THE ROTATIONAL HISTORY OF SOLAR-TYPE STARS: DOES IT AFFECT LITHIUM ABUNDANCES?

J. BOUVIER
Laboratoire d'Astrophysique, Observatoire de Grenoble
Université Joseph Fourier, B.P.53, F-38041 Grenoble Cedex 9

Recent studies of lithium abundances in solar-type stars suggest that second order effects, such as rotation and/or mass-loss, might affect the rate at which lithium is depleted at the surface of cool stars. This conclusion mainly stems from the dispersion of lithium abundances observed in late-type stars with otherwise similar mass and age. The dispersion of lithium abundances is relatively small in pre-main sequence (PMS) stars [1], reaches a maximum of about 2 dex in ZAMS stars (Soderblom, this volume), and decreases later during main sequence evolution, although significant dispersion may still be present by the age of the Sun [2], and perhaps even during the giant stage (Balachandran, this volume).

Such a pattern of lithium dispersion is difficult to understand in the framework of conventional models in which lithium burning occurs at the base of the convective zone of non-rotating, non-mass losing stars. That two stars of the same age and mass can exhibit different lithium content strongly suggests that other, so far neglected, mechanisms play a role in lithium depletion.

In this context, it may be relevant to stress that the pattern of lithium *dispersion* varies with age in much a similar way than does the *dispersion* of stellar rotation, namely: the dispersion in both rotation rates and lithium abundances is relatively small in the PMS stage, then strongly increases from the PMS to the ZAMS, and subsequently decreases on the main sequence. The parallel evolution of the range of lithium abundances and of rotation rates observed in solar-type stars is strongly suggestive of a physical link between rotation and lithium depletion.

Such a link, however, may be indirect: that one finds no clear, one-to-one relationship between lithium abundance and rotation rate in any of these stars may indicate that another mechanism is more directly involved in the lithium depletion process. Mass-loss, whose strength is presumably

I. Appenzeller (ed.), Highlights of Astronomy, Vol. 10, 445–446.

https://doi.org/10.1017/S1539299600011679 Published online by Cambridge University Press

connected with rotation in cool dwarfs, might be such a mechanism (S. Vauclair, this volume).

Alternatively, the lack of a tight relationship between lithium abundance and rotation may come from the fact that it is not so much the "instantaneous" rotation rate that matters for lithium depletion (or inhibition thereof) but more the whole rotational history of the star (e.g., [3], Zahn, this volume). If correct, it is then not enough to measure the star's rotation rate at a given age to infer what the effect of rotation onto lithium depletion may be. Instead, *it is indeed necessary to trace the past rotational history of the star back to its very early evolution* to understand the fate of lithium abundances in cool stars.

Modern studies of rotation in cool stars indicate that their rotational history can be quite dramatic and, more importantly, that it strongly varies from one star to the other, especially in the very early phases of evolution. To start with, most solar-type stars in the T Tauri phase (1-5 10^6 yr) have moderate rotation rates between 10 and 30 kms^{-1}. A few of these stars will strongly spin up as they contract during the PMS phase to reach the ZAMS (3-5 10^7 yr) with velocities up to 200 kms^{-1}. These few ultrafast rotators are subsequently braked extremely efficiently down to velocities of a few kms^{-1} within about 10^8yr. Hence, a few solar-type stars do experience huge and rapid changes in their rotation rates. If rotation does impact onto lithium depletion, it is most likely that its effect will be the strongest during these early phases of evolution.

Not all cool stars, however, undergo such dramatic changes in their rotation rates. In fact, a significant fraction of solar-type stars, perhaps as much as half of them, remain in slow rotation with velocities not exceeding 20 kms^{-1} even in the PMS phase. Whether a star does or does not experience strong spin up during its PMS evolution is presumably related to the lifetime of circumstellar disks which varies from star to star [4].

It is thus conceivable that the different rotational histories experienced by cool stars during their early evolution is the cause, direct or indirect, of the dispersion of lithium abundances observed in young stars and older ones. A more complete account of these rotational histories will be given in the proceedings of IAU 22's Joint Discussion 11.

References

1. Martin E.L. et al. 1994, A&A 282, 503
2. Pasquini L. et al. 1994, A&A 287, 191
3. Pinsonneault M.H. et al. 1990, ApJS 74, 501
4. Bouvier J. 1994, in: Cool Stars, Stellar Systems, and the Sun, ed. J.-P. Caillault, ASP Conf. Ser. Vol.64, p.689