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Sub-Millimeterwave Spectroscopy of D_2H^+

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In the recent astrophysics, the deuterium fractionation is one of the hottest topics. According to latest chemical model, H_2D^+, which has already been detected in cold extreme CO-depleted clouds, is responsible for the deuterium fractionation because it is a good deuterium-donor for most of abundant species in space. It is also suggested that D_2H^+ can also play an important role and is similarly abundant to H_2D^+ in the region where H_2D^+ is found [1]. However, none has discovered this molecule in interstellar space because no accurate rest frequency of D_2H^+ has been reported.
The first spectroscopic detection of D_2H^+ was made in the infrared region at NRC [2], followed by observations of two rotational transitions (2_{20}-2_{11} and 1_{11}-0_{00}) in the THz region [3]. Polyansky and McKellar derived more accurate molecular constants and term values by combining all the available data [4]. However, since the molecule is very light, even such revised molecular constants should better be subjected to critical tests.

The line position of only one accessible transition (1_{10}-1_{01}) in survey with available radio-telescopes as well as our spectrometer was predicted to be 691.705 ± 0.090 GHz by using previous IR data. Initially the chemical condition of D_2H^+ was set on the basis of the optimum condition for H_2D^+ with a line at 372.42133 GHz [5]. The H_2D^+ molecules were generated in an extended negative glow discharge in mixture of H_2 and D_2 with Ar as buffer gas near the liquid nitrogen temperature (77 K). Following numerous efforts, in the range of the expected spectral region, we discovered only one line at 691.660440(19) GHz that is highly magnetic field sensitive. This absorption line vanishes by cutting off H_2 or D_2 gases, by inducing tiny leak, or by raising cell temperature. The optimum mixing ratio of gases is found to be H_2 / D_2 / Ar = 4 / 2 / 17 mTorr and discharge current

is about 8 mA. The observed line width (FWHM = 2.1 MHz) is comparable with the Doppler line width of the molecule (FWHM = 1.9 MHz), assuming that the temperature of the cell is 77 K. A set of the improved molecular constants is obtained by combining all available IR data.

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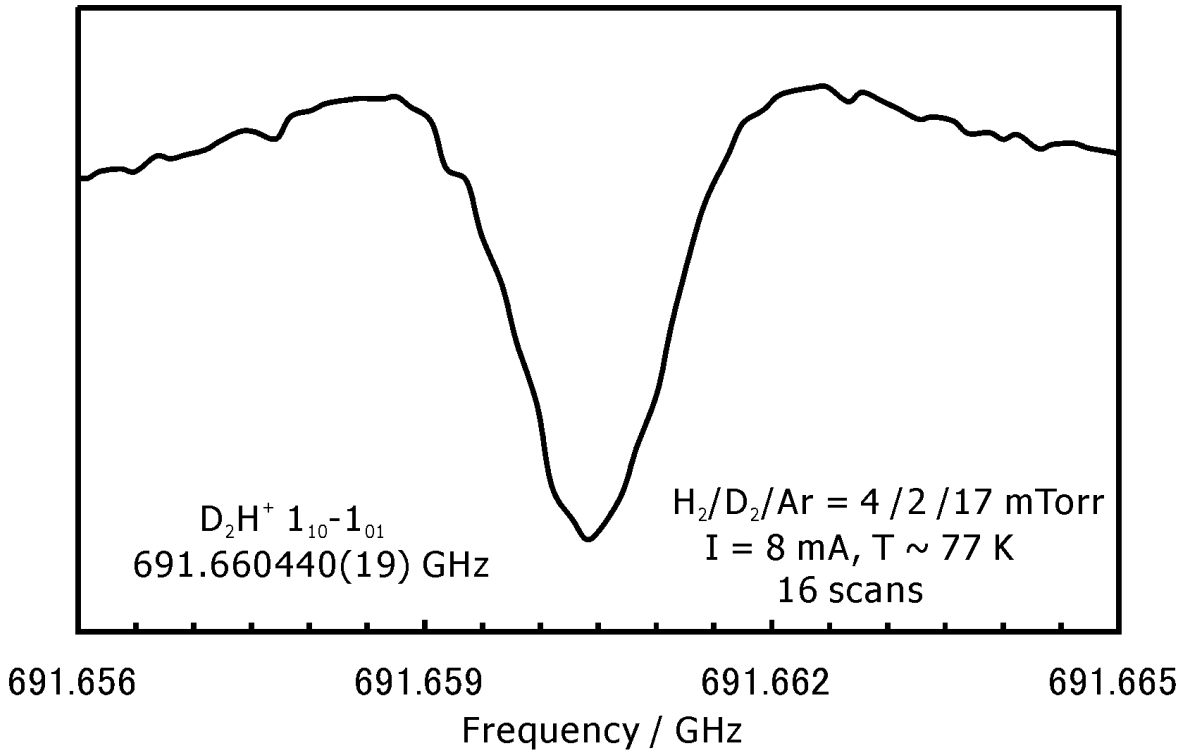

Figure 1 The observed spectral line of D_2H^+.