The EXCITING experiment: understanding the isotopic and elemental evolution of noble gases trapped in water ice

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Laboratory investigations of noble gas trapping in amorphous water ice have been used to predict the composition of comets and infer on the origin of volatile elements within planetary bodies [1, 2]. However, recent measurements of noble gas in ice sublimating from comet 67P/Churyumov-Gerasimenko by the Rosetta mission [3] has shown discrepencies between predictions and observations, especially regarding the elemental ratios of cometary noble gases. This calls for novel experiments regarding the mechanism of noble gas trapping and evolution within cometary ice analogues.

We have therefore developped an experimental setup (labelled EXCITING, for **E**xploring **X**enon in **C**ometary **I**ce by **T**rapping and **I**rradiating **N**oble **G**ases) to study the elemental and isotopic behaviour of noble gases trapped in amorphous water ice, when subject to conditions akin to outer solar system bodies (e.g., down to 25K and 10^{-8} mbar). In addition, the experimental setup is equipped with a Lyman-alpha lamp allowing irradiation of the condensed ices. Upon heating, sublimating gases can be either analysed on a quadrupole mass spectrometer, or introduced into a purification line for high precision isotopic analysis by static mass spectrometry.

We investigate the evolution of Ar/Kr/Xe ratios in ice from their condensation temperature to their release into the gas phase. Beyond sublimation temperature, a fraction of the volatiles remains physically trapped within the water ice lattice, which is only released during the transition from amorphous to crystalline ice at around 150K. We investigate the potential effects of this trapping mechanism on the isotope composition of noble gases carried in water ice. Taken together, these experimental investigations will ultimately help us to better understand the genesis and evolution of volatile elements within outer solar system icy bodies, and their role as precursors to the terrestrial atmopshere.

[1] Notesco et al., 2003. Icarus, 162 [2] Bar-Nun, A. and Kleinfeld, I., 1989. Icarus, 80 [3] Rubin et al., 2018. Science advances, 4.