SiO Isotope Emissions from Late-Type Stars

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Abstract

The J=2-1, v=0 emissions of ^{28}SiO, ^{29}SiO, and ^{30}SiO from three late-type stars were simultaneously observed with the Nobeyama 45-m telescope in Jaunuary 1987. The relative intensities of [^{29}SiO] / [^{30}SiO] were measured to be 2.4 for χ Cyg, 1.5 for NML Tau, and 2.9 for V1111 Oph. These values are lower limits for the relative isotope abundance of [^{29}Si] / [^{30}Si], and are larger than the terrestrial value of 1.51. Recent theoretical studies suggest that hydrostatic nucleosysnthesis and supernova explosions result in smaller values of [^{29}Si] / [^{30}Si] than solar. These models cannot explain the observed excess of ^{29}Si.

1. Introduction

Observations of isotopic abundances provides information on the nucleosynthesis operating in the compact core of stars and supernova explosions and on the chemical evolution of the Galaxy. The CNO nuclides in late-type stars are affected by freshly synthesized core material brought up by "dredge-up" events. On the other hand, the Si isotopes are involved in later phases of nuclear burning, a narrow span of the red giant lifetime before planetary nebulae or supernovae. Therefore relative abundances of Si isotopes we observe remain unchanged from those of interstellar matter from which a star was formed.

2. Observations and Results

The J=2-1, v=0 emissions of ^{28}SiO, ^{29}SiO, and ^{30}SiO from V1111 Oph, NML Tau, and χ Cyg were observed with the Nobeyama 45-m telescope in Jaunuary 1987. At 86 GHz, the half-power beamwidth was 20", and the aperture efficiency 0.37. The three lines were simultaneously observed using two receivers with instantaneous bandwidths of 2 GHz and 0.5 GHz to reduce errors in relative intensities due to pointing and intensity calibration errors. The intensity scale reported here is the antenna temperature T , corrected for atmospheric and ohmic losses.

Figure 1 shows line profiles of NML Tau. NML Tau shows spike components at Vlsr=38 km/s in the spectra of ^{28}SiO and ^{29}SiO. We excluded this velocity range

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in the following analysis. Table 1 summarizes integrated intensities and relative line intensities for these stars, together with those for IRC+10216 observed with the IRAM 30-m telescope.

3. Discussion

The ^{28}SiO emissions show parabolic line profiles, suggesting that they are optically thick thermal emissions. Optically thin emissions should display rectangular line profiles. The line profiles of the ^{29}SiO and ^{30}SiO emissions seems to be rectangular, at most intermediate between them. The optical thickness of the line usually leads to underestimates of the abundances of the most abundant isotopes. Therefore we concentrate on the two minor isotopes.

The relative intensities of 〔^{29}SiO 〕/ 〔^{30}SiO 〕 were measured to be 2.9 for V1111 Oph, 1.5 for NML Tau, and 2.4 for χ Cyg, giving lower limits for the relative isotope abundance of 〔^{29}Si〕/ 〔^{30}Si〕. Our mesurements indicate that the relative isotope abundances of 〔^{29}Si〕/ 〔^{30}Si〕 vary from star to star and that they are equal to or larger than the terrestrial value of 1.51.

A model of hydrostatic nucleosysnthesis(Thielemann and Arnett, 1985) suggests that ^{29}Si and ^{30}Si are mainly produced in He, C, Ne burning, and that a smaller relative abundance of 〔^{29}Si〕/ 〔^{30}Si〕 than solar is expected. Recent models of supernova explosion indicate that expected relative abundance of 〔^{29}Si〕/ 〔^{30}Si〕 is 0.1 for type II supernovae(Nomoto et al., 1984) and 0.8 for type II supernovae(Woosley and Weaver, 1986). These models cannot explain the observed excess of ^{29}Si.

Refernces

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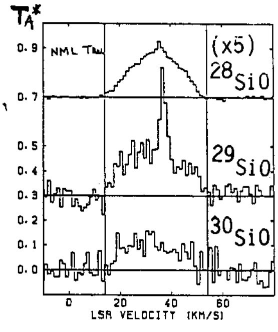

Table 1. Line Intensities

Source	Type	^{28}SiO (K km/s)	^{29}SiO (K km/s)	^{30}SiO (K km/s)	Relative Intensity 〔^{29}SiO 〕/ 〔^{30}SiO 〕
χ Cyg	S	8.6+0.10	2.74+0.17	1.13+0.17	2.4+0.6
NML Tau	M	11.7+0.10*	2.74+0.17*	1.88+0.17*	1.5+0.2
V1111 Oph	M	10.9+0.10	2.31+0.16	0.81+0.14	2.9+0.8
IRC+10216	C	36.0+1.0	3.09+0.26	1.80+0.11	1.68+0.20 #
Terrestrial					1.51

* integrated intensities for 4<V<35 km/s

\# measurements with the IRAM 30-m telescope, Kahane et al.(1987, preprint)