Observations of the Nitrogen Isotopic Composition around Low-Mass Protostars

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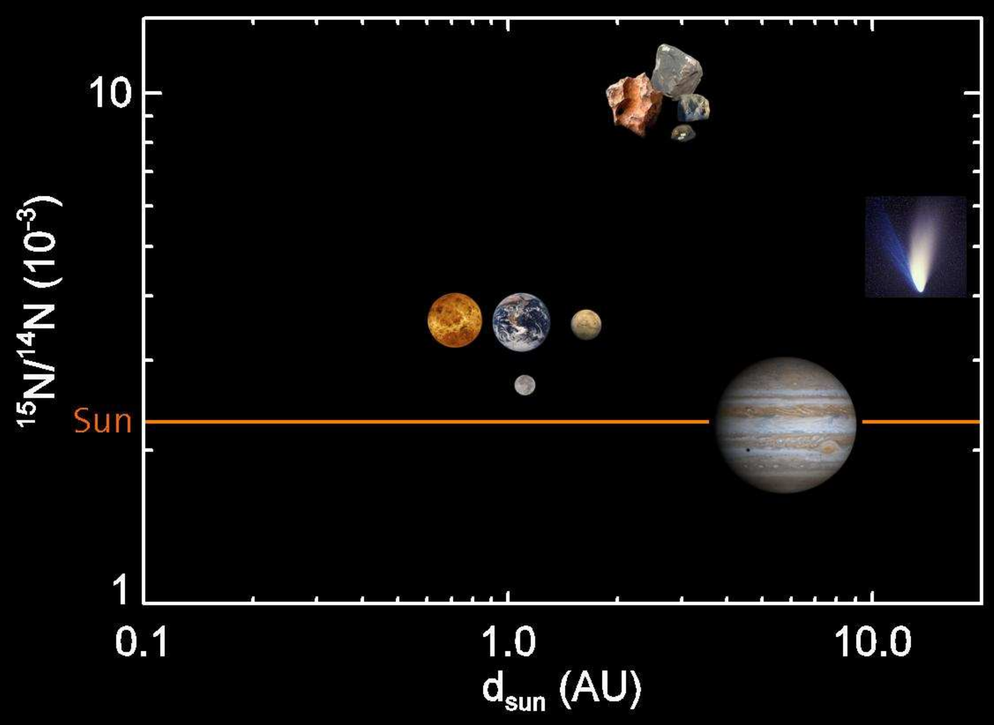
The Nitrogen Isotope Heterogeneity of the Solar System



All solid solar system bodies show a *significant enhancement of ^{15}N* compared to the gas phase reservoir, sampled by the Sun and Jupiter.

What mechanism caused this heterogeneity?

Scenario 1: Chemical fractionation

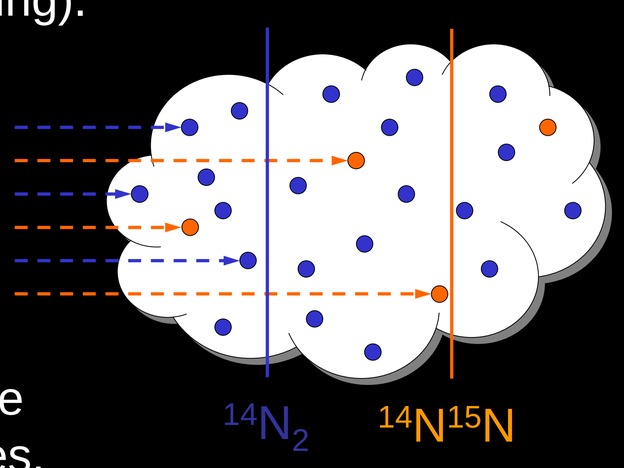
Chemical fractionation is a thermodynamical effect. The isotopic exchange in a pair of chemical reactions can have a favoured direction at low temperatures due to exothermicity. An example:

$$^{15}N + HC^{14}NH^+ \rightleftharpoons {}^{14}N + HC^{15}NH^+ + \Delta E.$$

When molecular species with enhanced ^{15}N later freeze-out onto dust grains as ice, the solids are expected to have an enhanced $^{15}N/^{14}N$ ratio, while the gas is left poor in ^{15}N.

Scenario 2: Photo-dissociation of N_2

A similar number of photons is available to dissociate $^{14}N_2$ and $^{14}N^{15}N$. Because $^{14}N_2$ is more abundant, those photons are absorbed quickly (self-shielding). $^{14}N^{15}N$ can be dissociated much further into the cloud. When the dissociation products recombine into other molecules, their isotopic composition varies with distance from the cloud edge.



StarPlan Project

Ultimate goal: Identify the dominant mechanism that determined the N-isotope composition of the solar system by comparison to active star-forming regions.

Method:
1. Pilot study with single-dish telescopes
2. Spatially resolved observations
3. Test for variations with source properties

Observations

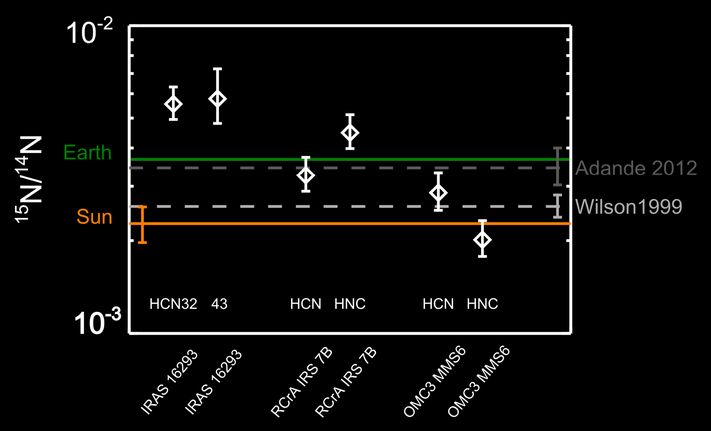
Observations of HCN and HNC isotopologues for three nearby, embedded protostars were carried out at the Atacama Pathfinder Experiment (APEX) 12m telescope in Chile.

The analysis is based on the double isotope method, assuming $^{12}C/^{13}C = 69$.

$$\frac{HC^{15}N}{H^{13}CN} \cdot \frac{^{13}C}{^{12}C} = \frac{^{15}N}{^{14}N}$$

Results & Conclusions

• Most inferred $^{15}N/^{14}N$ ratios are enhanced compared to the solar (and local ISM) value → local processing occurs



• Source with coldest outer envelope temperatures (IRAS 16293A) shows highest $^{15}N/^{14}N$ ratio → indication for chemical fractionation

• Spatially resolved observations are crucial to distinguish between the two scenarios.

What is next?

Interferometric observations to probe variations of the $^{15}N/^{14}N$ ratio in a class 0 protostar.

References

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