Possible observation of linear H_3^+ in the laboratory

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H_3^+ was discovered by J. J. Thomson in 1911 in the laboratory with a mass spectroscopic method, determined its structure by T. Oka in 1980 with infrared spectroscopy, and observed as an interstellar molecule by T. Oka in 1996. Now, we regard H_3^+ as one of the most critical species in interstellar clouds because many complex molecules are produced via the reaction involving H_3^+ [1].

We performed the ion mobility measurements after injecting H_2^+ into a drift tube filled with normal H_2 gas at the liquid nitrogen temperature of 77 K using a very low-temperature drift tube mass spectrometer [2]. The following ion-molecule reaction produces H_3^+ in the gas phase [3]:

$$H_2^+ + H_2 \rightarrow H_3^+ + H$$

This is one of the important reactions that produce H_3^+ in molecular clouds, and it has been investigated in laboratories. We measured the arrival time spectra of H_3^+ at various H_2 gas pressures and electric field strengths in the drift tube to obtain the reduced mobility of H_3^+ in H_2 gas at 77K.

Arrival time spectra of H_3^+ surprisingly split two components in weak electric fields. As the mobility of molecular ions depends on their molecular structure, we consider that two peaks correspond to two isomers, namely triangle and linear structures of H_3^+. The ground state of H3+ has a triangle structure confirmed with spectroscopic observation, and theoretical calculations proposed the first excited triplet state with a linear structure [4]. However, the energy of this triplet state is too high to be produced in the low-energy collision of H_2^+ with H_2. Then the meta-stable linear structure in the electronic ground state will be the candidate. If this interpretation is correct, this result might be the first observation of linear H_3^+ ions in experiments.

References

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