Commissioning of a new measurement system for ion—polar-molecule reactions under low-temperature conditions

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We have been developing an experimental apparatus designed to measure rate coefficients and branching ratios of ion—polar-molecule reactions in the low- to intermediate-temperature range. The system consists of a storage ion source (SIS) [1], a wavy/linear Stark velocity filter [2], and a cryogenic linear octupole radio-frequency (RF) ion trap (OPIT) [1]. The primary objective of this research project is to measure reaction rates of H_3^+ and hydrocarbon ions CH_n^+ (n = 0–5) with polar molecules. These reactions are believed to play crucial roles in the formation processes of interstellar molecules; however, only a limited number of reaction rate coefficients at low temperatures have been reported to date. In this context, hydrogen/methane gas was introduced into the SIS to produce H_3^+ and CH_n^+ ions, and a quadrupole mass spectrometer was used to selectively extract specific ion species. Figure 1 shows the mass spectrum of CH_n^+ ions detected at the end of the beamline through the OPIT (see Fig. 2). Based on the observed pressure dependence of the mass spectra, CH_5^+ is considered to be formed via the ion–molecule reaction $CH_4^+ + CH_4 \rightarrow CH_5^+ + CH_3$ in the SIS. In this poster presentation, we will report in detail on the production of low-energy H_3^+/ CH_n^+ ions using the SIS and discuss the optimization of beam transport and trapping of externally injected ions in the cryogenic OPIT via the sextupole RF ion beam guide.

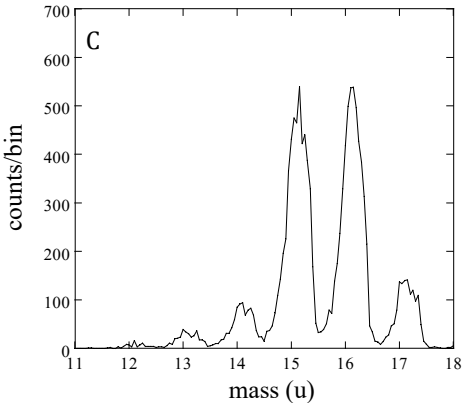

Figure 1: Mass spectra of CH_n^+ (n =0-5) obtained using a quadrupole mass spectrometer (SRS, RGA100) located at the end of the beamline.

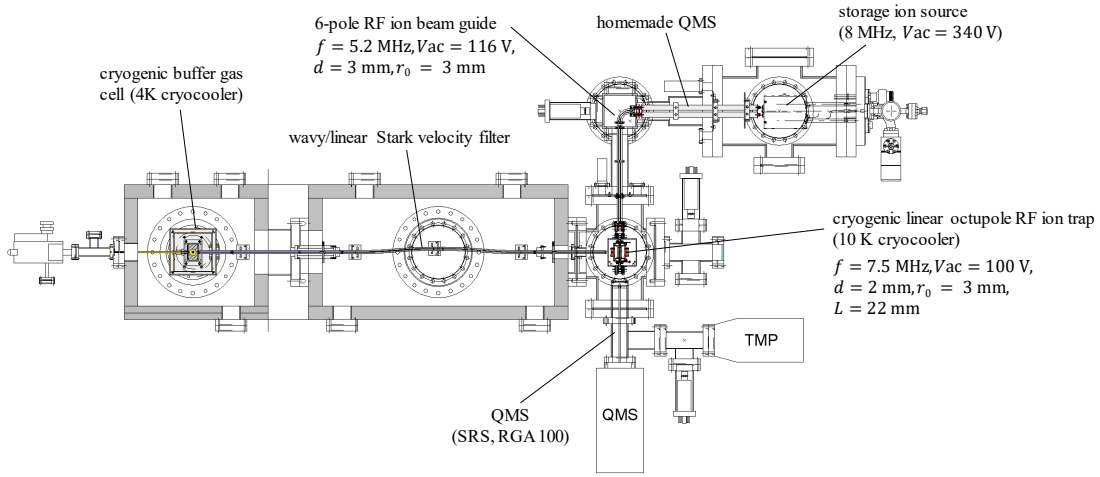

Figure 2: Schematic diagram of a new measurement system for ion—polar-molecule reactions under low-temperature conditions.

References

[1] E. Teloy and D. Gerlich, Chem. Phys. 4, 417 (1974).
[2] K. Okada et al., Rev. Sci. Instrum.88, 083106 (2017).