

Signatures of an intermediate-age metal-rich bulge population

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Abstract. We have determined detailed elemental abundances and stellar ages for a sample of now 38 microlensed dwarf and subgiant stars in the Galactic bulge. Stars with sub-solar metallicities are all old and have enhanced α -element abundances – very similar to what is seen for local thick disk stars. The metal-rich stars on the other hand show a wide variety of stellar ages, ranging from 3-4 Gyr to 12 Gyr, and an average around 7-8 Gyr. The existence of young and metal-rich stars are in conflict with recent photometric studies of the bulge which claim that the bulge only contains old stars.

1. Signatures on an intermediate-age metal-rich bulge population

The first 26 microlensed dwarf and subgiant stars in the bulge from Bensby et al. (2010, 2011) showed that the metallicity distribution of the Galactic bulge is likely bimodal with a paucity of stars around solar metallicities. Adding another 12 microlensed bulge dwarfs from the 2011 observing campaign the metallicity distribution of the current sample of 38 microlensed dwarfs is still bi-modal with two distinct peaks: one metal-poor peak with 16 stars and an average metallicity of $[\text{Fe}/\text{H}] \approx -0.6$ and one metal-rich peak with 22 stars and an average metallicity of $[\text{Fe}/\text{H}] \approx +0.3$. A two-sided KS-test with the red giant sample in Baades window from Zoccali et al. (2008), re-analysed by Hill et al. (2011), gives a p -value of 0.47. This means that we can not reject the null hypothesis that the microlensed sample and the red giant sample are drawn from the same underlying metallicity distribution.

Figure 1 (left-hand plot) shows the age-metallicity diagram for the microlensed bulge dwarfs. At sub-solar metallicities the stars are pre-dominantly old with ages between 9 and 13 Gyr. The average age is 10.6 Gyr with a spread of 3.3 Gyr. The 22 stars at super-solar metallicities on the other hand show a wide range of ages from only a few billion years old to as old as the Universe, i.e. spanning the full range of ages from the Galactic disk to the halo. The average age is 6.9 Gyr with a spread of 3.6 Gyr for the stars at super-solar $[\text{Fe}/\text{H}]$.

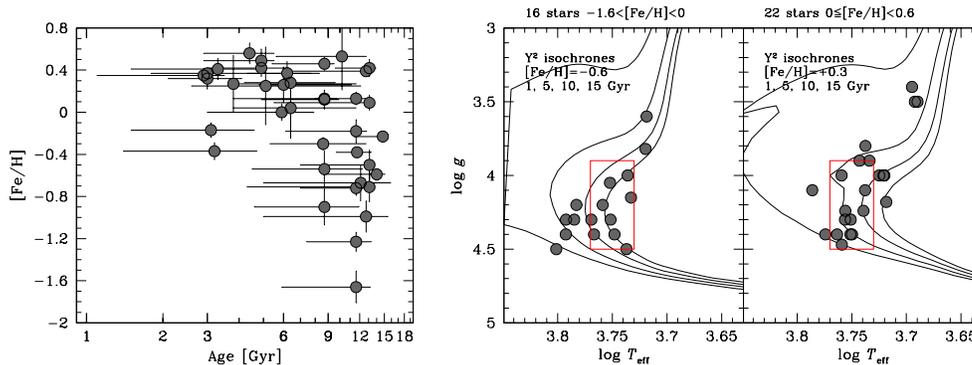


Figure 1. *Left:* Age-metallicity diagram. *Right:* The metal-poor and metal-rich bulge dwarfs plotted on isochrones representative of their respective average metallicity. The red rectangle occupy the same region in each plot.

Photometric studies toward the Galactic bulge appear to indicate that the bulge population is all old and that there are no signs of a young or intermediate age population in the HR diagrams (e.g., Zoccali et al. 2003; Clarkson et al. 2008). However, the metallicity distribution of the bulge spans a large range of metallicities (e.g., Fulbright et al. 2007). In the right-hand plot of Fig. 1 we show the microlensed sample, divided into the metal-poor and metal-rich sub-samples, on top are shown isochrones with different metallicities. The rectangle outlines the same $T_{\text{eff}} - \log g$ region in each of the two plots. It is clear that, if a metal-poor isochrone would be plotted on top of the metal-rich stars, they would all appear old. This demonstrates the importance of taking isochrones with a suitable range of metallicities into account when estimating the age of the bulge from HR diagrams.

In summary, the sample of microlensed dwarf stars in the bulge shows evidence for a bi-modal bulge population and that the metal-rich population has a significant fraction of intermediate-age stars (but see Nataf & Gould 2011). This will be further investigated in an upcoming paper.

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References

- Bensby, T., Adén, D., Meléndez, J., Gould, A., Feltzing, S., Asplund, M., Johnson, J. A., Lucatello, S., Yee, J. C., Ramírez, I., Cohen, J. G., Thompson, I., Bond, I. A., Gal-Yam, A., Han, C., Sumi, T., Suzuki, D., Wada, K., Miyake, N., Furusawa, K., Ohmori, K., Saito, T., Tristram, P., & Bennett, D. 2011, *A&A*, 533, A134
- Bensby, T., Feltzing, S., Johnson, J. A., Gould, A., Adén, D., M., A., Meléndez, J., Gal-Yam, A., Lucatello, S., Sana, H., Sumi, T., Miyake, N., Suzuki, D., Han, C., Bond, I., & Udalski, A. 2010, *A&A*, 512, A41
- Clarkson, W., Sahu, K., Anderson, J., et al. 2008, *ApJ*, 684, 1110
- Fulbright, J. P., McWilliam, A., & Rich, R. M. 2007, *ApJ*, 661, 1152
- Hill, V., Lecureur, A., Gómez, A., et al. 2011, *A&A*, 534, A80
- Nataf, D. M., & Gould, A. P. 2011, arXiv:1112.1072 [astro-ph.GA]
- Zoccali, M., Hill, V., Lecureur, A., et al. 2008, *A&A*, 486, 177
- Zoccali, M., Renzini, A., Ortolani, S., et al. 2003, *A&A*, 399, 931