Colloquium

SFB 956

Conditions and Impact of Star Formation

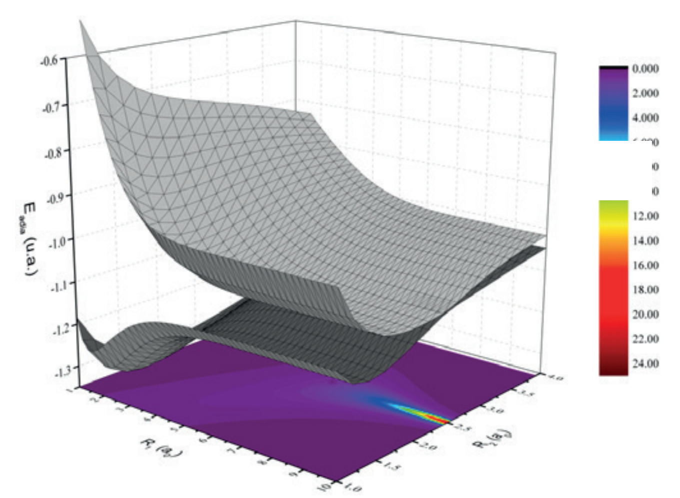
1 April 2019

Monday 3:00 pm

Physikalische Institute Köln

Lecture Hall III

Zülpicher Straße 77 | 50937 Köln



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Exploring the H_3^+ and H_4^+ Potential Energy Landscape by Photodissociation and Reactive Scattering

The H_3^+ and H_4^+ species both exhibit a rich potential energy surface topology, which affects their collisional and laser induced dynamics. We have investigated the charge transfer and atom interchange in a series of fast-beam experiments. Photodissociation experiments were conducted to investigate the role of the avoided crossing seam between the ground and first excited potential energy surface of H_3^+[1]. Three-dimensional imaging of dissociation products was used to determine the kinetic energy release and branching ratio among the fragmentation channels. Vibrational distributions were measured by dissociative charge transfer of H_2^+ products. It is found that the photodissociation of hot H_3^+ in the near ultraviolet produces cold H_2^+, but hot H_2. Modelling the wavepacket dynamics along the repulsive potential energy surface accounts for the repopulation of the ground potential energy surface. The important role of the H_3^+ avoided crossing seam for the astrophysically relevant $H_2^+ + H_2$ charge transfer reactions [2] will be underlined.

The partially deuterated isotopologues of H_3^+, i.e. H_2D^+ and D_2H^+, have pure rotational spectra that can be excited at prestellar core temperatures, allowing for the total H_3^+ abundance to be inferred, provided the deuterating reactions of H_3^+ are well understood. Here, we present laboratory measurements of the rate coefficients for the reactions of atomic D with H_3^+, H_2D^+, and D_2H^+. The measurements were performed using a dual-source, merged fast beams apparatus [3]. In addition, high-level quantum ab initio calculations have been carried out to model the zero-point-energy corrected energy profile and the shape of the potential energy barrier, allowing an evaluation of tunneling effects. From the combination of our experimental and theoretical results, we derive thermal rate coefficients in the temperature range relevant for prestellar cores [4].

[1] X. Urbain, A. Dochain, R. Marion, T. Launoy, and J. Loreau 2019 Phil. Trans. R. Soc. A (submitted).
[2] X. Urbain, N. de Ruette, V.M. Andrianarijaona, M.F. Martin, L. Fernández Menchero, L. Errea, L. Méndez, I. Rabadán, B. Pons 2013 Phys. Rev. Lett. 111 203201.
[3] A. P. O'Connor, X. Urbain, J. Stützel, K. A. Miller, N. de Ruette, M. Garrido, and D. W. Savin 2015 ApJ Suppl. 219 6.
[4] P.-M. Hillenbrand, K. P. Bowen, J. Liévin, X. Urbain, and D. W. Savin 2019 ApJ (submitted).

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