Mobility and reaction of drifting ions in cooled hydrogen gas

H. Tanuma,* S. Imaizumi, T. Ito, & R. Ui
tanuma-hajime@tmu.ac.jp
Department of Physics, Tokyo Metropolitan University, Tokyo 192-0397, Japan

The ion drift tube technique has been widely used for the experimental investigation of mobility in gases and ion-molecule reactions. [1] However, this method has yet to be applied to the ion mobility in cooled hydrogen gas, even though we can find several experiments on the mobility measurements of ions in hydrogen gas at room temperature [2-4].

In this work, we measured the mobility of ions produced after the ion injections into a drift tube filled with normal hydrogen gas at the liquid nitrogen temperature of 77 K using a very low-temperature drift tube mass spectrometer [5, 6]. When we injected H_2^+ ions into H_2 gas, H_3^+, H_5^+, H_7^+, and H_9^+ ions were observed, but H_2^+ ions disappeared due to the reaction with H_2 [7, 8]. In the mobility measurements of H_3^+, H_5^+, H_7^+, and H_9^+, all ions show almost the same values. Therefore, we consider that the three-body association and collisional dissociation reactions might be in equilibrium with proton exchange reactions [9].

On the other hand, arrival time spectra of H_3^+ split surprisingly two components in weak electric fields. As the slow component shows almost the same mobility as other heavy ions, we consider that this corresponds to the ground-state triangle structure. Therefore, the fast component will be due to the lowest excited triplet state with a linear structure. If this interpretation is correct, this result might be the first observation of *linear* H_3^+ in experiments.

References:
1. E. A. Mason E. A. and McDaniel E. W. *Transport Properties of Ions in Gases* (Wiley, New York, 1988).
2. Saporoschenko, M. *Phys. Rev*.**139**, A349 (1965).
3. Albritton, D. L. *et al*., *Phys. Rev*. **171**, 94 (1968).
4. McFarland, M. *et al*., *J. Chem Pays.* **59**, 6610 (1973).
5. Tanuma, H. *et al*., *Rev. Sci. Instr.* **71**, 2019 (2000).
6. Tanuma, H. *et al*., *J. Chem. Phys*. **113**, 1738 (2000).
7. Bowers, M. T. *J. Chem. Phys*. **50**, 4787 (1969).
8. Merkt, F. *J. Phys. Chem. Lett.* **13**, 864 (2021).
9. Lin, Z. and McCoy, A. B. *J. Phys. Chem. A* **119** (2015) 12109.