A new derivation of the $^{12}C/^{13}C$ and $^{14}N/^{15}N$ isotopic ratios in the Jupiter stratosphere revealed by ALMA

Camille Lefour[1], Thibault Cavalié[1,2], Raphael Moreno[2], Ladi Rezac[3], Emmanuel Lellouch[2], Thierry Fouchet[2], Vincent Hue[4,5], and Paul Hartogh[3]

[1] Univ. Bordeaux, CNRS, LAB, UMR 5804, F-33600 Pessac, France
[2] LIRA - Laboratoire d'Instrumentation et de Recherche en Astrophysique, Observatoire de Paris, Section de Meudon, 5, place Jules Janssen - 92195 MEUDON Cedex
[3] Max-Planck-Institute for Solar System Research, Göttingen, Germany
[4] Aix-Marseille Université, CNRS, LAM, Marseille, France
[5] Aix-Marseille Université, CNES, Institut Origines, Marseille, France

Measuring the composition and isotopic ratios in different solar system objects is of prime interest to understand their formation (*Nomura et al. 2023*). In the giant planet atmospheres, these measurements should reflect the primordial composition of the solar nebula (*Fletcher et al. 2014*). The isotopic ratios in the giant planets are important tracers of their formation. In Jupiter and Saturn, the low ^{15}N enrichment in NH_3 indicates that the main contributor of nitrogen to the planet atmospheres was N_2, which is expected to be less enriched in ^{15}N than NH_3 in the nebula (*Fletcher et al. 2014*). The $^{12}C/^{13}C$ ratios measured in hydrocarbons are also close to the solar value (*Niemann et al. 1998*).

However, rare events can completely alter the atmospheric composition for decades, as the impacts of comet Shoemaker-Levy 9 (SL9) in the Jupiter atmosphere in July 1994 (*Lellouch et al. 1996, Cavalié et al. 2023b*). From shock-induced chemistry, new molecules that were previously undetected (e.g., HCN, CS...) were provided/formed in the jovian atmosphere from a recombination of the comet material and Jupiter air parcels (*Zahnle et al. 1995*). Intriguing isotopic ratios were measured a few years after the impacts in two of these new molecules, HCN and CS, by *Matthews et al. 2002*. They found an abnormally low abundance of the heavier isotopes compared to jovian values, questioning an unusual cometary composition or fractionation processes in the shocks.

Using radiative transfer modelling, we derive new $^{12}C/^{13}C$ and $^{14}N/^{15}N$ isotopic ratios in Jupiter's atmosphere 23 years after SL9, from 2017 observations of HCN, $H^{13}CN$, and $HC^{15}N$ with the Atacama Large Millimeter/submillimeter Array (ALMA). In contrast to the strong depletions reported in 1998 by *Matthews et al. 2002*, our values are instead compatible with an enrichment in the heavier isotopes relative to the jovian bulk. We interpret these enrichments as the direct signature of the cometary contribution in HCN and/or as 23 years of chemical evolution in the jovian atmosphere.

References:
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