Stellar Populations in the Milky Way and Beyond
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Galactic Stellar Halo Luminosity Function

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Abstract. We measure the luminosity function of the Milky Way's stellar halo using a magnitude complete, tangential velocity-selected sample from *Gaia* DR3. The dimmest main sequence halo dwarfs (subdwarfs) found reach an absolute M_G magnitude near 14 mag, and the dimmest halo white dwarfs reach 15 mag. We find our stellar halo luminosity function compares well with these previous results, although with higher accuracy and less bias as our stellar halo sample contains more stars and probes a wider range of absolute magnitudes than these previous studies. In further efforts we will use this result to measure the Milky Way's stellar halo mass function and mass-to-light ratio.

Keywords. galaxies: individual (Milky Way) — Galaxy: halo — Galaxy: kinematics and dynamics — Galaxy: stellar content — stars: kinematics and dynamics

1. Data and Analysis

We collect stars from *Gaia* DR3 (Gaia Collaboration et al. 2016, 2023a) within a column ($|Z| < 1\,\mathrm{kpc}$, $d < 100\,\mathrm{pc}$, $G < 18\,\mathrm{mag}$, $|b| > 30\,\mathrm{deg}$) around the Sun. Halo stars are selected by tangential velocity $> 200\,\mathrm{km\ s^{-1}}$. The halo sample totals to 5358 stars including main sequence dwarfs, giants, white dwarfs, and blue stragglers. We compare

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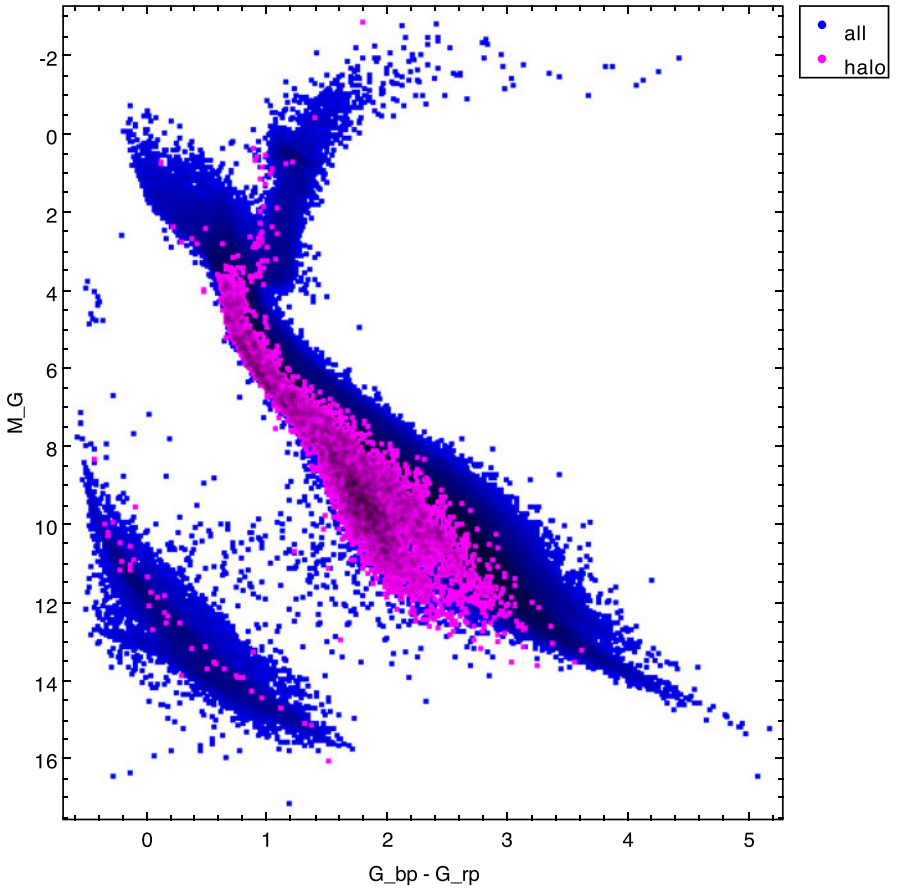


Figure 1. Color-magnitude diagram for our full sample (blue) and selected halo stars (magenta).

the color-magnitude diagram of this nearby halo sample to the sample of all stars in the same volume in Fig. 1 and exemplify our column selection in Fig. 2 (left panel).

2. Results and Discussion

After carefully correcting for sample completeness (Fig. 2, right panel), we measure the stellar halo luminosity function (Fig. 3). We find a turnover in the main sequence dwarf luminosity function at M_G around 10 mag after which the function falls to the extent of the subdwarf branch at 14 mag. We use the synthetic photometry of Gaia Collaboration et al. (2023b) to convert from G to other photometric bands. In Fig. 4, we compare our halo luminosity function in Johnson's V to that of Bahcall & Casertano (1986), Dahn et al. (1995), Gould et al. (1998), Gizis & Reid (1999), Cooke & Reid (2000), Gould (2003, 2004), and Digby et al. (2003).

We find our stellar halo luminosity function compares well with these previous results, although with higher accuracy and less bias as our stellar halo sample contains more stars and probes a wider range of absolute magnitudes than these previous studies. In further efforts we will use this result to measure the Milky Way's stellar halo mass function and mass-to-light ratio.

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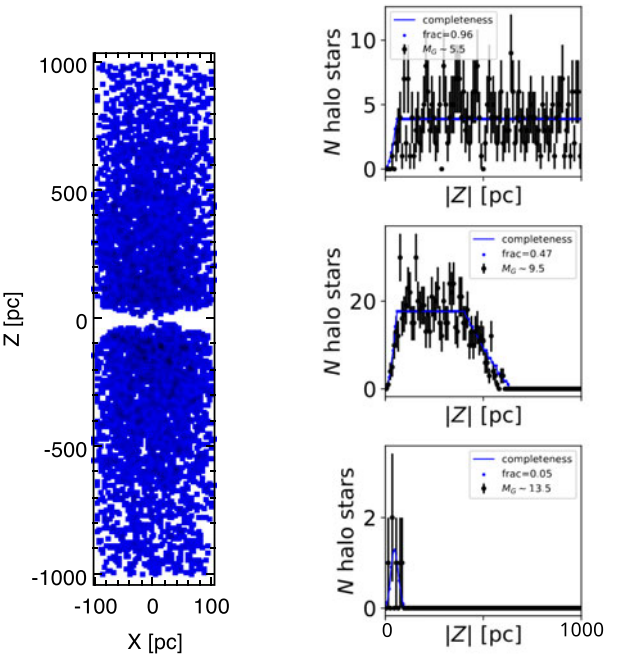


Figure 2. **Left**: Halo stars in the solar neighborhood are selected in a column with radius of 100 pc and height ±1 kpc. The decreasing number of stars with increasing Z is due to decreasing completeness. **Right**: Completeness curve (blue line) is calculated to correct the halo luminosity function. Black markers show the number of halo stars at $|Z|$ kpc above/below the disk midplane before completeness correction. At $M_G \sim -5.5$, top panel, the stars share absolute magnitude similar to the Sun and are complete within our sample. At dimmer absolute magnitudes ($M_G \sim -9.5$ and ~ -13.5, middle and lower panels) the more distant stars are too dim ($G > 18$) to be included in our *Gaia* DR3 halo sample.

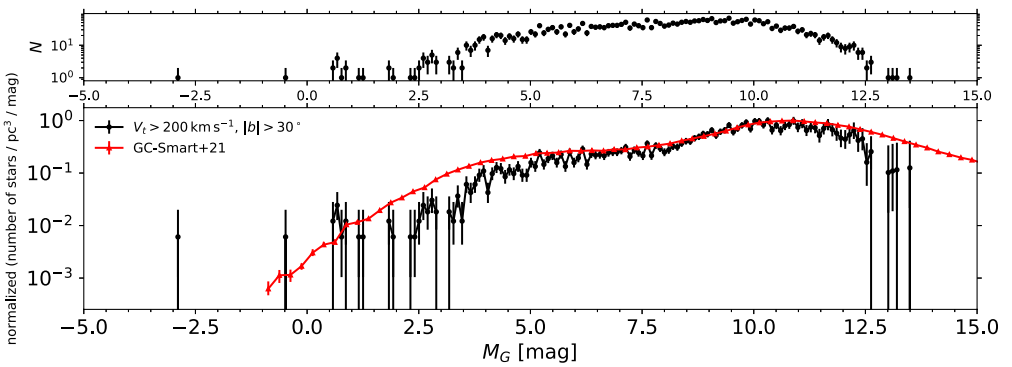


Figure 3. Luminosity function (lower panel) and number of stars per magnitude bin (upper panel) for the stellar halo (excluding white dwarfs) within the solar neighborhood (black markers) compared with the disk luminosity function (red markers; main sequence dwarfs within 100 pc of the Sun) from Gaia Collaboration et al. (2021, GC-Smart+21). Luminosity functions are normalized by their peak values. The GC-Smart+21 disk luminosity function extends to $M_G > 20$, but here we plot only till the brighter extent of the halo subdwarfs ($M_G < 15$). The bin widths are 0.1 (black) and 0.25 (red) magnitudes in absolute *Gaia* M_G magnitude and the confidence intervals are Poisson uncertainties (Gehrels 1986).

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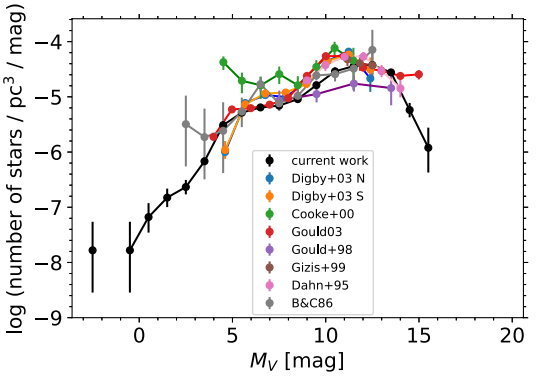


Figure 4. Luminosity function in Johnson's absolute magnitude M_V for halo stars (excluding white dwarfs) within the solar neighborhood (black markers; bin width of $M_V = 1$ mag; confidence intervals are Gehrels (1986) Poisson uncertainties) compared with stellar halo luminosity functions from the literature (colored markers). The functions compare well with the current sample that contains more stars and probes a wider range of absolute magnitude.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1743921325001085

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