tions will still continue to be an important activity for quite some time to come.

The 1990 WG meeting, which was moved from Nice to Garching at the last moment for technical reasons, attracted about 40 specialists, mainly from Europe and including a substantial complement from Eastern Europe. The discussions centred on a variety of subjects, in particular the extraction of information from photographical plates. There has been important progress in the accuracy and speed of microdensitometry, and image "manipulation" in the photographic laboratory allows us to see weak and/or extended structures which would otherwise not be visible.

The big Schmidt telescopes in the world continue their surveys of the northern and southern skies which will provide present and, not the least, future generations of astronomers with the possibility to learn about the past behaviour of objects with newly discovered, peculiar properties. Several "durchmusterung"-type projects are based on these surveys and provide extensive lists of selected objects for detailed studies with larger telescopes.

The Organizing Committee of the Working Group decided to study how this group can best be continued; photographic methods alone may become too narrow a delimitation in the future. The WG will meet again at the IAU General Assembly in Buenos Aires next year and expects to take the corresponding decision there.

R. M. WEST, ESO

Lithium in Chromospherically Active Stars

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1. Introduction

The abundance of Lithium in stars is perhaps one of the least understood problems in Astrophysics. Contrary to most other elements, Li is not produced in the standard way by stellar nucleosynthesis; rather, it is believed to have largely been created at the very beginning of the Universe. An accurate measure of the present Li abundance can thus provide stringent constraints on models of the Big Bang. Unfortunately, Li is a very fragile element and its isotopes Li^6 and Li^7 are destroyed by nuclear reactions at temperatures higher than 2.2×10^6K and 2.6×10^6K, respectively. Since most of the stellar interiors are at temperatures higher than this, Li is confined to shallow surface layers. It is not surprising that a number of mechanisms exist to mix the surface Li to the hotter interior, thus changing the present abundance of Li with respect to the primordial value. To make things even worse, there are also a number of mechanisms (nuclear spallation reactions by cosmic rays, production in novae and in red giants) that can potentially increase the abundance of Li on time scales comparable to the age of the Galaxy. For all these reasons, it is extremely important to understand the mechanisms that lead to Li depletion in stars or to a possible Li enrichment of the interstellar medium during the galactic evolution.

The "classical" picture of Li depletion in late-type stars was put forward by Herbig in the mid-sixties (see Herbig, 1965). He noticed that field stars of spectral type F8 to G5 present a very large spread in the Li abundance (more than two orders of magnitude) and that the largest Li abundances were ≈ 3.0 (these are logarithmic values on a scale where $\log n(H) = 12.0$). These values were similar to those found in T-Tauri stars and in meteorites. Herbig also found that Li depletion increases towards later spectral types. It is very rare to find large Li abundances in stars later than G5. Typically, K stars do not show a measurable Li line.

The easiest way to interpret these observations was to suppose that all stars (at least those of Population I, see later) were born with the same Li abundance and that Li was progressively depleted in late-type stars under the action of convective motions that bring surface material down to deeper layers. Li is more rapidly depleted in cooler stars which have deeper convective zones and hence higher temperatures at their base. Herbig's interpretation is at the origin of the well-known use of the Li line as an age indicator for solar-type stars, a notion that has commonly been accepted for nearly two decades. There were however a number of "disturbing" effects that, although usually neglected, should have cast doubts on the simplified classical picture. For instance, a substantial number of early F stars were known to have a low Li abundance, much lower than the initial value of about 3.0. Since these stars have very shallow convective zones, it is not clear how they could have been deprived of their Li. Moreover, if Li abundance in solar-type stars were related to age, one should observe a tight correlation between Li abundance and other indicators of age, such as surface rotation or chromospheric Ca II H and K emission. This is typically not observed.

There were also problems on the theoretical side. Standard models of the interior structure of stars show that the bottom of the convective zone in solar-type stars has a temperature significantly lower ($\approx 2.0 \times 10^6$K) than the minimum temperature needed to destroy Li^7 by nuclear reactions ($\approx 2.6 \times 10^6$K). Since the lithium we observe is mostly Li^7, some mechanism other than simple convective transport is required to provide for its depletion. The larger convective zones of K stars are expected to penetrate deep enough to allow nuclear burning of Li, but in the Sun, and in general in all late F and G dwarfs, some extra mixing is definitely required. Several possibilities have been suggested: *turbulent diffusion* below the convective envelope driven by convective overshoot, *mixing* induced by radial differential rotation, *"evaporation"* of Li-rich surface layers through stellar winds, and others.

Over the past decade great advances have been made in the study of Li abundance in stars. In particular, new high-quality observations of open clusters (for a review, see Boesgaard, 1990) have revealed the existence of a "dip" at ≈ 6650 K in the Li abundance of all clusters with ages greater than $\approx 10^8$ years. In the dip, the Li abundance is reduced by at least two orders of magnitudes, while it is "normal" both a temperatures higher than ≈ 6900 K and in the temperature range 6300–6100 K (while decreasing sharply at still lower temperatures). The dip has also been identified in observations of F stars in the field. The reasons for this peculiar

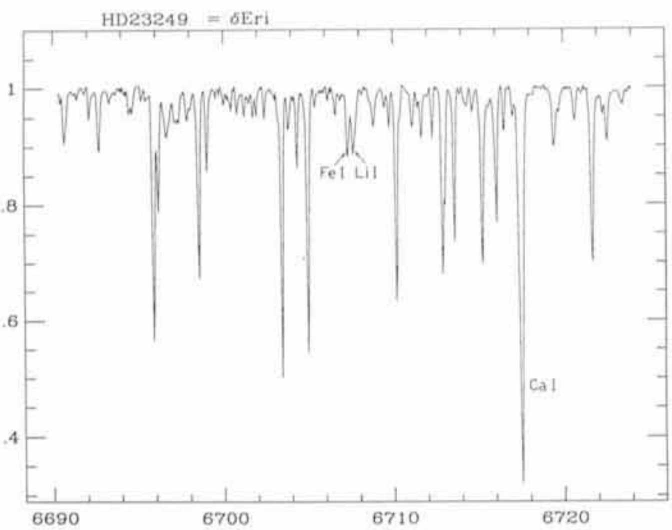

Figure 1: *CES spectrum of the comparison star δ Eri in the Li region. In this and in the following three figures the wavelength scale has not been corrected for the radial velocity of the star.*

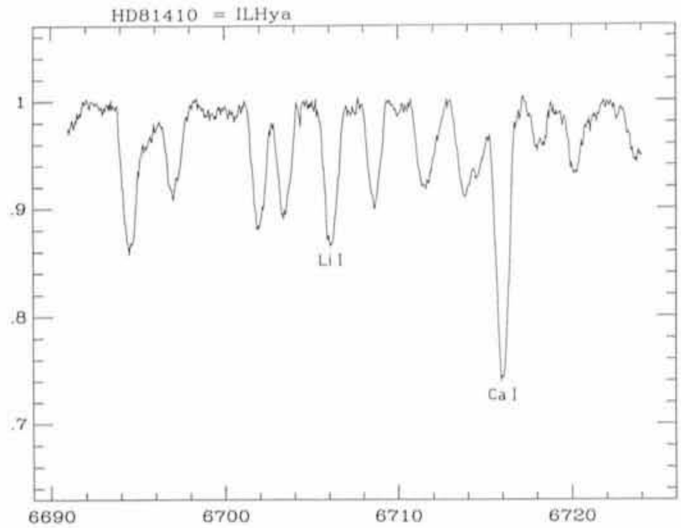

Figure 2: *CES spectrum of the RS CVn binary IL Hya. Note the strong Li line.*

behaviour are not clearly understood. Suggested mechanisms include diffusion under the action of gravity, dilution caused by meridional circulation, and rotationally induced turbulence at the base of the convective zone.

With regard to Population II stars, a real breakthrough has been the discovery of a high Li abundance in old halo stars having effective temperatures between ≈ 6300 and 5600 K (see Spite, 1990 for a recent review). Not only is Li preserved in these old stars, but its abundance appears to be remarkably constant for all halo stars over this temperature range. The approximately constant value is 2.0, a factor 10 less than the initial cosmic value for Population I stars. It has been suggested that the lower metallicity (and hence shallower convective zones) of Population II stars may have allowed them to preserve the original Li produced in the Big Bang. If so, the primordial Li abundance is a factor 10 lower than previously thought, and Li abundance has progressively increased to the present value during the lifetime of the Galaxy.

These and other recent advances have not yet solved the Li problem, but at least have shown clearly that the "classical" picture was oversimplified. Lithium can be depleted by a number of different mechanisms, and parameters so far neglected (such as metallicity and rotation) may actually play the dominant role. Observations of Li in RS CVn binaries and other chromospherically active stars have also provided unexpected results that are not easily interpreted in the framework of the classical theory. In the rest of this paper we will focus specifically on Li observations of chromospherically active stars, a topic which has been the subject of the long-term programme carried out by us at ESO over the past three years.

2. Observing Chromospherically Active Stars

Several years ago we carried out some Li observations of F, G and K stars in the field using the Coudé Echelle Spectrometer (CES) and Reticon detector at ESO. The aim of that programme was to relate the observed Li abundance to other age indicators such as rotation and chromospheric CaII emission. Beside rediscovering the usual pattern that Li abundance rapidly decreases towards lower effective temperatures, and that late F and early G stars present a large range of different Li abundances, we found two interesting results (Pallavicini et al., 1987). First, that a high Li abundance in F8-G5 stars is a necessary, but not sufficient condition for the star to be young; and, second, that there were a few K stars in the sample that showed an unusually high Li abundance.

With regard to the second point, a quick inspection of the literature showed that several K stars reported to have the Li line (including those in our sample) were chromospherically active stars known or suspected to be *RS CVn binaries*. These are close binaries typically formed by a hotter component of spectral type F or G and luminosity class V or IV and a cooler component of spectral type close to K0 IV. They are characterized by an extreme degree of surface activity at optical, UV, radio and X-ray wavelengths. It is generally believed that the high surface activity of these stars is due to their rapid rotation and the subsequent generation of surface magnetic fields by a dynamo process. The evolutionary status of RS CVn binaries has been a matter of debate for some time, until Popper and Ulrich (1977) convincingly showed that RS CVn systems are evolved post-main sequence objects. Li therefore is not expected in these binaries, except in those few cases in which the brightest component is a main-sequence F star.

For these reasons, we thought that a systematic survey of RS CVn stars in the Li region might be worth doing. The primary source for our programme stars is the list of chromospherically active stars of Bidelman and MacConnell (1973) which is based on emission in the CaII H and K lines in low-resolution objective prism spectra. Since this list uses only one indicator of chromospheric activity, it is likely to include a variety of active stars in addition to genuine RS CVn binaries. A second group of sources in our sample comes from the list of active binaries of Strassmeier et al. (1988) which comprises many catalogued RS CVn binaries. Finally, other programme stars were taken from current lists of southern RS CVn candidates. In total the sample comprises more than 60 southern stars of spectral types G and K and luminosity classes V, IV and III. Several inactive stars of various spectral types and luminosity classes were also observed for comparison.

The observations were carried out at La Silla during several observing runs (Nov. '86, Dec. '87, Jan. '89, June '89 and April '90; the run of June '89 through the courtesy of Dr. Luca Pasquini). In all observing seasons we used the Coudé Echelle Spectrometer (CES) fed by the 1.4-m CAT telescope. The

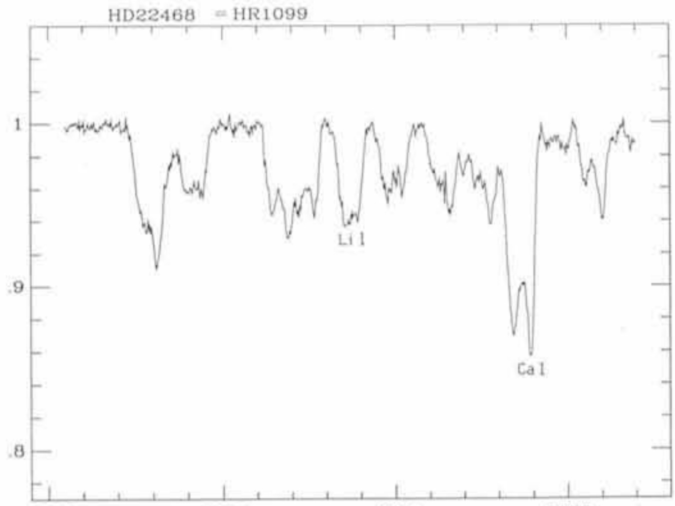

Figure 3: *CES spectrum of the double-lined spectroscopic binary HR 1099, the brightest RS CVn star.*

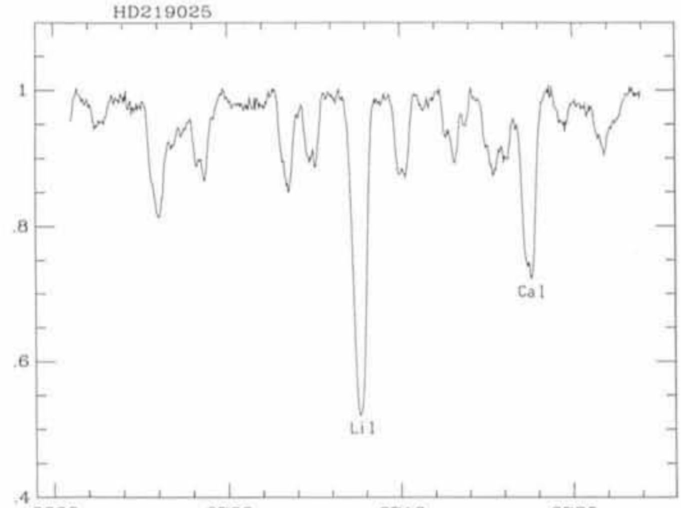

Figure 4: *CES spectrum of HD 219025. Note the extremely strong Li line.*

short camera and a CCD detector were used. The nominal resolving power was R = 50,000 and the S/N ratio was in all cases greater than 100. The spectral range available in the Li region is ≈ 50 Å and was centred at 6708 Å. The LiI unresolved doublet at 6707.81 Å is close to a FeI line at 6704.44 Å. The spectrum of the K0 IV comparison star δ Eri in Figure 1 shows clearly both lines. However, since most stars in our sample are rapid rotators (with V sini greater than ≈ 10 km/s), the Li line is usually blended with the Fe line at 6707.44 Å. A correction must be made for the contribution of the FeI line. The available spectral range allows also observations of the CaI line at 6717.69 Å and a number of other FeI lines that can be used to estimate the metallicity of our stars.

Figure 2 shows the spectrum of the catalogued RS CVn binary HD 81410 = IL Hya (Sp. K1 III) which shows a strong Li I+Fe I blend. The equivalent width of the blend is 113±5 mÅ, of which we estimate that only 37 mÅ can be attributed to the FeI line. In other RS CVn stars the Li blend is not so strong, but still anomalously high for the spectral type. Figure 3 shows the spectrum of the well-known RS CVn binary HR 1099 (HD 22468, Sp. G5 IV+K1V). In spite of the complications introduced by the SB2 nature of this system and by its rapid rotation, it is obvious that the Li blend is present with an equivalent width of 85±8 mÅ, of which only ≈ 25% can be attributed to the FeI line. Finally, in several active stars in our sample, the LiI line is extremely strong, even stronger than the CaI line at 6718 Å. An example is the K2 IIIp star HD 219025 shown in Figure 4 for which an equivalent width of 430±10 mÅ was measured for the LiI+FeI blend, almost a factor 2 larger than the equivalent width of the CaI line.

The results of our survey are summarised in Figure 5 where we plot the derived Li abundances versus effective temperature (filled symbols). We also plot for comparison (open symbols) the results previously obtained by us for a sample of field stars (see Pallavicini et al., 1987). The comparison clearly shows that a large number of cool chromospherically active stars in our sample show *excess Li abundance* with respect to typical stars of the same spectral type. This conclusion is reinforced by the comparison we have made with a random sample of K-type giants observed with the same instrument. Only a couple of stars in the latter sample showed a detectable Li line. Also evident in Figure 5 are the extremely large Li abundances derived from a few stars in the sample.

Roughly, nearly two thirds of our stars appear to have an anomalously high Li abundance, including five stars for which the Li 6708 Å line is stronger than the CaI line at 6718 Å. For four of these stars, the extremely strong (and probably saturated) Li 6708 Å line gives Li abundances comparable to or even larger than the initial cosmic abundance of Li in Population I stars (i.e. ≥ 3.1–3.2). For the vast majority of the other stars in the sample, the derived Li abundances are not so extreme, but they are still large for the spectral type.

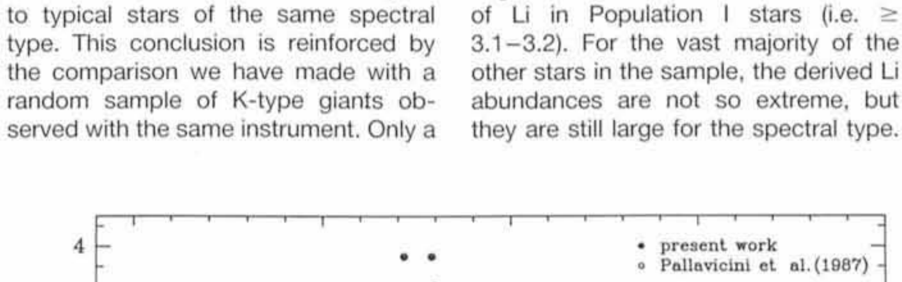

Figure 5: *Li abundance vs. effective temperature for the chromospherically active stars in our sample and for the stars in Pallavicini et al. (1987). Note the excess Li abundance for most stars in our sample.*

In particular, most K stars have Li abundances log n(Li) ranging from ≈ 0 to 2, and only a small number of them show a very weak or absent Li line. This contrasts with what is typically observed for K stars.

3. Search for Rotational Modulation

Before trying to explain why Li is preserved in many K-type active stars, we should test the hypothesis that we are observing a genuine abundance effect. Giampapa (1984) has suggested that surface activity in stars may significantly affect the strength of the Li line. This line is a factor 20–40 stronger in sunspots (owing to the lower ionization of Li in the cool spots), and about a factor 2 weaker in plages, with respect to the undisturbed solar photosphere. If similar enhancement and reduction factors also apply to stars cooler than the Sun, and if these stars are covered by large spots as has been inferred from photometry, the Li line may become enhanced, independently of true abundance effects. This possibility can be tested by observing a rotating star at different phases. Simultaneous optical photometry is necessary because changes of the Li line with phase could only be detected for a highly inhomogeneous distribution of active regions over the stellar surface.

We carried out this test in December 1987 at ESO. We monitored four stars nearly simultaneously in the LiI line and in broad-band $UBV(RI)_c$ filters. The photometric observations were carried out over a two-weak period immediately preceeding the spectroscopic observations. We used the 50-cm ESO telescope equipped with a single-channel photometer and standard $UBV(RI)_c$ filters. The spectroscopic observations were carried out over 6 consecutive nights using the CES fed by the 1.4-m CAT. The instrument setup was the same as the one used by us in all other Li observations. The four stars monitored were HR 1099, YY Men, AB Dor and IL Hya. All are well-known "spotted" stars and were also known from our previous observations to have a strong Li line.

The derived light curves show a clear photometric variation for all stars with amplitudes of ≈ 0.05–0.1 magnitudes in the V band. The ephemerides derived from the photometric variations were used to determine the phases at which the spectroscopic data were obtained. Figure 6 shows the results of the spectroscopic observations for two of the monitored stars. We have plotted, as a function of phase, the measured equivalent widths of the LiI+FeI blend and of the CaI 6718 Å line. No significant variation of the equivalent widths with phase was observed for any for the four stars in spite of the fact that significant photometric variations were observed at the same time.

The upper limits we derive for the variations of the LiI equivalent width (less than 5–10%) are much smaller than what had previously been suggested on the basis of the solar analogy. If we assume that the enhancement of the equivalent width of the LiI line in starspots is about the same as for the Sun, the derived upper limits imply a spot coverage factor of only a few per cent, much smaller than that derived from the photometric variations (≈ 15–25%). It is clear therefore that the enhancement of the Li line in the spots of these stars, if present, is certainly lower than for the Sun.

4. Towards an Understanding of the Li Excess

The negative result obtained above shows that the observed Li excess in many K-type giants and subgiants with active chromospheres must be due to a real decrease of Li depletion for these stars. But what are the reasons for this lower depletion?

An interesting possibility has been suggested by Fekel et al. (1987), i.e. that chromospherically active stars showing a moderate or strong Li line may have evolved from late A or early F-type stars with shallow convective zones. These stars would not have time to substantially deplete their Li while on the main-sequence. This interpretation is attractive, but it is not completely satisfying. Only stars sufficiently massive, say with masses larger than ≈ 1.5 $M_\odot$, have subphotospheric convective zones so thin as to prevent a significant Li depletion on the main-sequence. For lower-mass stars, the observations of the Li dip in clusters with ages greater than ≈ 10^8 years show that Li depletion on the contrary may be very efficient. For stars of still lower masses, Li is depleted owing to the increased depth of the convective zones. The masses of RS CVn stars are not well determined (in many cases we have only lower limits or the mass functions); however, it seems that the masses may cover the entire range ≈ 1–2 $M_\odot$. Since a Li excess is observed for the majority of the active stars in our sample, it appears unlikely that all these stars are on the upper side of the allowed mass range and that only the few stars with no detectable Li have masses lower than ≈ 1.5 $M_\odot$.

There is another property of the active stars in our sample that is systematically different from what is typically observed in quiet stars of similar spectral type. This is *rotation*. Virtually all active stars in the sample have in fact a rotational velocity well in excess of what is usually observed for K-type stars. This is not surprising, since our sample has been selected on the basis of surface activity. If the activity is of magnetic origin, and derives from dynamo-generated magnetic fields (as commonly accepted), a correlation should be expected between rotation and surface activity.

At first sight, the relationship observed between rotation and Li abundance for the stars in our sample could be interpreted as simply due to an age effect. The active, more rapidly rotating stars are younger and hence they had not enough time to deplete their surface

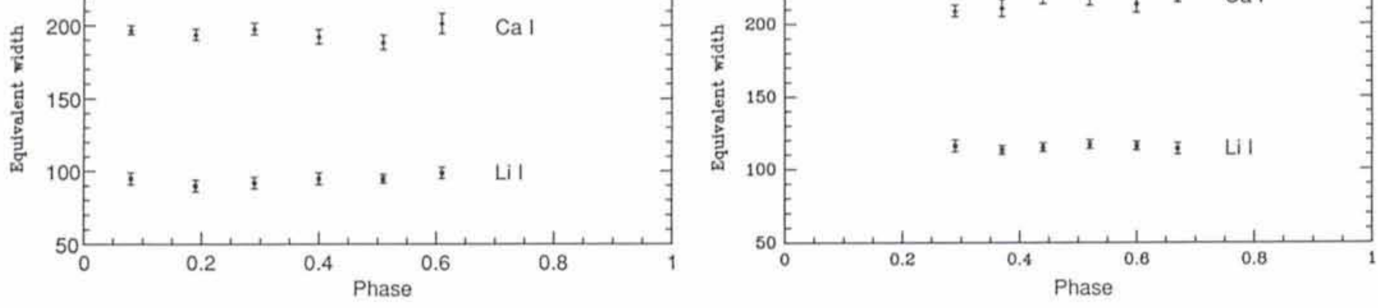

Figure 6: *Equivalent widths of the LiI 6708 Å and of the CaI 6718 Å lines vs. phase for the spotted stars IL Hya and YY Men.*

Li, in agreement with the prescription of the "classical" theory. However, there is evidence that many stars in our sample (particularly the RS CVn binaries) are evolved post-main sequence objects with ages of at least 10^9 years. A few stars in our sample may be very young, but this is not true for most of them. Note also that for close binaries there is no causal relationship between rotation and age. An RS CVn star rotates rapidly, not because there was not enough time during main-sequence evolution to slow it down by stellar winds and magnetic fields, but rather because tidal interaction prevented an efficient braking by locking the star rotation period to the orbital period.

Naïvely, one could expect that more rapid rotation should increase Li depletion by facilitating the circulation of surface Li to deeper layers (see, e.g., Boesgaard, 1990). However, recent calculations by Pinsonneault et al. (1990) suggest instead that there may be an *anti-correlation* between rotation and Li depletion, in the sense that stars that have lost more angular momentum, and hence rotate more slowly, should have suffered more Li depletion than stars of the same spectral type that have only spun down by modest amounts. Pinsonneault et al. base their conclusions on detailed calculations of the rotational evolution of the Sun up to the present epoch. They show that the surface layers of the Sun (at $r \gtrsim 0.6R_{\odot}$) may have been braked more efficiently than the interior, thus causing differential rotation in the radial direction. Transport of angular momentum leads to rotationally induced mixing which reproduces the Li depletion observed at present in the Sun (we remind that the Li abundance in the Sun is log n(Li) $\approx$ 1.0, i.e. two orders of magnitude lower than the "primordial" value for Population I stars).

According to the model of Pinsonneault et al., we can speculate that the absence of efficient braking in tidally coupled RS CVn binaries may have prevented the onset of a strong radial differential rotation, and hence of an efficient rotationally induced mixing. Li therefore should be more preserved in rapidly rotating stars than in stars of similar spectral type that have suffered a greater loss of angular momentum. The amount of Li depletion does not depend on the rotational velocity *per se*, but rather on how much the rotational velocity has changed during stellar lifetime, i.e. on the amount of angular momentum loss. A star rotating rapidly at the present epoch (either because it is young or because tidal interaction has prevented loss of angular momentum) should have preserved most or a large part of its original Li.

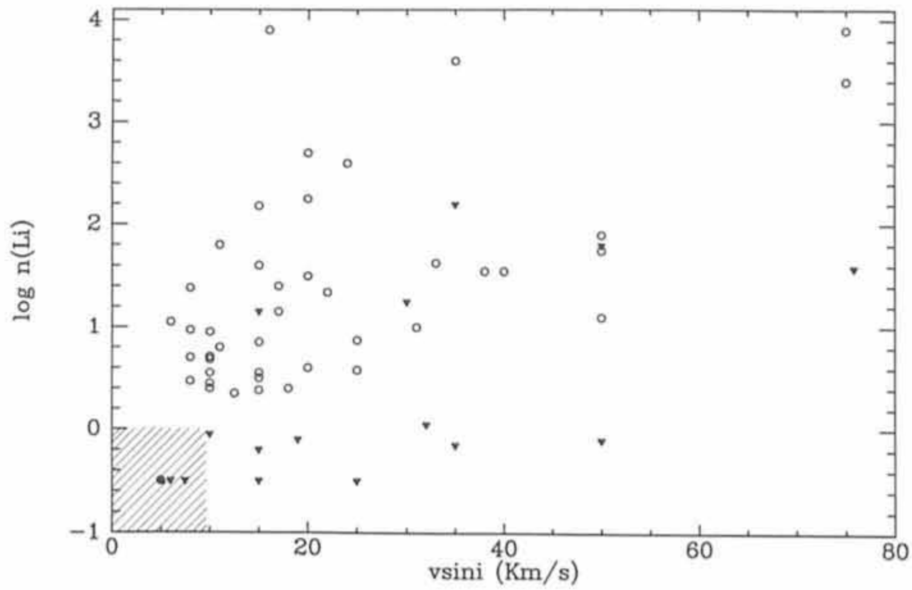

Figure 7: *Li abundance vs. projected rotational velocity for the stars in our sample. Filled triangles indicate upper limits on Li abundance. The dashed area in the lower left corner indicates the region of the diagram typically occupied by inactive K-type stars.*

The conclusions of Pinsonneault et al. depend on the assumption that no significant coupling by magnetic fields exists in the stellar interior. While this is likely to be so for the Sun, it is unclear whether the same also holds for magnetically active stars. Unfortunately, it is difficult to test the model by Pinsonneault et al. by looking directly at a correlation between Li abundance and rotation. Any spread in the initial angular momentum distribution would severely affect the tightness of the correlation. This difficulty is even more severe in our case since our sample of chromospherically active stars is likely to include objects that differ not only in the initial angular momentum, but also in mass, age and metallicity. A plot of Li abundance vs. rotational velocity for our sample is shown in Figure 7. Clearly, the situation is very confusing and no obvious correlation appears to exist. However, the plot reinforces our previous conclusion that *on average* the stars in our sample show both higher Li abundances and higher rotational velocities than a random sample of inactive stars of similar spectral types (dashed area at the lower left corner).

Roughly, we can distinguish three broad regions in the diagram. First, there is a group of very late stars that appear to be "normal" in the sense that they are all depleted of Li and have abundances less than *log* n(Li) $\approx$ 0. In our limited sample, both slowly and rapidly rotating stars appear to be present among them. A second group of objects is that at the top of the diagram. They have a very high Li abundance, comparable to, or higher than, the cosmic "primordial" value of $\approx$ 3.0. They tend to be fast rotators, but in this case too there is a broad range of projected rotational velocities. Finally, in the middle part of the diagram there is a broad region of active stars, which on average have both higher Li abundances and higher rotational velocities than inactive stars of the same spectral types; they show, however, little dependence of Li abundance upon rotation within the group itself (at most, there may be a slight tendency of the more rapidly rotating stars to have also higher Li abundances).

At present, it may be quite unsafe to draw conclusions. However, we can at least attempt some plausible interpretation in the light of the considerations above. The stars at the bottom of Figure 7 may be the less massive ones. Their progenitors on the main sequence had sufficiently deep convective zones to allow efficient burning of Li, independently of rotation. Since they are also older, they had enough time to deplete Li during their main-sequence lifetime and/or may have already entered the post main-sequence Li dilution phase. The stars in the middle group, which have preserved a substantial (but varying) amount of Li may have done so, either because they were rather massive (and then originated from late A or early F stars with very thin convective zones); or, if they were less massive (in the range 1.2 to 1.5 $M_{\odot}$), because they are rotating rapidly and hence have suffered less differential rotation mixing. A distribution of initial angular momenta may contribute to the scatter in the Li abundance vs. rotation diagram. Finally, the stars with extremely high Li abundance at the top of the diagram are almost certainly very young objects that have recently arrived at the main sequence or are approaching it. The spectra of these stars in the Li region resemble very closely those of the rapidly rotating K stars in the Pleiades as well as those of naked T Tauri stars. Moreover, two of these stars (AB Dor and PZ Tel) have already been shown on kinematic grounds to belong to the Pleiades moving group.

5. Conclusions

Our survey has shown that chromospherically active K stars have a definite Li excess with respect to inactive stars of similar spectral type. This excess cannot simply be an age effect, since it is also present in many RS CVn binaries and other supposedly evolved stars. It cannot be due either to an enhancement of the Li line by large cool spots since observations of a few stars at different phases have shown no rotational modulation of the Li line. We have suggested that a combination of thin convective zones in their main-sequence progenitors, together with little angular momentum loss during the evolution of these tidally-locked rapidly rotating stars, may qualitatively explain the lower Li depletion. It is not easy however to disentangle the various relevant effects in a highly heterogeneous sample as the present one, which may also contain young, rapidly rotating single stars.

More work needs to be done for a proper understanding of the Li problem in chromospherically active stars. First of all, a separation of the total sample in smaller, more homogeneous subsamples is necessary. Secondly, it is desirable to extend the observations to northern stars since most "classical" well-studied RS CVn binaries, with better determined masses and evolutionary states, are located at northern declinations. Third, the metallicity of the various stars in the sample should be accurately determined. Finally, we should be careful in identifying very young stars and possibly pre-main sequence objects in the sample by studying their kinematic properties and surface activity. Research along these lines is currently being carried out by us; the results are expected to provide essential clues for the understanding of Li abundance in chromospherically active stars.

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Lithium in Carbon Stars

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Carbon Stars

Carbon stars (C stars in the following) are characterized by a surface carbon to oxygen ratio (C/O ratio) greater than unity (detected by the presence of strong molecular bands of C_2, CN and CH) and an excess of heavy elements (presence of ZrO molecular bands instead of TiO bands, as seen in M giants, and presence of enhanced atomic lines of Sr, Y, Ba), as well as a huge mass loss.

Those stars are located on the poorly known asymptotic giant branch (AGB) of the H-R diagram. This branch constitutes the locus of intermediate mass ($0.8 \lesssim M/M_{\odot} \lesssim 8$) stars in which hydrogen and helium burn alternately in shells around an electron degenerate carbon-oxygen core (Iben and Renzini, 1983). These stars are also characterized by the occurrence of thermal pulses. After each thermal pulse, the carbon and the s-process isotopes, made in the convective helium-burning zone, can be brought to the surface of the stars by convective dredge-up. Therefore, it is believed that along the AGB, a star evolves from spectral type M (i.e. $C/O < 1$) to S ($C/O \approx 1$) and finally C ($C/O > 1$) when it experiences more and more thermal pulses.

The presence of the unstable s-element technetium in the spectra of some C stars (Peery 1971) is a clear indication that an intense nucleosynthesis is taking place in those stars and that the freshly synthesized material is brought to the surface. The exact mechanism by which this processed material comes to the surface, as well as the conditions present in the pulses, however, are not very well known. Therefore, it is of prime importance to study the Li in AGB stars, as the great sensitivity of this element to the physical conditions makes it a good tracer to constrain those conditions prevailing in the stellar atmospheres.

Lithium

Lithium is a fragile element, easily destroyed by proton captures in the stellar envelopes at temperatures higher than $2.5\ 10^6$ K. In fact, in main-sequence stars, Li only survives in the outer 2 to 3% (in mass) of the stars, its surface abundance depending on the depth of the convective envelope in this phase, itself depending mainly on the effective temperature and metallicity of the star. Observations in main-sequence stars generally show that the abundance of Li correlates strongly with the effective temperature, in the sense of lower abundance for decreasing temperature (from F to G-K dwarfs). But, if phenomena as semiconvection, diffusion or mass loss are also active in this phase, the surface Li abundance will be reduced even more, either by exposing Li to energetic protons, or by removing it from the star. During the ascent of the red giant branch, the convective mixing (first dredge-up) dilutes the surviving Li with Li-free material from the interior. After this process, the expected surface abundance of Li is at most 1/30 of the initial abundance in the stars, that value depending on the initial mass of the star.

In general, the observations of red giants are not in agreement with the theoretical predictions: either the Li abundance is higher than predicted, as is the case for some G-K giants (Brown