Deciphering Chemical Reactions in Icy Environments

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Matrix isolation experiments, such as those carried out in NASA Ames Laboratory and Leiden University, have been used to determine many of the physical and chemical attributes of icy interstellar grain mantles. However, the tools of modern surface science offer us the potential to probe gas-grain interactions under more realistic, yet highly controlled conditions, that more closely mimic interstellar environments.

The Leiden Surface Reaction Simulation Device (Surfreside) combines UHV (Ultra High Vacuum) surface science techniques with an atomic beam to study chemical reactions occurring on the SURFACE and in the BULK of interstellar ice grain mimics. By simultaneously combining two or more surface analysis techniques, the chemical kinetics, reaction mechanisms and activation energies can be determined directly. The experiment is aimed at identifying the key barrierless reactions and desorption pathways on H_2O and CO ices under interstellar conditions.

Solid CO_2 has been observed towards both active star forming regions and quiescent clouds [Gerakines *et al.*, (1999)]. It is chiefly found in H_2O rich ice mantles, with an abundance of 10-25% of the H_2O ice. The high abundance of CO_2 in the solid phase, and its low abundance in the gas phase, support the idea that CO_2 is almost exclusively formed in the solid state. Several possible formation mechanisms have been postulated [Ruffle & Herbst (2001); Charnley & Kaufman (2000)], and it is known that CO_2 is formed extremely efficiently in laboratory experiments where H_2O:CO ice mixtures are irradiated with electrons or UV photons. However, the detection of CO_2 towards quiescent sources such as Elias 16 [Whittet *et al.*, (1998)] clearly suggests that CO_2 can be produced in the absence of UV radiation. The most likely route is via the surface reaction between O-atoms and CO. The results from UHV studies of this reaction will be presented in this paper. A comparison will be made between these results and recent HV matrix isolation studies.

References:

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Acknowledgments:

This work was supported by NOVA, the Dutch Astronomy School and the Spinoza fund. HF thanks LKBF for supporting her attendance at this meeting.