The Light Elements and Their Evolution
IAU Symposium, Vol. 198, *2000*
L. da Silva, M. Spite, J. R. de Medeiros, eds.

The Lithium Abundance and Mass Loss Rate in Galactic Super-Li-Rich Carbon and S Stars

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Abstract. The super-Li-rich (SLR) stars are rare AGB stars containing enhanced Li/H $\approx$ 2000 times the ISM Li/H. In order to determine if mass loss from SLR stars is a significant source of ISM Li, we measured their Li/H and the mass loss rate. From the weak Li I 8126 Å line in 2/4 SLR C stars and 6/8 SLR S stars we obtained Li/H = $(0.2 - 5) \times 10^{-6}$ for SLR C stars and Li/H = $(0.2 - 5) \times 10^{-7}$ for the SLR S stars. We determined dM/dt from the expansion velocity and line profiles of the circumstellar CO. The $dM/dt = 1.3 \times 10^{-5} M_{\odot}$/yr, $2.6 \times 10^{-7} M_{\odot}$/yr, and $2.6 \times 10^{-8} M_{\odot}$/yr for the C stars IY Hya, T Ara, and WZ Cas; and average $dM/dt = 5.5 \times 10^{-7} M_{\odot}$/yr for the S stars. Thus mass loss from SLR stars is a significant source of Galactic Li.

1. Introduction

Super-Li-rich (SLR) stars are unique stars(4 C and 8 S) with strong lines of Li at 6707 Å (equivalent widths (EW) = (2-10) Å) and Li/H up to 3×10^{-6} or $\approx$ 2000 times the ISM Li/H (Denn, Luck, & Lambert 1991). These are AGB stars (2-6 $M_{\odot}$) where their envelopes are ejected by strong stellar winds (up to $10^{-4} M_{\odot}$/yr) giving birth to PN. In the Magellanic Clouds the SLR stars are the most luminous and massive stars (Smith et al., 1995).

Cameron & Fowler (1971) proposed that the enhanced Li in these stars is produced via ^{3}He(^{4}He,γ)^{7}Be(e,ν)^{7}Li. The ^{7}Be is brought to the surface via convective diffusion from the hot-bottom envelope burning during the third dredge-up of the He-burning shell for all 3-6 $M_{\odot}$ AGB stars (Sackmann & Boothroyd 1992), resulting in a SLR phase lasting for 10^{4-5} years. However, the atmospheric Li will be transported back into the stellar interior and burned into He

via ^{7}Li(p,α)^{4}He at T $> 2 \times 10^6$ K unless there is mass loss or some other mechanism preventing the Li from being destroyed. Scalo (1976) proposed that mass loss from SLR stars is a major source of ISM lithium. The contribution of SLR stars to the ISM Li can be estimated from (Li/H)$\times$(dM/dt)$\times$(lifetime of SLR phase)$\times$(number of SLR stars).

2. Observations and results

The optical observations were done 22-24 July 1998 with the CTIO 4m telescope, the echelle grating, and T2KA CCD. The radio observations were done with the SEST 15m telescope (1991) and the NRAO 12m telecope (1991 & 1999). At CTIO we observed the C stars: IY Hya and T Ara and the S stars: RZ Sgr, T Sgr, VX Aql, CSS 703, CSS 861, and CSS 935 (CSS = Case Catalog of Galactic S stars, 2d edition). At SEST we observed T Ara, RZ Sgr, T Sgr, VX Aql, CSS 703, and CSS 935. At NRAO we observed IY Hya and WZ Cas. We will observe the WX Cyg (C*)and GS Per (S*) at NRAO in Jan. 2000; and CSS 583 and CSS 861 at SEST in April 2000.

The Li/H was determined from the weaker 8126 Å Li line and is (1.5-2) $\times$ larger than the Li/H determined from the strong variable 6707 Å line (Li/H in IY Hya varies by 30 $\times$; Boffin et al. 1993). Li/H = $(0.2 - 5) \times 10^{-6}$ for the SLR C stars and Li/H = $(0.2 - 5) \times 10^{-7}$ for the SLR S stars. It is not known if the variations in Li/H are due to the differences in mass, evolutionary phase, or lifetime of the SLR phase for the C and S stars.

The dM/dt is determined from the expansion velocity of the circumstellar CO and the IR luminosity. The dM/dt for the SLR C stars IY Hya (possible proto-PN), WZ Cas, and T Ara are: $dM/dt = 1.3 \times 10^{-5} M_\odot$/yr, $dM/dt = 2.6 \times 10^{-8} M_\odot$/yr, and $dM/dt = 2.6 \times 10^{-7} M_\odot$/yr respectively (Knapp & Morris 1985; Olofsson et al. 1993). The dM/dt for the SLR S stars RZ Sgr, T Sgr, and VX Aql average $dM/dt = 5.5 \times 10^{-7} M_\odot$/yr (Sahia & Liecht, 1995). CO was not detected in WX Cyg, CSS 703, or CSS 935.

Thus mass loss from the SLR stars are a major source of the ISM Li. The C stars yield more ISM Li because they have larger Li/H and dM/dt. However, if all AGB stars went through an SLR phase with the lowest Li/H and dM/dt, then the SLR stars would contribute a small portion of the ISM Li.

References

Boffin, H.M.J., Abia, C., Isern, J., & Rebelo, R., 1993, A&AS, 102, 361
Cameron, A. G. W. & Fowler. W. A. 1971, ApJ, 161, 11
Denn, G. R., Luck, R. E., & Lambert, D. L. 1991, ApJ, 377, 349
Knapp, G. R. & Morris, M. 1985, ApJ, 292, 640
Olofsson,H., Eriksson, K., Gustafsson, B., & Carlstrom, U. 1993, ApJS, 87, 267
Sackmann, I-J. & Boothroyd, A. I. 1992, ApJ, 392, L71
Sahai, R. & Liechti, S. 1995, A&A, 293, 198
Scalo. J. M. 1976, ApJ, 355, 18
Smith, V.V., Plez, B., Lambert, D. L., & Lubowich, D. A. 1995 ApJ, 441, 735

https://doi.org/10.1017/S0074180900166938 Published online by Cambridge University Press