INTERSTELLAR NITROGEN ISOTOPE RATIOS

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We report first results of a systematic study of the galactic interstellar nitrogen isotope ratios, based upon measurements of the (J,K) = (1,1) and (2,2) lines of the $^{14}NH_3$ and $^{15}NH_3$ molecules. We find significant deviations of the $[^{14}N]/[^{15}N]$ abundance ratio from the solar-system value (∿270), with the most extreme enrichment in the galactic-center region, where $[^{14}N]/[^{15}N] \sim 1500$. This value is consistent with a nitrogen nuclear-synthesis scheme in which ^{14}N is the main product of normal secondary CNO-burning, whereas ^{15}N is depleted by the same process.

Although nitrogen is one of the most abundant elements, research on its interstellar isotope abundances is still rudimentary. The processes by which the ^{14}N and ^{15}N nuclei are synthesized are rather well identified: ^{14}N is the product of 'normal' (cold) CNO-burning and ^{15}N is formed in the hot CN-cycle. On the other hand, the production efficiencies of the various stellar sites (i.e. where their nucleosynthesis and liberation into the interstellar medium occur) are uncertain, and predictions of the nitrogen yields by stellar-evolution models require an observational calibration (see Güsten and Mezger, 1983, for a recent compilation). In particular it is not known whether the production of ^{14}N requires a pre-enrichment of the star with, e.g., ^{12}C seed nuclei from a previous generation of stars, or whether its synthesis can take place in one stellar generation by CNO-burning in self-enriched giant envelopes (Renzini and Voli, 1981); in short, whether ^{14}N is a 'secondary' or 'primary' product of nucleo-synthesis (see, e.g., Pagel and Edmunds, 1981).

Up to now, determinations of the interstellar nitrogen abundance ratios have been based upon double isotope ratios of hydrocyanic acid $[H^{12}C^{15}N]/[H^{13}C^{14}N]$ (Wannier et al., 1981). These have the advantage of avoiding the problems caused by the strong saturation in the main isotope lines, but they suffer in accuracy from the required independent determination of the carbon isotope ratio. Moreover, in the very massive clouds close to the galactic center, line saturation becomes important even for $H^{13}C^{14}N$, and causes the nitrogen isotope ratio to be underestimated. For these reasons we have begun a systematic study of the single isotope ratio of the (J,K) = (1,1) and (2,2) lines of ammonia, $^{14}NH_3$ and $^{15}NH_3$, using the 100-m telescope of the MPIfR at

H. van Woerden et al. (eds.), The Milky Way Galaxy, 585–586.

https://doi.org/10.1017/S0074180900243209 Published online by Cambridge University Press

Effelsberg. The rare-isotope lines were first detected in 1977 in the Orion molecular cloud (Wilson and Pauls, 1979).

In this short report we present the first results for two molecular clouds close to the galactic center as well as for DR21(OH), which is situated in the local galactic disk. We find that the gas in DR21(OH) has $[^{14}N]/[^{15}N]$ ∿400, and hence that the local disk has been only moderately enriched since the time when the solar system was formed 4.5×10^9yr ago. The ratio we find for the galactic-center clouds, ∿1500, is significantly larger than the lower limit (>500) which was given by Wannier et al. (1981), and means an enhancement by a factor of ∿5 over the solar-system abundance ratio (∿270).

Table 1: Solar System and Interstellar Abundances

Isotope	Solar System[5]	Galactic Disk 9-11 kpc	Galactic Disk 4-6 kpc	Galactic Center <0.3 kpc		IRC10216[8]
$[^{16}O/H]$		$\sim 5\cdot 10^{-4}$	$\sim 12\cdot 10^{-4}$	$(5-10)\,10^{-4}$	[1,2]	
$[^{14}N/H]$		$\sim 4\cdot 10^{-5}$	$(\sim 12\cdot 10^{-5})$	?	[1,3,4]	
$[^{12}C]/[^{13}C]$	89	70-75	∿50	∿20	[6]	40(±10)
$[^{14}N]/[^{15}N]$	270	∿400		∿1500	[7]	∿3000

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In table I we compare our results for nitrogen with determinations of the abundance gradients of oxygen and nitrogen as well as the ratio of the carbon isotopes. The general trend in these data is consistent with the assumption that the material in the inner Galaxy is in a chemically more evolved state. For the carbon data this is most evident for the immediate galactic-center region. Nitrogen, however, does not follow the carbon isotope enrichment, as we would expect if both ^{14}N and ^{12}C were produced by primary nucleosynthesis. On the contrary, the strong $[^{14}N]/[^{15}N]$ enhancement in the galactic center suggests that:
(1) the bulk of the ^{14}N in the galactic center is of secondary origin,
(2) the ^{14}N enhancement which occurs mainly in low-mass stars is accompanied by strong ^{15}N depletion, as is both expected from nucleosynthesis theory and observed in the circumstellar shell ejected by the evolved giant star IRC10216 (compare last column of table I).

In a highly evolved stellar population such as the central bulge, the material ejected by low-mass stars is a major contribution to the enrichment of the ISM by astrated matter, and hence a large $[^{14}N]/[^{15}N]$ ratio is to be expected. A more quantitative analysis of our data in terms of a chemical-evolution model will be given in a future paper.

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