Highlights of Astronomy, Volume 16
XXVIIIth IAU General Assembly, August 2012
T. Montmerle, ed.

doi:10.1017/S1743921314005778

CN Anomalies in the Halo System

Daniela Carollo[1,2]

[1]Dept. of Physics and Astronomy - Astronomy Astrophysics
and Astrophotonic Research Center
Macquarie University - North Ryde, 2109, NSW, Australia
email: daniela.carollo@mq.edu.au

[2]INAF - Astronomical Observatory of Turin - Italy

Abstract. I present an evaluation of the kinematic properties of halo red giants thought to have formed in globular clusters based on the strength of their UV/blue CN and CH absorption features. The sample has been selected from the catalog of Martell *et al.* (2011). The orbital parameters of CN-strong halo stars are compared to those of the inner and outer halo populations, and to the orbital parameters of globular clusters with well-studied Galactic orbits. It has been found that both the clusters and the CN-strong field stars exhibit kinematic and orbital properties similar to the inner halo population, indicating that globular clusters could be a significant source of inner halo field stars, and suggesting that both globular clusters and CN-strong stars could belong primarily to the inner halo population of the Milky Way.

Keywords. Galaxy: halo, Galaxy: formation, Galaxy: structure, Galaxy: kinematics and dynamics, Galaxy: stellar content, Globular Clusters: general

1. Selection of the sample

The Martell & Grebel (2010) and Martell *et al.* (2011) studies of halo field giants drew their data from the SDSS-II/SEGUE (Abazajian *et al.* 2009; Yanny *et al.* 2009) and SDSS-III/SEGUE-2 (Aihara *et al.* 2011; Eisenstein *et al.* 2011) surveys, respectively. The sample have been further refined to include only those stars with available proper motions, which means that the star satisfies additional criteria designed to eliminate spurious reported motions. Also, stars belonging to the SDSS/SEGUE fields that fall in the direction of the Sagittarius stream were removed, in order to remove possible contaminants. A sample of Galactic globular clusters (hereafter, GCs) with available proper motions from the literature (http://www.astro.yale.edu/dana/gc.html), has also been selected in order to compare the properties of these GCs with those of the CN-strong stars, and discuss them in the context of the inner- and outer-halo populations described in Carollo *et al.* (2007, 2010). The sample comprises 59 GCs for which positions, absolute proper motions, distances, and radial velocities are listed.

2. Results

The analysis shows that the CN-strong stars are concentrated in the Inner Halo Region (IHR; Carollo *et al.*, in prep., Tissera *et al.*, in prep.), and their frequency drops rapidly beyond 20 kpc, as previously pointed out by Martell *et al.* (2011). Another remarkable feature is that the great majority of the orbits of the CN-strong stars are located within $Z_{max} < 10$ kpc, again corresponding to the IHR, where the Inner Halo Population (IHP; Carollo *et al.*, in prep., Tissera *et al.*, in prep.) dominates in the metallicity range $-2.0 < [Fe/H] < -1.5$. It has been found that the mean rotational velocity and dispersion for the metal poor CN-normal stars is $\langle V_\phi \rangle = 25 \pm 6$ km s^{-1}, and $\sigma_{V_\phi} = 100 \pm 4$ km s^{-1}, consistent with membership in the inner-halo population ($\langle V_\phi \rangle = 7 \pm 4$ km s^{-1}, and $\sigma_{V_\phi} = 95 \pm 2$ km s^{-1}; Carollo *et al.* 2010). Application of a two-sample Kolmogorov-Smirnoff test to the distributions of rotational velocity for the low-metallicity CN-normal and CN-strong stars is unable to reject the hypothesis that they were drawn from the same parent population ($p = 0.62$). Note that the number of stars with highly retrograde velocities in the low-metallicity subsample is very small, $N_{retr} = 33$ at $V_\phi < -100$ km s^{-1}, and $N_{retr} = 7$, at $V_\phi < -200$ km s^{-1}, respectively. Among these groups of stars, none of them are CN-strong. The general properties of the GCs in our sample with available absolute proper motions are typical of the Milky Way's cluster population in terms of their spatial and metallicity distributions. The values of rotational velocity and dispersion for the sub-sample at low metallicity are consistent with membership in the IHP, perhaps with some contamination from a higher-dispersion population.

3. Implications

The fact that the CN-strong stars exhibit spatial distributions, rotational velocities, and orbital properties in agreement with the IHP provides important clues on the origin and fate of GCs in the Milky Way. The primordial sub-Galactic fragments of higher mass and gas content presented favorable conditions to form GCs in the inner cores of giant high-density clouds. By way of contrast, smaller-mass fragments may not have had sufficient masses of gas to form GCs. These lower-mass mini-halos would likely have had a truncated star-formation history, relative to the higher-mass mini-halos, since they would not have been able to retain gas once star-formation commenced. Although further investigation is required, this may account in a natural way for the apparent lack of Galactic GCs with metallicity below [Fe/H] ~ -2.3. Since it is expected that CN-strong stars *require* the dense environment of GCs in order to form in the first place, their observed properties strongly suggest that a significant fraction of GCs have been stripped or disrupted in the IHR. In this context, the similarity of the global properties of the metal-poor GCs, including their spatial, kinematical and orbital properties, to those of the CN-strong stars is especially intriguing. Our present data certainly suggest a strong relationship between these two samples – both appear to be associated with the IHP of the Milky Way.

References

Aihara, H., *et al.* 2011, *AJ* 193, 29
Abazajian., *et al.* 2009, *ApJS* 182, 543
Carollo, D., *et al.* 2007, *ApJ* 450, 1020
Carollo, D., *et al.* 2010, *ApJ* 712, 692
Martell, S. L. & Grebel, E. K. 2010, *A&A* 519, 14
Martell, S. L., Smolinski, J. P., Beers, T. C., & Grebel, E. K. 2011, *A&A* 534, 136
Yanny, B., *et al.* 2009, *AJ* 137, 4377
Eisenstein, D., *et al.* 2011, *AJ* 142, 72

https://doi.org/10.1017/S1743921314005778 Published online by Cambridge University Press