On the formation history of nearby Sun-like stars (and their planetary systems)

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Ph. Gondoin (ESA exoplanet team)

Nearby Sun-like stars are prime targets for the detection and characterization of exo-planets and possibly exo-Earths. Understanding their formation history and determining the age of these stars (and their planetary systems) is thus essential.

The present study addresses the formation history of nearby solar-type stars using the emission reversal in the cores of their Ca II H&K Fraunhofer lines as an age indicator. A representative sample of nearby (< 65pc) main-sequence G-type stars with near-solar metallicity and known magnetic activity levels is built from a catalogue of chromospheric activity indices (Gomes da Silva et al. 2021) derived from high-resolution spectra obtained with the HARPS spectrograph between 2003 and 2019, as compiled in the AMBRE project. I used an empirical age-activity relationship derived from stellar rotation period measurements in intermediate-age open clusters (Gondoin 2020) to infer the age distribution of these sample stars.

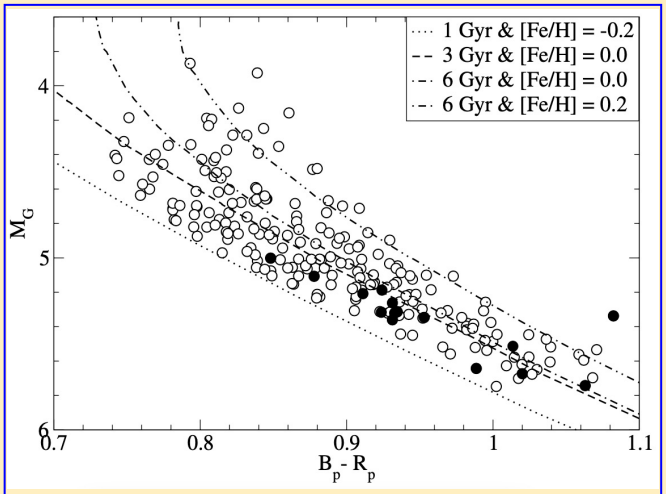

Figure 1: colour-magnitude diagram of a representative sample of nearby (d < 65pc) G-type main-sequence stars with -0.2 < [Fe/H] < 0.2 extracted from the AMBRE catalogue of R'_{HK} indices. Filled circles mark stars with $R'_{HK} > 4.10^{-5}$ i.e. the most active stars of the samples.

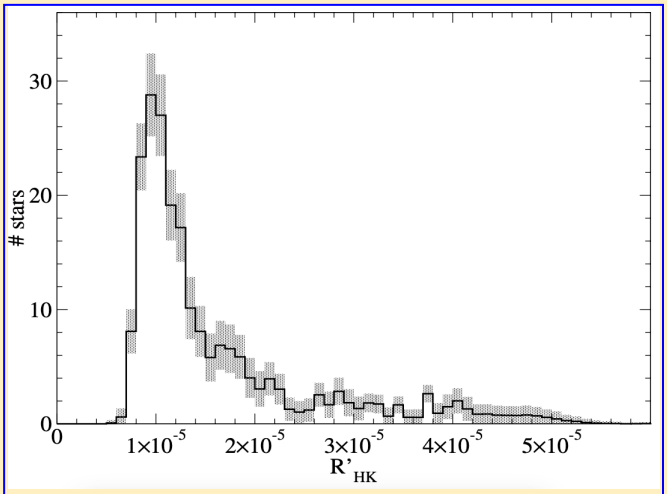

Figure 2: Mean R'_{HK} index distribution of the sample stars. The grey areas represent the $\pm$ 1 σ envelopes of the histograms of 1000 realisations of the distribution of R'_{HK} indices assuming a Gaussian distribution around the mean measurement values with the standard deviations provided in the AMBER catalogue of R'_{HK} indices.

The inferred age distribution shows a steep rise of the star formation rate in the solar neighbourhood between 7 and 6 Gyr ago with a maximum ~ 5 Gyr ago. The star formation then decay till ~2 Gyr and rises again in the recent past.

This timeline is consistent with a scenario (Ruiz-Lara et al. 2020) where the steep rise in the age distribution of nearby Sun-like stars around 7-6 Gyr ago would be linked to an external perturbation induced by a first encounter of the Milky Way disc with the Sgr galaxy ~6.5 Gyr ago. A more recent star formation event at ~1.8 Gyr could have been triggered by a subsequent pericentric passage of the dwarf galaxy.

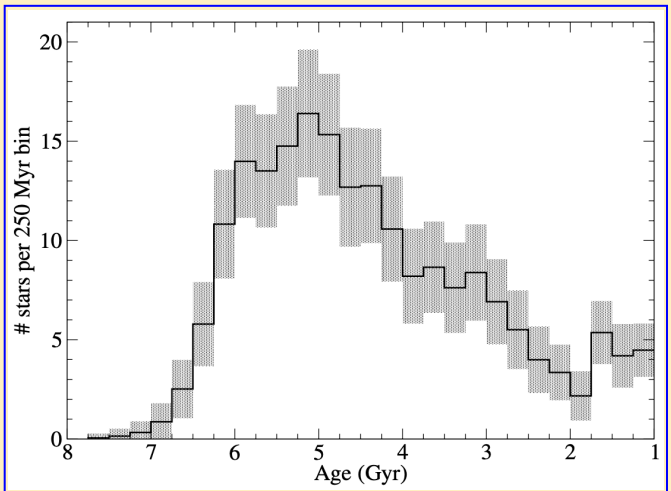

Figure 3: Age distributions derived by inverting the R'_{HK} index distributions of the sample stars. The grey areas represent the $\pm$ 1 σ envelopes of the histograms of 1000 realisations of the distribution of R'_{HK} indices.

References:

Gomes da Silva et al. 2021, A&A, 646, A77
Gondoin 2020, A&A, 641, A110
Ruiz-Lara et al. 2020, Nat. Astron. 4, 965

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