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# The luminosity function of nearby thick-disk sub-dwarfs

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**Abstract.** We derived the luminosity function of thick disk using $V/V_{max}$ method for nearby sub-dwarf stars based on the sample stars of Carney *et al.* (1994). Hipparcos parallaxes and proper motions and Tycho2 proper motions were combined with radial velocities and metallicities from CLLA. We found that the luminosity function in the absolute magnitude range $M_V = 4-6$ mag agree well with the luminosity function derived from the initial mass function (Reyle & Robin 2001).

**Keywords.** Galaxy: general, Galaxy: disk, stars: fundamental parameters (luminosities, masses), subdwarfs

## 1. Introduction

The thick disk population has a mean metallicity of $-0.7 \leqslant [Fe/H] \leqslant -0.4$ (e.g., Buser *et al.* 1999) which is similar to the disk globular cluster 47 Tuc (Carney *et al.* 1989). The thick-disk LF is thought to have the same shape as the metal rich globular cluster 47 Tuc (Buser *et al.* 1999). Until now no direct measurement of the thick disk LF has been done. Reyle and Robin (2001) derived the LF from their thick disk initial mass function (IMF) based on the star counts at high and intermediate galactic latitudes.

## 2. Selection of thick disk stars

The data set constructed by Arifyanto *et al.* (2005) was based on the sample of F and G sub-dwarfs of Carney et al. (1994). The sample of AFJW, which forms the basis of our analysis, contains 740 sub-dwarfs with greatly improved parallax and proper motion data. The photometric distances were corrected by a factor of about 10%.

We selected for the thick disk all stars with $-1.0 \leqslant [Fe/H] \leqslant -0.4$. They are all brighter than $m_V = 12.5$ mag and with proper motion larger than $\mu = 155$ mas yr$^{-1}$. We defined the general restriction of the sample, in which our sample is complete, with $m_V \sim 9.2$ mag. and $\mu \geqslant 180$ mas yr$^{-1}$. The contamination of thin-disk stars in our proper motion selected sample is minimized by setting up the minimum proper motion cut. The proper motion selection magnifies the contribution from the higher-velocity old populations, since they are effectively sampled over larger volume than the lower-velocity disk stars.

## 3. The luminosity function

The luminosity function is derived by $V/V_{max}$ method for the 89 thick disk sub-dwarf stars. Each star represents a single sampling over the maximum volume. Therefore each will contribute to the LF $1/V_{max}$ and sum of all the sample stars. We performed our Monte Carlo simulations and derive the correction factor ($\chi_{TD}$) and simulated LF. We ran 200 simulations, where for each simulation $3 \times 10^5$ stars were generated and then, after applying our selection criteria, chose 89 surviving stars, equal to the number of thick disk stars in our sample. We scale the thick disk LF following the method used by Digby *et al.* (2003). We consider any possible contamination by the thin disk stars.

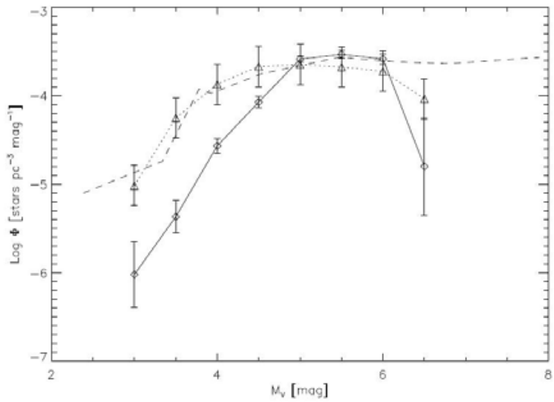


**Figure 1.** Simulated luminosity function taken from Bergbusch & Vandenberg (1992) for metallicity [Fe/H]= −0.65 with ages 12 Gyrs (dotted line). We plot also the luminosity function of thick disk from our calculation (solid line) and the LF derived from the initial mass function of Reyle & Robin, 2001 (dashed line).

The LF has a steep slope in the range $M_V = +3$ to $+5$ and a constant value for $M_V$=5 − 6 mag. At $M_V > 6.5$ mag the luminosity function decreases. The reason of this decrease could be the Wielen Dip at $M_V \sim 7$ mag and incompleteness in our sample. We performed Monte Carlo simulations to understand the selection bias in our sample. We use the LFs of Bergbusch & Vandenberg (1992) for metallicity [Fe/H] = −0.65 with ages of 12 Gyrs. Bergbusch & Vandenberg (1992) used their LF to fit with the observed luminosity function of globular cluster 47 Tuc. The simulated LFs for metallicity [Fe/H] = −0.65 with ages of 12 Gyrs agree well with the luminosity function derived by Reyle & Robin (2001) for $M_V = 3.0 - 6.0$. The differences in the slope between the simulations and observations in the range $M_V = 3 - 5$ mag could be due to the lack of bright stars in the sub-dwarf sample. Gilmore & Reid (1983) found that the LF at $z > 1$ kpc, steepen rapidly for $M_V < 4$ mag.

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