Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Kolloquium der Physikalischen und Theoretischen Chemie

Dienstag, 28.01.2020 **Hörsaal D, Chemiezentralgebäude, 17:15 Uhr**

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Titel: Ion-molecule reactions below 1 K

Abstract:

The study of ion-molecule reactions at low collision energies (E_{coll}) or low temperatures below E_{coll}/k_B = 10 K is experimentally challenging because stray electric fields in the reaction volume heat up the ion samples. A potential difference of 1 mV across a reaction region of 1 cm accelerates the ions to 1 meV, which corresponds to heating them up to about 12 K. To overcome this problem and study ion-molecule reactions below 10 K, we have developed a new method, in which the ion molecule reaction takes place within the orbit of a Rydberg electron at high values of the principal quantum number *n*. In high-*n* Rydberg states, the Rydberg electron only very weakly interacts with the ion core, so that it does not significantly influence the ion-molecule reaction but shields the ions from heating by stray electric fields. Instead of studying exothermic and barrier-free ion-molecule reactions of the type

$$I_1^+ + M_1 \rightarrow I_2^+ + M_2,$$

we thus study the reactions

$$I_1^* + M_1 \rightarrow I_2^* + M_2,$$

in which I_1^* and I_2^* represent atoms or molecules in high Rydberg states. To reach very low collision energies we use chip-based Rydberg-Stark decelerators and deflectors to merge cold supersonic beams of I_1^* and M_1 and to vary the relative velocity of I_1^* and M_1 [1]. Monitoring the product yield as a function of the relative mean velocity of the two beams, we obtain the relative reaction cross sections as a function of the collision energy [2]. At temperatures below 1 K, we find that the reaction rate coefficients deviate from those estimated with Langevin-type capture models. The deviations become particularly large when M_1 has a permanent dipole moment, but are also noticeable when it has a quadrupole moment.

The talk will present studies of reactions of H_2^+ and He^+ ions (I_1^+) with neutral molecules such as N_2, H_2, CH_3F and CH_4 (M_1) at collision energies down to below 1 K. The observed low-temperature behaviour will be discussed in terms of the electric dipole and quadrupole moments of M_1.

[1] Surface-electrode decelerator and deflector for Rydberg atoms and molecules, P. Allmendinger, J. Deiglmayr, J. A. Agner, H. Schmutz, and F. Merkt, Phys. Rev. A **90**, 043403 (2014)

[2] New method to study ion-molecule reactions at low temperatures and application to the $H2^+ + H2 \rightarrow H3^+ + H$ reaction P. Allmendinger, J. Deiglmayr, O. Schullian, K. Höveler, J. A. Agner, H. Schmutz, and F. Merkt, ChemPhysChem **17**, 3596 (2016)

Organisation: I. Fischer

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Weitere Informationen unter:
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