THE AGE OF OLD GALACTIC POPULATIONS

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1. Introduction

As a preparation to the HIPPARCOS mission, a large observing programme on NLTT stars (proper-motion > 0.18″/yr) was started in Geneva photometry. The original programme consists of 10047 stars brighter than mR = 11.5, or mR = 12.5 if of colour class m. Among them, 7813 targets could be included in the HIPPARCOS programme, selected according to their observability and internal priorities in favour of large parallaxe stars (photometric distances < 100 pc) and high-velocity stars. The bulk of new nearby, halo, mild-metal poor and SMR stars in the HIP Catalogue originates from this proposal ($N°$ 139). No less than 208 new nearby stars with $\pi \geq 40$ mas were discovered south of δ +10°, the closest has π(HIP)= 182 mas. Radial velocities were obtained with CORAVEL at OHP and ESO. Most aspects of the early evolution of the Galaxy may be addressed with this sample. Here we discuss, as examples, the ages of the thick disk and of the galactic bulge.

2. The stellar physical and kinematical parameters

For stars measured with Geneva photometry, the quantities Mv, T_{eff}, and, if T_{eff} > 4800°K, [M/H] are obtained with uncertainties of ± .15 mag, 20°K and 0.05 dex respectively. The Geneva calibration provides [Fe/H] = 0.142 ± 0.008 for Hyades for all T_{eff}. Space velocities and galactic orbits are computed for 4222 F to M stars. 2930 stars have now their kinematical and physical parameters presently defined, [M/H] included. This material, free from bias against metal-rich stars namely, is ideal to address the question: how old are the early galactic populations.

3. The thick-disk age

Because the space velocities and metal-abundances distributions overlap for halo, thick disk (TD) and old thin disk populations, the concept of TD is not unique in literature. Here we consider as typical TD members, stars having, in the solar vicinity, V velocity component from -170 to -50 km/s, Zmax < 2 kpc and [M/H] from -0.90 to -0.55. The comparison of trigonometric and photometric parallaxes reveals binaries undetected by HIPPARCOS which may appear as spurious metal-poor stars. With the condition photometric and HIPPARCOS parallaxes > 10 mas, 198 stars are retained. Their mean [M/H] is -0.67. The HR-diagram of single TD stars shows a well defined isochrone, typical of metal-rich globulars, with Mv(RHB) = 0.75. With similar [M/H], the TD population and 47 Tuc show an age identity from their HR-diagram, i.e. δMv(mid-SGB - RHB) = 3.10 in both cases.

At mid-subgiant branch (SGB), effects as He sedimentation, rotation, C, N, O abundance anomalies cancel, and small errors on E(B-V) have a negligible impact. Mv(SGB) turns out to be the best age estimator for old mild metal-poor to metal-rich stars. Around log(T_{eff}) = 3.735, TD Mv(SGB) = 3.89, hence an age of 14 Gyr is found from Bergbush et al. (1992) isochrones. The fit of the empirical HR-diagram to theoretical isochrones requires a shift of -0.026 in theoretical log(T_{eff}) or 300°K around T_{eff} 5400°K, making the absolute dating still questionable.

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4. The age and evolution of the bulge

The simplest way to identify bulge-like stars in the solar vicinity is to select high eccentricity SMR stars with [M/H] higher than that of disk stars moving on nearly circular orbits. The majority of the 203 stars with [M/H] $> +0.30$ forms the metal-rich tail of the local disk having reached lately the maximum metallicity observable at solar galactocentric distance. Stars with V $<$ -110 to -50 km/s are members of the inner disk or of the bulge. From [O/Fe] anomalies Barbuy & Grenon (1990) assigned extreme SMRs to the bulge population. The local counterparts of the bulge are moving on trifoil orbits, with Zmax $\leq$ 1 kpc and pericentric distances Rp as small as 2 - 3 kpc. The age of old SMRs is deduced from the HR-diagram Mv(HIP) versus T_{eff} from Geneva photometry. When binaries and blue stragglers are taken into account, no noticeable age dispersion is detected for stars with Rp $<$ 5.2 kpc. Both from the turn-off location and the SGB luminosity, an age of 10.5 $\pm$ 0.5 Gyr is found from Schaerer et al.(1993) isochrones with Z = 0.04. SMRs represent few percent of the bulge population; their age corresponds to the epoch of the end of the star formation in the bulge. [O/Fe] excess and [Ba/Fe] deficiency, (Castro et al. 1997) indicate that SN Ia and AGBs played a limited role in the bulge nucleosynthesis.

If few bulge SMRs are seen in the solar vicinity, less metal-rich bulge stars are also scattered out up to the solar orbit. When stars are selected according to Rp $\leq$ 5.2 kpc, the metal abundance distribution happens to be the same as that observed in the bulge by Mc William & Rich (1994), i.e. a bell shaped distribution with [M/H] from -0.70 to +0.50, a maximum around -0.10 dex and a tail of more metal-poor stars as seen in the bulge. With the constraints from the SN II, SN Ia and AGB yields, the time scale for the bulge chemical evolution must be $<$ 1 Gyr, thus the onset of star formation may have occured about 11 Gyr ago.

5. Summary

The inner old disk and the bulge appear to be built from the same stellar populations as for their age and chemistry are concerned, but with distinct subsequent kinematical evolution. The orbital diffusion, triggered by a central bar, played a major role on the old stars space distribution. It is why the metallicity gradient from old stars with eccentric orbits (Grenon 1987) tends to flatten or vanish inside the solar orbit, contrarily to the situation in the young disk as observed from B type stars or the gas. The thick disk appears related to the inner halo rather than to the thin disk although some continuity seems to exist between the thick and the thin disk. The time delay between the formation of the so-called thick-disk and the onset of the main burst of star formation in the bulge could be as large as 2 Gyr.

References

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