KINEMATICS OF NEARBY SUBDWARFS

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Abstract. A sample of subdwarfs with accurate space velocities and standarized metallicities is presented. This was constructed by combining Hipparcos parallaxes and proper motions with radial velocities and metallicities from Carney et al. (1994; CLLA). The accurate Hipparcos parallaxes lead to an - upward - correction factor of 11% of the photometric distance scale of CLLA. The kinematical behaviour of the subdwarfs is discussed in particular in relation to their metallicities. Most of the stars turn out to be thick disk stars, but the sample contains also many genuine halo stars. While the extreme metal poor halo does not rotate, a population of subdwarfs with metallicities in the range $-1.6 < [Fe/H] < -1.0$ dex appears to rotate around the galactic center with a mean rotation speed of about 100 km/s.

1. Data

The data material, which we have analyzed, is based on the sample of high proper motion stars by Carney et al. (1994; CLLA). CLLA have measured photometric parallaxes, radial velocities, and metallicities of most of the A to early G stars, many late G and some early K stars in the *Lowell Proper Motion Catalogue*. This data set of 1464 stars has been cross-identified with the Hipparcos catalogue (ESA 1997) and we found 767 stars in common. However, the sample had to be cleaned under various aspects. For instance, for some stars not all data were available or some Hipparcos parallaxes were not accurate enough. In Fig. 1 the colour-magnitude diagram of the remaining stars is shown. Despite the efforts of CLLA to avoid them the sample is still contaminated by giants and subgiants, which can be detected now due to the improved accuracies of the absolute magnitudes. We have removed all stars lying above a line in the CMD defined by the zero age main sequence of stars with solar metallicity shifted upwards by $\Delta M_{\rm V} = 0.8$ mag.

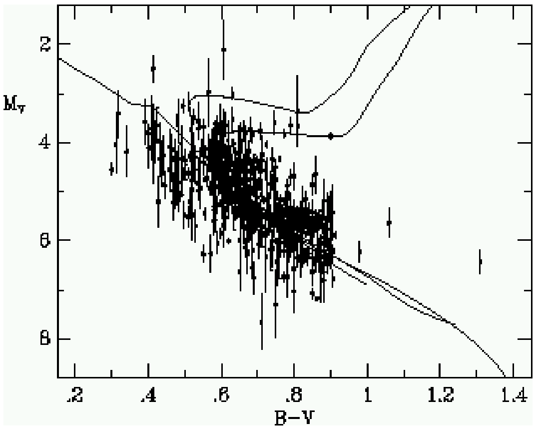

Figure 1. CM-diagram of 617 identified CLLA stars. Hipparcos parallaxes were used to determine the absolute magnitudes. The full lines indicate the main sequence and the CMDs of the old clusters M 67 and NGC 188, respectively.

Furthermore we have determined an overall correction factor of the photometric distance scale of CLLA by analyzing parallax differences $\pi_{\rm Hipp} - \pi_{\rm CLLA}$. A linear regression analysis $\Delta\pi = f \cdot \pi_{\rm CLLA}$ gives a coefficient $f = -0.113 \pm 0.007$, indicating an upward correction of the photometric distances by 11%. Jahreiß et al. (1997) have already found a similar correction on the basis of a smaller sample of subdwarfs.

2. Kinematics

We have determined reliable space velocities of 560 nearby subdwarfs. These are shown in Fig. 2 versus the metallicities of the stars as scatter plots. The populations of thick disk and halo stars can be clearly distinguished by the widths of the distributions and the mean rotational velocities. Since our sample is based originally on a proper motion survey, the sample is biased in the sense that low velocity stars are underrepresented. This can be seen clearly as a trough in the U-velocity distribution in Fig. 2 or the asymmetric V-velocity distribution of the disk stars in Fig. 3. However, since we are mainly interested in the kinematics of the halo stars, this bias is of no consequence in the present context.

In order to determine mean velocities and velocity dispersions we have considered three metallicity groups. Results are given in Table 1. The corresponding V-velocity distributions are shown in Fig. 3. The first and largest

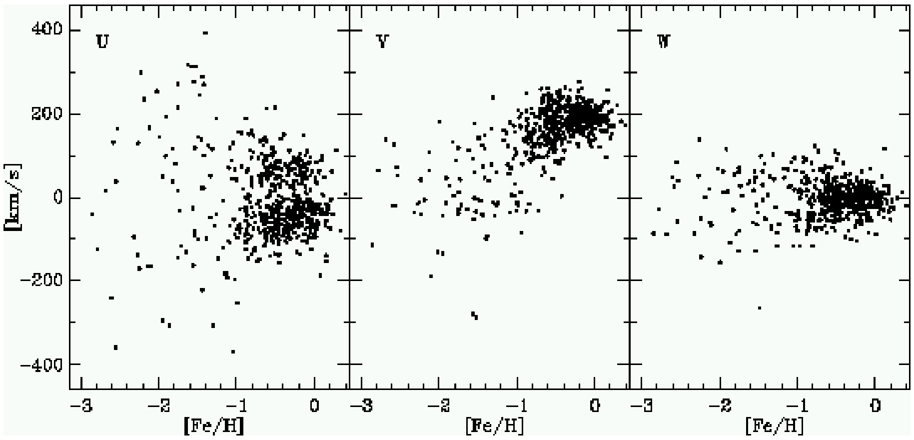

Figure 2. Space velocity components versus metallicity [Fe/H]. U points towards the galactic center, V in the direction of galactic rotation, and W towards the galactic north pole. The space velocities have been reduced to the local standard of rest and a rotation velocity of the LSR of 220 km/s has been assumed.

group ([Fe/H] > –1 dex) represents obviously thick disk stars. The third group ([Fe/H] < –1.6 dex) has the same kinematics as other tracers of the extreme metal poor halo (cf. the article by Norris in this volume). The second group (–1.6 < [Fe/H] < –1) shows peculiar kinematics. The V-velocity distribution is rather skewed with respect to the mean. The V-velocity distribution at velocities less than the mean velocity of the extreme metal poor halo of –220 km/s is statistically indistinguishable from that of the extreme metal poor halo, while at velocities larger than –220 km/s there is an excess of 15 stars compared to the corresponding distribution of the extreme metal poor halo. Indeed, 19 out of the sample of 48 stars lie beyond one standard deviation of the velocity distribution of the extreme metal poor halo, i.e. at velocities less than –133 km/s. We have carried out Monte-Carlo simulations, which show that such a distribution has *not* been drawn with a probability of 99.99% from a gaussian distribution resembling that of the extreme metal poor halo. This is illustrated further in the fourth panel of Fig. 3, where we show the resulting distribution, if the left part of the V-velocity distribution is folded at V = –220 km/s, subtracted from the right part of the distribution and smoothed by a running mean. This gives the distinct impression of an excess population of subdwarfs in this metallicity range, which rotates with a velocity of about 100 km/s around the galactic center, while the rest of the subdwarfs in this metallicity range have the same kinematics as the extreme metal poor halo.

The nature of this excess population is not clear at present. It may well

TABLE 1. Kinematic parameters

	N	$\overline{U}$	$\overline{V}$	$\overline{W}$	$\sigma_{\rm U}$	$\sigma_{\rm V}$	$\sigma_{\rm W}$
dex				km/s			
[Fe/H]> -1	477	–21	–54	–10	72	46	38
$-1.6 <$ [Fe/H] < -1	48	6	–186	–17	168	105	73
[Fe/H] < -1.6	35	4	–216	–15	181	83	74

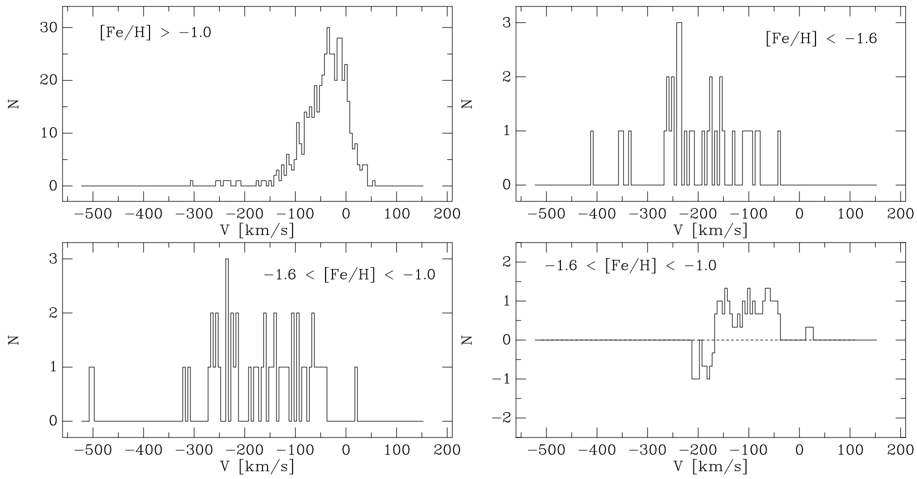

Figure 3. V-velocity distributions of the subdwarfs grouped according to their metallicities. The velocities are reduced to the local standard of rest. The panel in the lower right shows the excess population (see text for details).

be that these stars represent a metal weak – and dynamically hot – tail of the thick disk. It is conspicuous that their asymmetric drift coefficient, $\overline{V}/\sigma_{\rm U}^2 = –1.2{\cdot}10^{-2}$ (km/s)$^{-1}$, is very similar to that of the thick disk $\overline{V}/\sigma_{\rm U}^2$ $= –1{\cdot}10^{-2}$ (km/s)$^{-1}$. According to this interpretation late stages of halo formation and early phases of disk formation would have overlapped. Alternatively, this population may be a relic of earlier accretion events (cf. the article by Majewski in this volume).

References

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