter lifetimes of the $3d$ complex make the line shape of the 3900 cm$^{-1}$ band simpler, a superposition of two absorption profiles with different widths. It is found that the widths of the lines of the 3900 cm$^{-1}$ band are larger than those for the 3600 cm$^{-1}$ band lines. The greater widths of the 3900 cm$^{-1}$ band are attributed to unresolved spin-splittings. Attempts to observe similar absorption lines of H$_3$ were unsuccessful, presumably due to much shorter lifetimes.

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