Spectroscopic Distances and Kinematics of Local Field M Dwarfs and M Subdwarfs

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Abstract. We combine parallax measurements from the literature to optical spectroscopy of 1459 M dwarfs and M subdwarfs to update the calibration of the spectroscopic distance relationships, and in particular their dependence on metallicity subclass (dM, sdM, esdM, usdM). We use the revised calibration to calculate distances and transverse motions for 4525 spectroscopically confirmed M dwarfs, 183 subdwarfs (sdM), 134 extreme subdwarfs (esdM) and 105 ultrasubdwarfs (usdM) in the solar vicinity (d< 100pc). Results demonstrate again the clear association of esdM and usdM stars with the Galactic halo population. The velocity-space distribution shows substructure in the local disk population consistent with previous studies, including the Coma, Sirius, and Hercules streams. However, we find no evidence for dynamical substructure in the local thick disk and halo populations.

1. The current 100 parsec census

The current census of red dwarfs within 100 parsecs of the Sun, is largely assembled from surveys of high proper motion stars, such as my SUPERBLINK proper motion survey (Lépine & Shara 2005; Lépine & Gaidos 2011). The distribution shown in Figure 1 is the one from SUPERBLINK for the entire northern hemisphere (120,000 stars). Most M dwarfs within 100 pc are identified based on color and proper motion alone, and have no parallax or spectroscopic measurements as yet. Spectra are available for 11,500 northern stars from various surveys, including SDSS (West et al. 2011) and my own survey carried out at MDM observatory over the past 12 years. Parallaxes are available only for about 3000 stars - including recent parallaxes of 1507 stars from (Dittmann et al. 2014).

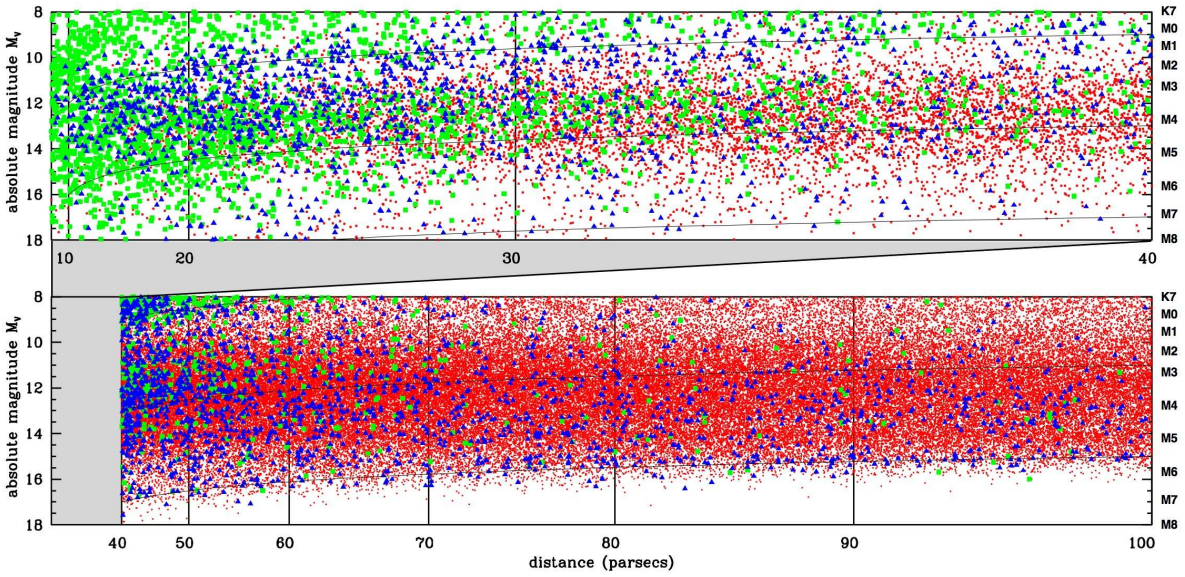

Figure .1: Current census of low-mass stars within 100 parsecs of the Sun, plotted in a volume-independant distance scale. Red dots are stars with not current spectroscopic or parallax data; blue triangles are stars with spectroscopic data but no parallax measurement; green squares are stars with both spectroscopic data and parallax measurements.

2. Spectroscopic distance calibration

Spectroscopic distance calibration, is critical to determine distances for the specroscopically identified M subdwarfs (sdM), extreme subdwarfs (esdM), and ultrasubdwarfs (usdM), which likely represent metallicity classes, with the more common M dwarfs (dM) being the most metal rich, and usdM stars the most metal poor (Lépine et al. 2007). Despite recent additions, relatively few parallaxes exist for sdM / esdM / usdM stars. A proposed calibration based on the existing data is shown in Figure 2.

3. Kinematics of M dwarfs and M subdwarfs

Kinematics of the M dwarfs, shown in Figure 3 (top panels), are consistent with the motions of the nearby F and G dwarfs in the local Galactic disk, as determined e.g. by Nordström et al. (2004), with an anisotropic distribution and substructures, or "streams" which are believed to be the signature of the Galactic spiral arms and bar (Quillen & Minchev 2005). Because the SUPERBLINK catalog only has stars with proper motions > 40 mas/yr, it is missing stars with very low components of motion relative to the Sun (black circles).

Kinematics of the M subdwarfs (sdM, esdM, usdM), show the large asymmetric drift of the Galactic halo, but otherwise is relatively isotropic and homogeneous (Figure 3, bottom panels). The more metal poor esdM and usdM stars are clearly members of the halo population, with most of the esdM and usdM stars in the solar neighborhood have low velocities

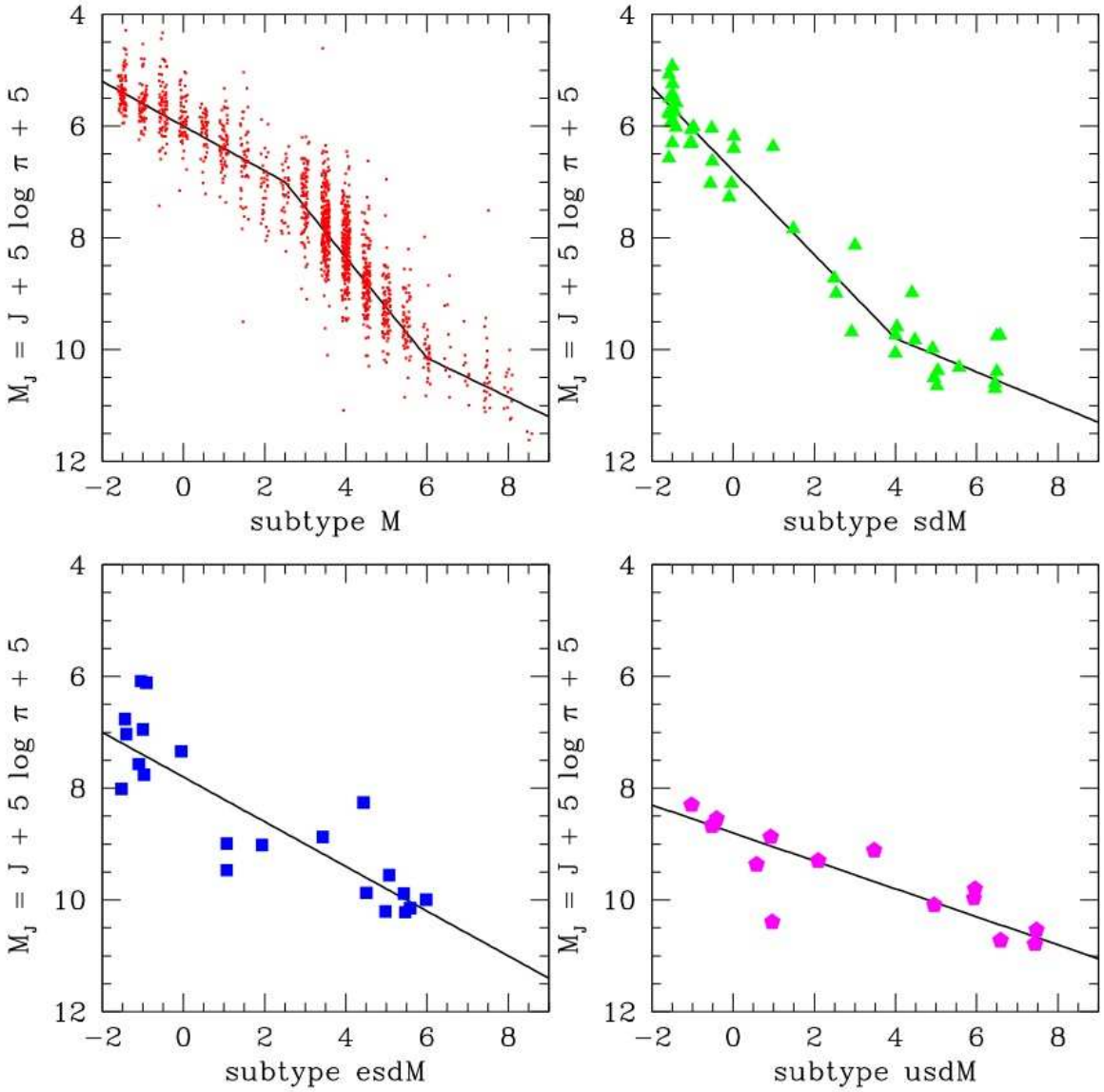

Figure .2: Spectroscopic distance calibrations for M dwarfs (red dots) and M subdwarfs (sdM: green, esdM: blue, usdM: purple), based on existing parallax data, combined with spectroscopic data from SDSS and observations carried out at the MDM observatory.

in the galactic rest frame, which indicates the stars mostly come from inside the Solar circle, i.e. they are from the inner halo of the Galaxy.

4. Conclusions

The census of low-mass stars to 100 parsecs of the Sun now comprises over 120,000 stars for the northern sky alone. However, parallax and spectrocopic data remains very fragmentary

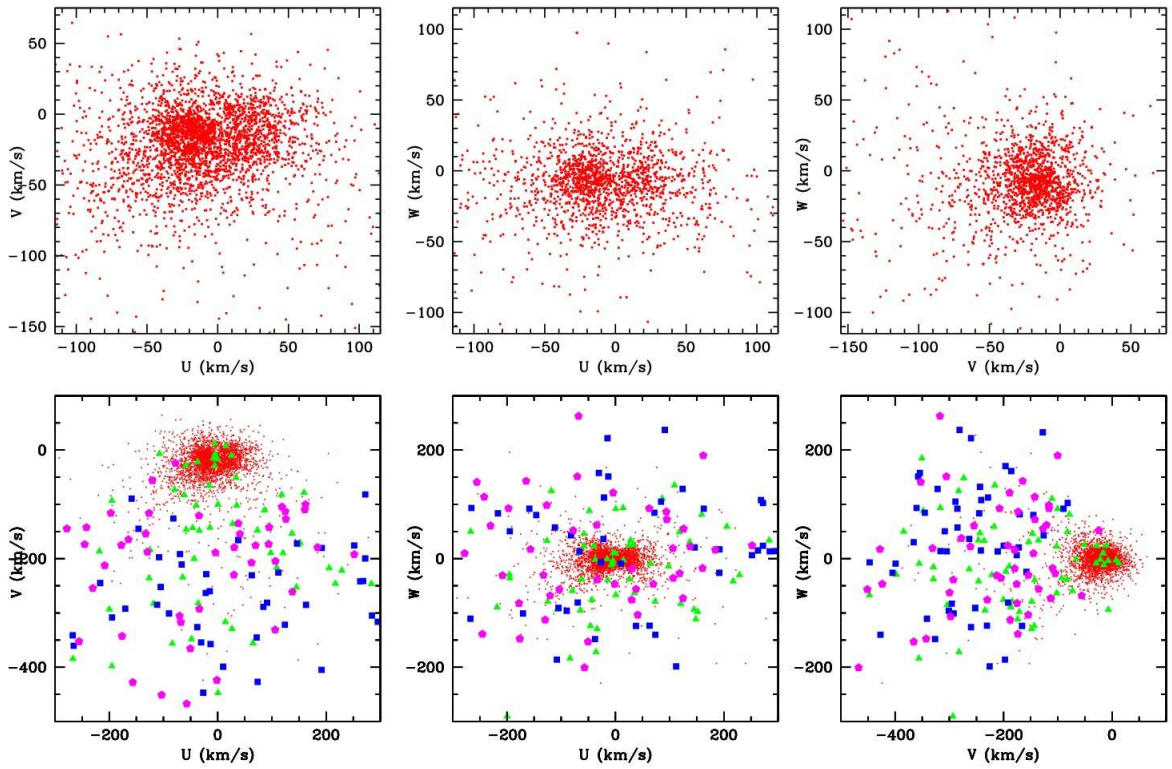

Figure .3: Kinematics of M dwarfs (top panels) and M subdwarfs (bottom panels). Velocity component U is towards the Galactic center, V is in the direction of Galactic rotation, and W is towards the north Galactic pole.

expect for stars within about 20 parsecs. Spectroscpic and photometric distances are strongly dependent on star metallicities (dwarf/subdwarf), which means that in the absence of parallax data, metallicity information must be used to estimate distances. Kinematics analysis shows that metal-rich M dwarfs have motions consistent with the local disk population, while nearby M subdwarfs are associated with the Galactic halo.

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