Quantifying non-thermal desorption from molecular ices- Comparative study of photon and electron irradiation in the valence- and core-shell energy ranges

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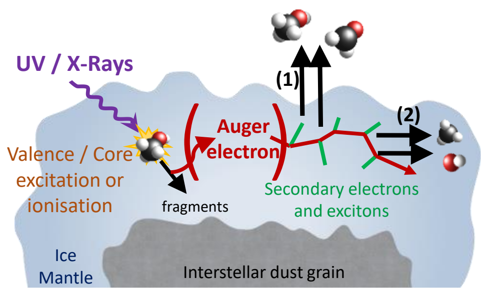
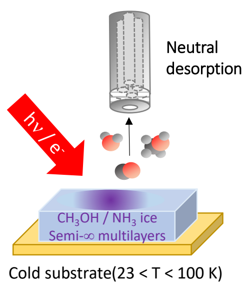
Chemistry in the interstellar medium (ISM) takes place both in the gas phase and on the surface of interstellar dust grains, where films of physisorbed molecules build up. These ices undergo processing by photons, cosmic rays, and by the large number of secondary electrons produced through their interaction with the ice. This chemistry feeds the medium with new molecular species. Desorption is the key step in this interplay between gas phase, solid phase and radiation, and is central in the interpretation of the most recent observational data obtained by the latest generation of telescopes (ALMA, NOEMA, JWST). Desorption can be induced thermally (by heating) or non-thermally (by radiation, including the promoted chemical processes.)
In order to quantify the non-thermal desorption from cryogenic molecular films and to gain insights into the processes at play, we have conducted comparative measurements of photo- and electron-induced desorption (PSD and ESD). Two setups were used for these experiments, the SPICES setup of the LERMA group, and the E/SOLID setup at ISMO. In both setups, model molecular ices of methanol (CH_3OH) [1,2] and ammonia (NH_3) [3,4] were vapour deposited onto gold and the desorption of neutral species was measured by mass spectrometry. Thermal desorption analysis (TPD) was used to calibrate the mass spectrometer signal, determine the ice thickness and morphology, and chemically analyse the processed layers. The SPICES setup was coupled to two SOLEIL synchrotron beamlines: (i) DESIRS in the valence-shell range (6-12 eV) and (ii) SEXTANTS in the core-shell range (O and N-K edges). The electron irradiation twin experiments were performed using the E/SOLID setup, in the low-energy range (typical for secondary electrons < 20 eV) and at several hundreds of eV in order to mimic the secondary Auger electrons. Desorption yields per incident/absorbed particle are compared for photon and electron irradiation either as a function of the incident energy in the low-dose regime (spectroscopic study), or as a function of the cumulated dose at a fixed irradiation energy (kinetic study).





References:

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