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MOBILITY OF D ATOMS ON POROUS AMORPHOUS WATER ICE SURFACES UNDER INTERSTELLAR CONDITIONS

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Abstract. We report here the results of a set of experiments on the mobility of deuterium at 10 K on porous amorphous solid water (p-ASW) ice under interstellar conditions, using a temperature programmed desorption technique. Beams of O_2 and D_2 were irradiated on the surface of a p-ASW ice film and the mobility of D atoms at 10 K was investigated via their property of reacting with the O_2 molecules.

1 Introduction

Mobility of hydrogen atoms on the icy mantles of interstellar dust grains has been at the centre of numerous debates over the years, since it is crucial for the formation of the H2 molecule and hydrogenated species in the interstellar medium. Some theoretical works have predicted that atoms are mobile on amorphous surfaces (Buch & Zhang 1991), which have been corroborated by modelling of experimental data (Hornekaer & al. 2003). However, there is not a general consensus on these results, neither theoretically (Smoluchowski 1981) nor experimentally (Perets 2005). Here we will try to shed some light on this important question.

2 Methods, Results and Conclusions

To do this, we have conducted a laboratory study concerning the mobility of hydrogen atoms with the FORMOLISM (FORmation of MOLecules in the InterStellar Medium) set-up (which has been described elsewhere, e.g. Amiaud & al. 2007). In a UHV chamber, O2 molecules are deposited on porous amorphous water ice substrates of two different thickness at two different surface temperatures, 10 K and 25 K. Then the surface is exposed to varying amounts of cold D atoms (50 K). Temperature-programmed desorption (TPD) experiments are subsequently used to monitor simultaneously desorptions of both O2 molecules left on the surface and D2 molecules. The latter come from both the D2 undissociated fraction in the D beam and that of D atoms that have recombined on the surface.
In a first experiment we deposit 0.5 ML of O2 on a 20 ML porous ASW film held at 10 K. This experiment shows that the desorbing quantity of O2 decreases with respect to the increase of the amounts of D atoms. This decrease is explained by the destruction of O2 molecules by the D atoms beam. Our results show a competition between two mechanisms: D2 formation and O2 destruction. When O2 molecules are within the reach of D atoms their destruction is then favored over the formation of D2. From the TPD traces shown in Fig. 1, we notice that the decrease of the O2 signal is initially proportional to the increase of the exposure time of D atoms. The second experiment is done in order to validate the result of the first experiment on a very thick and porous ASW surface (250 ML) and by depositing O2 molecules at 10 K and at 25 K to induce their mobility. The results show very clearly that the desorbing signal of O2 still decreases (though slower than in the first experiment) with the increase of the deposited D amounts. This indicates that, even on a very thick and porous ASW surface, D atoms are able to diffuse and find the deeply hidden O2.
The experimental data we present are best explained if D atoms are mobile on the ice surface during the time of the experiment (before the TPD heating ramp), thus supporting the chemical models that include the mobility of H atoms at 10 K.

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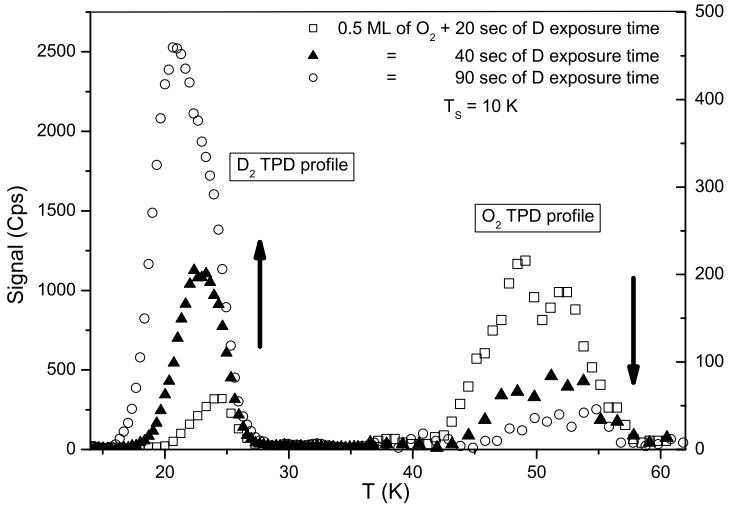

Fig. 1. TPD profiles of D2 and O2 for different exposure times of D atoms at constant O2 dose on 20 ML p-ASW. The decrease of the O2 signal is linked to the increase of the exposure time of D atoms (as indicated by the arrows)

References

V. Buch, and Q. Zhang, ApJ., 379 (1991) 647

L. Hornekaer, A. Baurichter, V. V. Petrunin, D. Field, and C. A. Luntz, Science, 302 (2003) 1943

R. Smoluchowski, Astr. Space Sci. 75 (1981) 353-363

H. B. Perets, O. Biham, G. Manico, V. Pirronello, J. Roser, S. Swords, and G. Vidali, ApJ, 627 (2005) 850

Amiaud, L., Dulieu, F., Fillion, J.-H., Momeni, A., Lemaire, J. L, J. Chem. Phys., 127 (2007) 144709