Spectroscopic and reaction-dynamics experiments with cold molecules

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Synopsis Experimental methods to prepare cold samples of the few-electron molecules H_2^+, H_2, He_2^+ and He_2 will be described. Spectroscopic and reaction-dynamics experiments with these samples will be presented.

Methods will be presented with which cold samples (T < 1 K) of few-electron molecules, such as H_2, metastable He_2, H_2^+ and He_2^+ can be generated. With such samples, we carry out precision spectroscopic measurements of molecule structure and study low-temperature phenomena in chemical reactions. Because these molecules are light, quantum-mechanical effects play a larger role than in other molecules. Three experiments will be presented.

In the first, we generate cold samples of metastable He_2 by multistage Zeeman deceleration and measure transitions to high Rydberg states, from which we determine the energy level structure of metastable He_2 and He_2^+ with high precision. The measurements reveal the finest details of the interaction between He atoms in their ground and first excited states and with He^+ ions [1].

In the second experiment, we generate cold samples of H_2 Rydberg molecules using a surface-electrode Rydberg-Stark decelerator and deflector and use these samples to study the $H_2 + H_2^+ \rightarrow H_3^+ + H$ reaction at temperatures below 1 K using a merged-beam technique. The experiments rely on the fact that the Rydberg electron does not influence the ion-molecule reaction but shields the reaction from heating effects by stray fields [2].

In the last experiment, we study the radiative recombination reaction $H + H^+ \rightarrow H_2^+$ to quantify the effects of shape resonances in this process [3].

References

[1] L. Semeria, P. Jansen and F. Merkt 2016 *J. Chem. Phys.* **145** 204301
[2] P. Allmendinger, J. Deiglmayr, K. Höveler, O. Schullian and F. Merkt 2016 *J. Chem. Phys*. **145** 244316
[3] M. Beyer and F. Merkt 2016 *Phys. Rev. Lett.* **116** 093001

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