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NGC 3960: membership and lithium abundances

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Abstract. We determine here membership and Li abundances in a sample of candidate members of NGC 3960 (age ∼1 Gyr), to fill the gap between 0.6 and 2 Gyr in the empirical description of the behaviour of the average Li abundance as a function of the stellar age. We use VLT/FLAMES Giraffe spectra to determine the radial velocities (RVs) and thus the membership of a sample of 113 photometrically selected candidate members. We derive Li abundances for cluster members and nonmembers. Li abundances of the stars hotter than about 6000 K are similar to those of stars in the Hyades, while they are slightly smaller for cooler stars. This confirms that NGC 3960 is older than the Hyades. The average Li abundance of members cooler than about 6000 K indicates that the Li Pop. I plateau starts already at 0.9 Gyr rather than 2 Gyr that is the upper limit previously derived in Sestito & Randich (2005). We also derive the fraction of field stars with high Li abundance (≥1.5) and that of contaminating field stars.

1. Introduction

Old open clusters are useful targets to investigate lithium (Li) depletion during the MS. Comparison of the Li abundances in clusters of different age allows us to understand the efficiency of the Li destruction process. Given its age (∼0.9 Gyr), NGC 3960 provides a good sample to investigate the evolution of Li abundance during the MS and, in particular, to fill the gap in age coverage between the Hyades (0.6 Gyr) and the ∼1.5-2.0 Gyr clusters for which Li data are available (NGC 752, IC 4651). We selected 113 photometric candidate members on the MS with 16<V<18 (Sp. Types from F to early K). The targets are indicated in Fig. 1 that shows the V vs. V-I diagram of the region within 7' from the cluster centroid obtained from the Prisinzano et al. (2004) photometry corrected for differential reddening. The targets were observed with Giraffe/FLAMES at the VLT using the grating HR15 (R=19300), including the Li line at 6707.8 Å, in four 45 min exposures for each setup. Details on data reduction are given in Prisinzano & Randich (2007).

2. Radial velocities and cluster membership

Heliocentric RVs were computed using the function giCrossC of the GIRAFFE pipeline. Fig. 2 shows the density distribution of the RVs that we fitted with a double gaussian using the maximum likelihood fitting to consider both the RV distribution of NGC 3960 and that of the field stars. The mean cluster RV is 20.0±0.7 km/s with a standard devia-

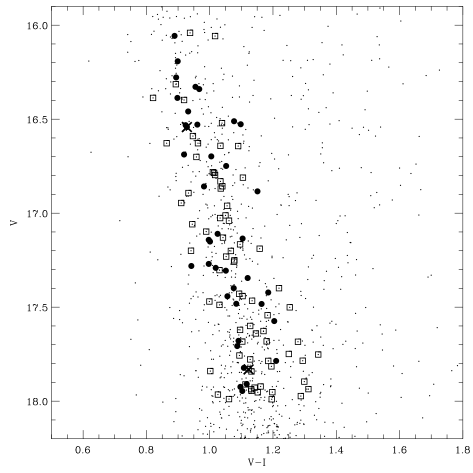

Fig. 1. V vs V-I diagram for stars within 7' from the cluster center. Targets are indicated by large symbols. Filled circles and squares are, respectively, members and nonmembers for RV.

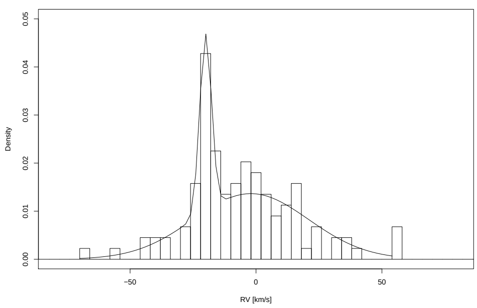

Fig. 2. Density distribution of the RVs of the 113 targets. Solid line is the fitted double gaussian.

tion of 2.3±0.6 km/s, while the field star RV is 2.1±2.6 km/s with a standard deviation of 22.9±1.8 km/s. We consider RV members the 39 stars within $\pm 3\sigma$ of the cluster RV distribution. This sample includes 16 contaminating field stars, as computed from the Gaussian field star distribution.

3. Lithium analysis

Li EWs were measured on the coadded normalized spectra with IRAF/SPLOT. We detected 55 objects with Li and 2 SB2 binaries; upper limits (UL) of the Li EWs for the remaining 56 stars were estimated. After correcting the EWs for the contribution of the Fe I 6707.4 Å feature (Soderblom et al. 1993a), we converted Li EWs in LTE Li abundances using the effective temperatures derived from the B-V colors and the growth curves of Soderblom et al. (1993a). NLTE Li abundances n(Li) were derived using the Carlsson et al. (1994) code. Fig. 3 shows the n(Li) values for different samples as a function of the effective temperatures and the comparison with the Hyades.

4. Results and conclusions

Among the 39 RV members, only 29 show the Li line; thus the remaining 10 objects are likely contaminants, even if the coolest of them have ULs comparable to the n(Li) of stars with detected Li (see Fig. 3, panel b). The sample of 29 RV members with Li includes about 6 contaminating objects which could contribute to the spread in the Li abundances. By considering the 29 stars as members, we computed the average Li abundances for NGC 3960 in 3 different temperature ranges as in Sestito & Randich (2005). The results are shown in Fig. 4. For members hotter than ~6000 K, the average n(Li) of NGC 3960 confirms the trend of slow depletion at ages older than the Hyades, while for cooler stars, it is compatible with that of older clusters and this allows us to constrain the age (~1 Gyr) at which the Li depletion stops.

We have a total of 90 field stars, 113-39 no RV members + 16 with RV consistent with that of the cluster. Those with Li are 26+6 and thus about 1/3 are field stars with log n(Li)>2. This fraction is slightly lower than that (~1/2) found by Pasquini et al. (1994). The large spread in the field star Li abundances is both consistent with a mixed population and possibly/in part due to another unknown parameter responsible of the MS Li depletion (e.g. (Pasquini et al. 1994; Randich et al. 2006, and references therein).

Using the 84 individually known field stars we estimated the fraction of contaminating

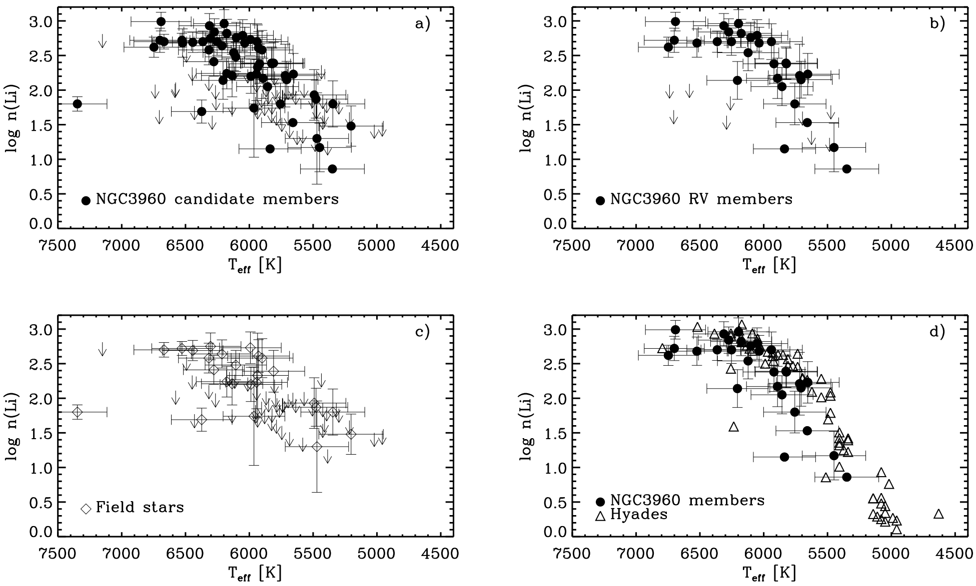

Fig. 3. Li abundances and ULs for all NGC 3960 candidate members (panel a), RV members (panel b), RV nonmembers (panel c), NGC 3960 and Hyades members (panel d) as function of the effective temperature.

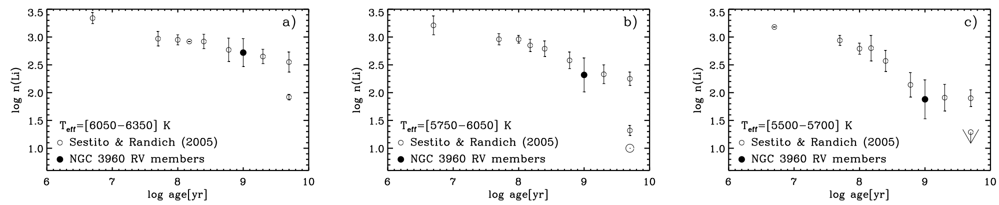

Fig. 4. Plots adapted from Fig. 7 of Sestito & Randich (2005) showing the average log n(Li) as a function of cluster age in 3 different temperature ranges.

field stars in our sample as a function of the V magnitude. We compared it with that statistically found in Prisinzano et al. (2004) using a field region outside the cluster. Within the errors, the fractions are compatible and this allows us to confirm the results about the Mass Function derived in Prisinzano et al. (2004) that strongly depends on the field star contamination.

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