

Experimental study of H₂ formation on ices

L. Hornekær¹, A. Baurichter², S. Baouche², V. V. Petrunin², A. C. Luntz², D. Field¹, T. Zechho³ and J. Küppers³

¹Department of physics and astronomy, Aarhus university,
Ny Munkegade bygn. 520, 8000 Aarhus C, Denmark
email: liv@phys.au.dk

²Department of physics, University of southern Denmark,
Campusvej 55, 5230 Odense M, Denmark

³Max-Planck Institute for Plasma Physics, 95748 Garching, Germany

Abstract. The most abundant molecule in the interstellar medium, molecular hydrogen, is believed to be formed on the surface of interstellar dust grains. Recent experiments on molecular hydrogen formation on interstellar dust grain analogues have shown that such processes are indeed possible (see e.g. Katz *et al.*(1999), Manico *et al.*(2001) and Hornekær *et al.*(2003)). However, it still remains largely unclear how the 4.5 eV of recombination energy liberated in the formation process is distributed between the various degrees of freedom, i.e. between translational and internal energy of the formed molecule and heating of the grain surface. Theoretical simulations have shown that the thermal evolution of interstellar dust and molecular clouds is highly dependent on how the energy released in molecular hydrogen formation is distributed (Flower & Des Forets (1990)).

In the talk I will present detailed laboratory experiments on the formation of HD from atom recombination on both Amorphous Solid Water (ASW) and graphite surfaces. ASW films are believed to be a good analogue of grain surfaces in dense interstellar clouds. Experiments show that H₂ formation on ASW is extremely efficient in a temperature range of 8 - 20 K, temperatures relevant for H₂ formation on dust grains in the interstellar medium. The experiments also show that the morphology of the surface plays a dominant role in determining the partitioning of the 4.5 eV recombination energy between the surface and the molecular degrees of freedom (Hornekær *et al.*(2003)), as well as in determining the desorption rate of the formed H₂ molecules (Hornekær *et al.*(2005)). H₂ molecules formed on porous ASW surfaces are retained in the porous structure delivering all the recombination energy to the surface. H₂ formation from chemisorbed H atoms on graphite surfaces (Zecho *et al.*(2002) and Cazeaux & Tielens (2004)) is a candidate for H₂ formation in Photo Dissociation Regions (PDRs). Results on this system show a very different picture. In this case, a substantial fraction of the 4.5 eV recombination energy is released as translational energy of the formed molecules. The results indicate that the observed efficient H₂ formation under interstellar conditions ranging from dense interstellar clouds to PDRs can be ascribed not to a single recombination mechanism, but to a number of different mechanisms, each displaying varying kinetics and each active under a specified set of conditions.

References

- Cazaux, S. & Tielens, A. G. G. M. 2004, *Astrophys. J.* 604, 222
Flower, D.R. & Des Forets, G. P. 1990, *Mon. Not. R. Astron. Soc.* 247, 500
Hornekær, L., Baurichter, A., Petrunin, V. V., Field, D. & Luntz, A. C. 2003, *Science* 302, 1943
Hornekær, L., Baurichter, A., Petrunin, V. V., Luntz, A. C., Kay, B. D. & Al-Halabi, A. 2005, *J. Chem. Phys.* 122, 124701
Katz, N., Furman, I., Biham, O., Pironello, V. & Vidali, G. 1999, *Astrophys. J.* 522, 305
Manico, G., Raguni, G., Pironello, V., Roser, J. & Vidali, G. 2001, *Astrophys. J.* 548, L235
Zecho, T., Gttler, A., Sha, X., Jackson, B. & Küppers, J. 2002, *J. Chem. Phys.* 117, 8486