THE LITHIUM DEPLETION PATTERN IN NGC 2264 AND NGC 2547

E. Franciosini, G.G. Sacco, L. Spina, F. Palla, S. Randich

INAF/Osservatorio Astrofisico di Arcetri, Italy

1. Introduction

Lithium measurements are a powerful tool to investigate young stellar evolution by probing the internal structure of PMS solar-type stars. Moreover, they provide an independent tool to estimate age in young clusters, allowing us to identify possible age spreads, which has important implications for the cluster star formation histories. The two young open clusters NGC 2264 and NGC 2547 allow us to investigate these issues at the onset of Li depletion, and at a critical age to put constraints on evolutionary models, respectively.

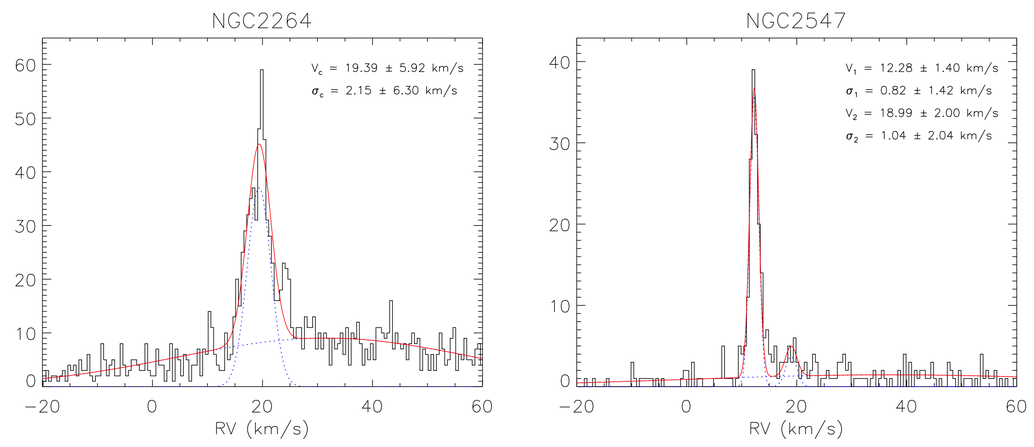
NGC 2264 is one of the richest star-forming regions in the solar vicinity, lying in the Mon OB1 association at a distance of $\sim$ 760 pc. It has an estimated age of $\sim$ 3 Myr (Sung et al. 2004) and a reddening E(B – V) = 0.146 (Rebull et al. 2002). Recent asteroseismic observations found evidence for a significant age spread among stars of 1.5 – 3 $M_\odot$ (Zwintz et al. 2014).

NGC 2547 (d $\sim$ 400 pc, E(B – V) = 0.03; Lyra et al. 2006) is located in the Vela OB2 association, $\sim$ 2° south of γ Vel. Jeffries & Oliveira (2005) derived a lithium depletion boundary (LDB) age of 35 $\pm$ 3 Myr. The GES data revealed the presence of a second kinematic population (NGC 2547B; Sacco et al. 2014) consistent with γ Vel B (Jeffries et al. 2014).

The GES obtained Giraffe HR15N spectra for 1706 and 450 stars in NGC 2264 and NGC 2547, respectively.

2. Membership selection

Radial velocities (RVs): We use RVs as our main membership criterium. Although young stars have strong Li absorption, we do not make any prior selection based on its equivalent width (EW) to avoid excluding Li-depleted members. The RV distributions for the two clusters are shown below:

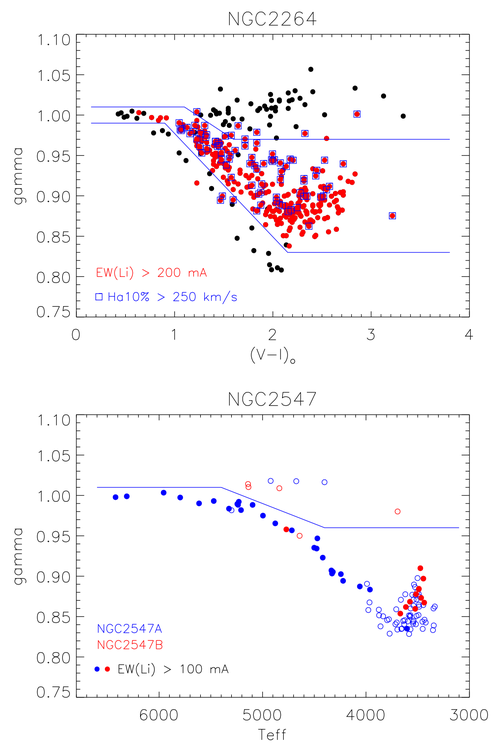


NGC 2264 shows a wide peak with some hint for kinematic substructures. A two-gaussian fit (cluster + field) gives V_c = 19.4 km/s with standard deviation σ_c = 2.1 km/s.

NGC 2547 shows a main narrow peak at V_A = 12.3 km/s with σ_A = 0.8 km/s (NGC 2547A), and a smaller one at V_B = 19.0 km/s with σ_B = 1.0 km/s (NGC 2547B).

We selected as cluster RV members stars lying within 2σ of the cluster peaks.

γ index: the γ index, defined by Damiani et al. (2014) as a proxy for log g, allows us to discriminate giants and field MS stars from PMS stars using the γ vs colour or γ vs T_{eff} diagrams.



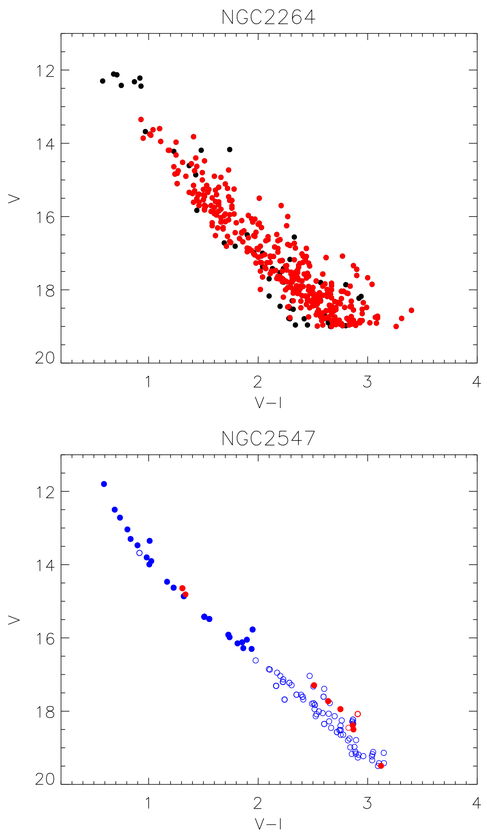
γ-index vs $(V - I)_o$ for RV members of NGC 2264. Red dots indicate cluster candidates with strong Li absorption, delineating the cluster locus; blue squares are accreting stars with Hα 10% width > 250 km/s. Non-accreting stars located above (giants) and below (MS) the blue lines were discarded.

γ-index vs T_{eff} for RV members of NGC 2547A (blue circles) and NGC 2547B (red circles). Filled circles indicate stars with EW(Li) > 100 mÅ. Only stars above the blue line were discarded.

Colour-magnitude diagram: For NGC 2264 an additional selection in the V vs V – I CMD was performed to exclude Li-poor objects falling below the 10 Myr isochrone.

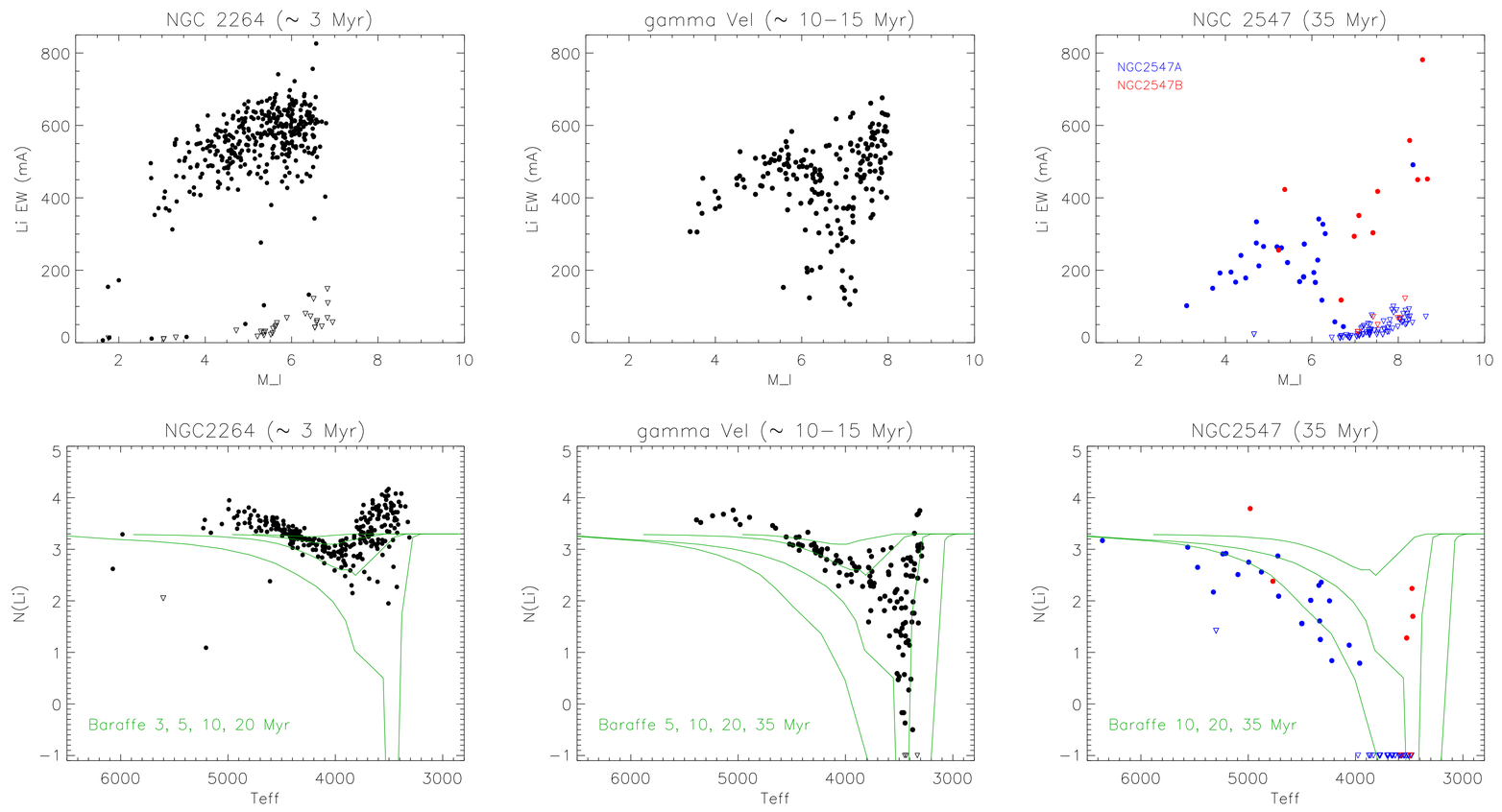
3. Colour-magnitude diagrams of selected members

The final samples contain 441 members of NGC 2264, and 163 and 27 members of NGC 2547 A and B, respectively.



CMD of selected members. Symbols are the same as in the previous figures.

4. Lithium abundances



Li EWs and abundances for NGC 2264 (left panels) and NGC 2547A and NGC 2547B (right panels) compared with those of the 10 – 15 Myr-old cluster γ Vel (center panels). In the lower panels the Baraffe et al. (1998) evolutionary models are also shown.

NGC 2264 shows a significant spread in Li EWs at a given magnitude, suggesting the presence of an age spread also among low-mass stars, but no evidence of significant Li depletion, contrary to what observed in the older γ Vel cluster (the Li-poor objects are most likely residual contaminants). The comparison with the Baraffe models (Baraffe et al. 1998) suggests an age between $\sim$ 3 – 5 and 10 Myr. The few objects below the 10 Myr isochrone are all strong accretors, whose measured abundance is likely affected by veiling.

On the other hand, NGC 2547A shows significant Li depletion at all magnitudes, consistently with its older age. The Li depletion pattern is consistent with the 35 Myr isochrone, in agreement with the LDB age derived by Jeffries & Oliveira (2005). Members of NGC 2547B instead show higher Li EWs and abundances, comparable to those of γ Vel and consistent with an age < 20 Myr, supporting the suggestion that NGC 2547B belongs to the same population of γ Vel B (Sacco et al. 2014).

References

Baraffe, I., Chabrier, G., Allard, F., Hauschildt, P. H. 1998 A&A, 337, 403
Damiani, F., Prisinzano, L., Micela, G. et al 2014, A&A, 566, A50
Jeffries, R.D., Oliveira, J.M. 2005, MNRAS, 358, 13
Jeffries, R. D., Jackson, R. J., Cottaar, M., et al. 2014, A&A, 563, A94
Lyra, W., Moitinho, A., van der Bliek, N. S., Alves, J. 2006, A&A, 453, 101
Rebull, L. M., Makidon, R. B., Strom, S. E., et al. 2002, AJ, 123, 1528
Sacco, G. G., Jeffries, R. D., Randich, S., et al. 2014, GES paper 30
Sung, H., Bessell, M. S., Chun, M.-Y. 2004, AJ 128, 1684
Zwintz, K., Fossati, L., Ryabchikova, T., et al. 2014, Sci, 34, 550