The nitrogen isotopic composition of comet 67P

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While the overall isotopic composition of our solar system is fairly homogeneous, large isotopic variations occur among the solar system bodies for some of the volatile elements, including nitrogen. The solar system solids, i.e. the terrestrial planets, meteorites, and cometary ices, are enriched in the rare nitrogen-15 isotope compared to the gas reservoir, represented by the Sun and Jupiter. While the existence of this nitrogen isotopic anomaly between the solids and the gas in our solar system is now fairly well established, its origin is still entirely unclear.

Because the highest enrichments of ^{15}N are associated with some of the most pristine solar system materials, an origin from the earliest phases of star formation seems likely. Studies of the nitrogen isotopic composition in star-forming regions have therefore been carried out to investigate when, where, and how nitrogen isotopes are fractionated during the star formation process. Based on these measurements, scenarios were proposed in which the nitrogen isotopes become fractionated in the gas-phase either by photochemistry or chemistry at low temperatures. Subsequently, the ^{15}N-rich molecules would then freeze-out onto dust grains, leading to ^{15}N-rich ices and ^{15}N-poor gas. The different behaviour observed for different molecules in star-forming regions was interpreted in favour of the existence of two nitrogen reservoirs with a distinct isotopic composition, one linked to atomic nitrogen, and one linked to molecular nitrogen N_2. However, ground-based data of comets show a very homogeneous nitrogen isotopic composition, independent of the tracer molecule, at odds with the measurements of star-forming regions. The homogeneous composition of comets was therefore sometimes attributed to coma processing.

Thanks to the ROSINA instrument on Rosetta, we can now for the first time test many of these nitrogen fractionation scenarios, because we can probe the composition of cometary ice. Using ROSINA-DFMS data, we measure the $^{14}N/^{15}N$ ratio in NH_3, N_2, and NO. These measurements do not only represent the first in-situ measurement of the nitrogen isotopic composition in a comet, but also allow us to rule out different compositions of the atomic and molecular nitrogen reservoirs. We will present our results on the nitrogen isotopic composition of comet 67P, and discuss their implications for our understanding of nitrogen isotope fractionation.