A new approach for reaction rate measurements of cold ion-polar molecule reactions

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Low-energy ion–polar-molecule reactions are important chemical processes in interstellar matter. However, due to experimental difficulties, the reaction rate constants have not been sufficiently measured at low temperatures. In this context, we have been working on the reaction rate measurements of cold ion-polar molecule reactions by combining velocity-selected polar molecules and sympathetically cooled ions in a linear Paul trap [1]. Additionally, we have proposed a new approach that combines buffer-gas cooling of trapped ions in a cryogenic ion trap with a wavy Stark velocity filter [2, 3]. As a proof-of-principle experiment for this new approach, we measured the electronic state-dependent reaction-rate constants of $Ca^+(^2S_{1/2}, ^2D_{3/2}) + CH_3F \rightarrow CaF^+ + CH_3$ at a translational temperature of about 110 K [3]. In addition, the rotational cooling effect on the rate constants was also observed by implementing a cryogenic buffer gas cell for the rotational cooling of polar molecules. Recently, we also measured the rate constants of $Ca^+(^2S_{1/2}, ^2D_{3/2}) + C_2H_5OH$ at a translational temperature of about 90 K. Since this new approach can be applied to various ion-polar molecule reactions over wide ranges of translational and rotational temperatures of molecular ions and polar molecules, we have been constructing a new experimental setup based on this new measurement method by combining a wavy Stark velocity filter and a cryogenic linear octupole rf ion trap (Fig.1). In this poster presentation, we will present the recent results on the reaction rate measurements on cold ion-polar molecule reactions as well as the status of the new experimental setup.

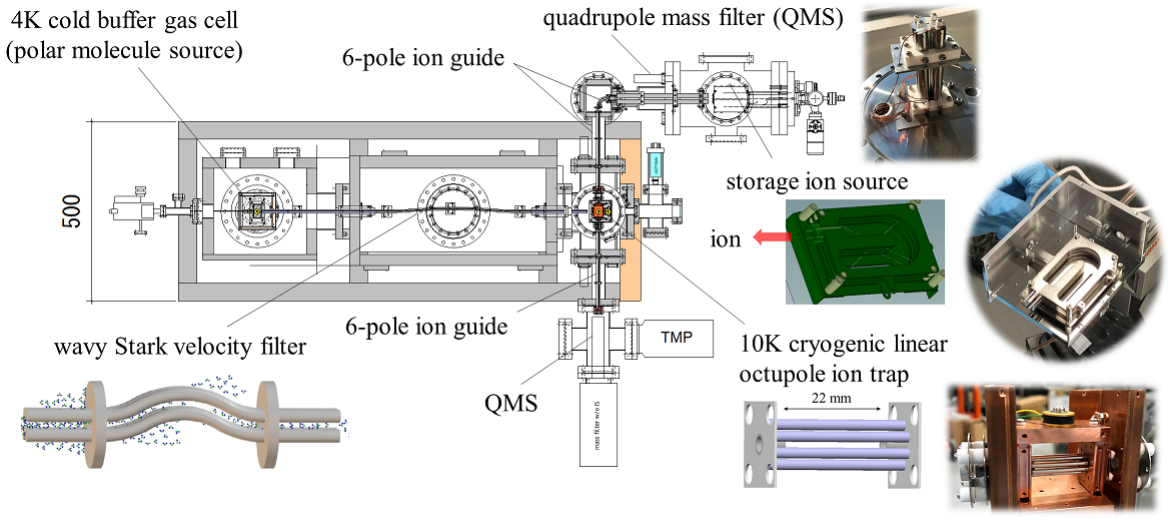

Figure 1: Wavy Stark velocity filter–cryogenic octupole ion trap apparatus with a storage ion source.

References

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