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Dissociative recombination measurements on halogen-hydride ions relevant for astrochemistry

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Synopsis We report on dissociative recombination measurements of several halogen-containing molecular ions using a merged electron and ion beams geometry.

Dissociative recombination (DR) of molecular ions is a key chemical process in the cold interstellar medium (ISM). DR affects the composition, charge state, and energy balance of such environments. Astrochemical models of the ISM require reliable total DR cross sections as well as knowledge of the chemical composition and excitation states of the neutral DR products. Theory cannot reliably provide these data.

We have systematically measured DR for many astrophysically relevant molecular ions utilizing the TSR storage ring at the Max-Planck-Institute for Nuclear Physics in Heidelberg, Germany. We used the merged ion-electron beam technique combined with an energy- and position-sensitive imaging detector and are able to study DR down to plasma temperatures of 10 K. The DR count rate is used to obtain an absolute DR rate coefficient. Additionally we determine the masses of the DR products by measuring their kinetic energy. This allows us to assign particular DR fragmentation channels and to obtain their branching ratios. Moreover, the distribution of detected fragment distances provides information on the kinetic energy released in DR and thus also on the internal excitation of the DR products. All of this information is particularly important for understanding DR of heteronuclear polyatomic ions.

HCl and HF molecules were recently identified as potentially good tracers for molecular hydrogen in interstellar clouds [1, 2]. To use these tracers the underlying chlorine and fluorine chemistry must be understood. Current astrochemical models, however, lack reliable DR data. To this end we have measured DR for HCl^+, D_2Cl^+, HF^+, D_2F^+, and CF^+.

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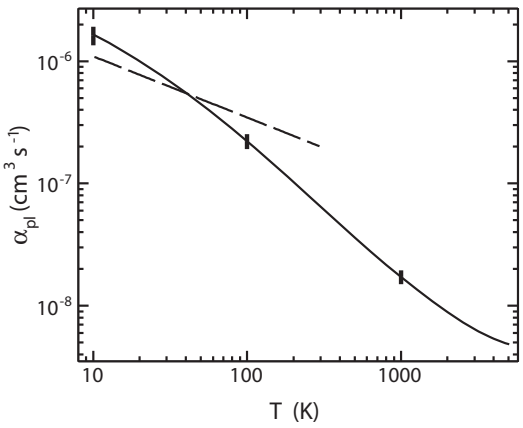

Figure 1. Experimentally derived plasma DR rate coefficient for HCl^+ (full line) compared to the data currently used in astrochemical models (dashed line). The total experimental uncertainty is given by the vertical error bars.

References

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