LITHIUM ABUNDANCES IN NEARBY SOLAR-LIKE STARS

L. PASQUINI
European Southern Observatory, casilla 19001, Santiago 19, Chile

B. EDVARDSSON
Astronomical Observatory, Box 515, S-751 20 Uppsala, Sweden

Q. LIU
Yunnan Observatory, P.O. Box 110, Kunming, 650011, P.R. of China

R. PALLAVICINI
Arcetri Astrophysical Observatory, Largo E. Fermi 5, I-50125 Firenze, Italy

ABSTRACT  We discuss Li abundances in a volume limited sample of nearby (G0-G5) solar like stars. We confirm the presence of a group of stars with high Li content, but apparently old age, finding that this group is rather conspicuous and not restricted to a few exceptional cases. The analysis of our data, together with published observations of G dwarfs in open clusters, strongly suggests that for stars older than \sim 1 Gyr some mechanism plays a relevant role in Li depletion. When this mechanism is effective, it depletes Li by a factor 10-100, but in some stars it may not act at all during a large part of their main sequence lifetime.

DATA SAMPLE AND OBSERVATIONS

The data sample is composed of nearby solar-type stars (G0-G5 dwarfs), brighter than $V=7.5$ and lying between $20h < \alpha < 8h$ and $-10 < \delta < -80$. The sample is discussed in detail in Pasquini (1992) where absolute chromospheric fluxes in the K line of Ca II were derived for the same stars using high quality, high resolution data.

The observations were obtained at ESO, La Silla, with the Coudé Echelle Spectrograph fed by the 1.4m CAT telescope. The nominal resolving power was 100,000 and the final signal to noise ratio ranges between \sim 150 and 230. To derive the fundamental stellar parameters we have mostly used Strömgren colours. The details of the calibration and of the atmospheric models are extensively discussed by Edvardsson et al. (1993).

The Ca II K line absolute flux is used as a primary indicator of stellar ages.
LITHIUM ABUNDANCES IN NEARBY STARS

FIGURE I  

a) Li abundance vs. stellar effective temperature. The Sun is also indicated (○); b) Li abundance vs. chromospheric emission.

DISCUSSION

Figure Ia shows the behaviour of Li abundance with effective temperature. The maximum Li abundances decrease for decreasing $T_{\text{eff}}$, but a very large spread is present at each colour. This spread was attributed in the past to an age spread among field stars. At each $T_{\text{eff}}$, the high Li stars were thought to be young and the low Li stars to be old. However, Duncan (1981) and Pallavicini et al. (1987) questioned this interpretation and found several G stars with high (> 2.0) Li abundance, but apparently old age.

To test whether the scatter in Li abundance at each colour could be due to an age effect we compare in Fig. Ib Li abundances with absolute chromospheric fluxes in the Ca II K line. Although statistically chromospherically active stars have higher Li content than quiet ones, it is clear that the correlation is not good. Note in particular that stars with Ca II surface fluxes similar to the solar one have Li abundances that may differ by more than a factor 30. If the Ca II flux is a good indicator of age for solar-type stars as usually assumed (e.g. Soderblom et al. 1991), the Li spread at each colour cannot be due uniquely to age. The number of stars that appear to deviate from a "good" correlation is at least ∼ 25% of the sample, and not confined to sporadic cases as could be inferred from previous studies.

To further investigate the dependence of Li abundance on age and other physical parameters, we compare in Figure II Li equivalent widths vs. colour index $(B-V)_{\odot}$ for four clusters for which data are available in the literature: the Hyades (Soderblom et al. 1990), NGC 752, M 67 and NGC 188 (Hobbs & Pilachowski 1988) and for the stars in our sample.

The Hyades data show little scatter and define a well determined curve in the $\log \epsilon(\text{Li})$ vs. $T_{\text{eff}}$ plane. The other clusters, all older than the Hyades, are below the Hyades curve and may show some dependence on age. However, this is not totally evident from the available data and, more importantly, all three clusters present a large scatter with both high and low Li stars at similar $T_{\text{eff}}$. Yet in spite of the fact that M67 and NGC 188 are, respectively, as old as the Sun and a factor of 2 older, they both show the existence of G type stars that have a much higher Li content than the present Sun. The behaviour of the stars belonging to the old clusters is similar to what we observe in the
field G dwarfs, particularly for those stars that have a Ca II K flux similar to the Sun. The small scatter presented by the Hyades data may suggest that this spread in Li abundances originates only at ages older than the Hyades. However, we regard these conclusions as somewhat dubious at this stage, because Thorburn et al. (1993) suggested that some scatter may be present in the Hyades G dwarfs; moreover, scatter is present in younger clusters like α Persei and the Pleiades (Balachandran et al. 1988, Soderblom et al. 1993). The simplest explanation of Figures I and II is that some extra parameter affects Li depletion in G type dwarfs in addition to $T_{\text{eff}}$, age and metallicity. We do not know what this parameter is, but we know that it may prevent some stars from depleting effectively their Li during a large part of their main sequence lifetime. Alternatively, this extra parameter may be the cause of the low Li abundance we observe at present on the Sun and other G dwarfs. If so, the high Li content we observe in some stars of the oldest clusters clearly indicates that this mechanism does not operate for certain stars.

REFERENCES