Kinematic determination of the luminosity function in the neighborhood

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AIMS

The luminosity function is crucial to know the structure of the galaxy as well as allowing the determination of the stellar mass function, two functions essential to know the star formation and evolution of the galaxy.

At present, all studies of the local luminosity function, the distance limit studied is given by the limiting magnitude of stars with accurate proper motions and distances.

In this work we have determined the luminosity function in the solar neighborhood up to 200 pc, whereas the proper motions as estimates of distances, using the method of mean absolute magnitudes.

SAMPLE TO STUDY

The sample chosen to determine the LF is out from the galactic plane and is complete (Fig. 1):

- spatially (260° < l < 340°, 45° < b < 60°)

- photometrically (Ks ≤ 12, less sensitive to extinction)

- kinematically (μ ≥ 0.03 "/ year)

Kinematic database: CdC-SF catalogue (Vicente et al. 2007, 2010), with precise proper motions similar to that of Hipparcos up to V = 16 and uniformity of data.

Photometric database: CdC-SF includes JHKs photometry from 2MASS catalogue (Cutri et al. 2003)

The detemination of the H-M regression to calibrate, we use the Hipparcos catalogue (ESA 1997) which includes trigonometric parallax up to V = 8.

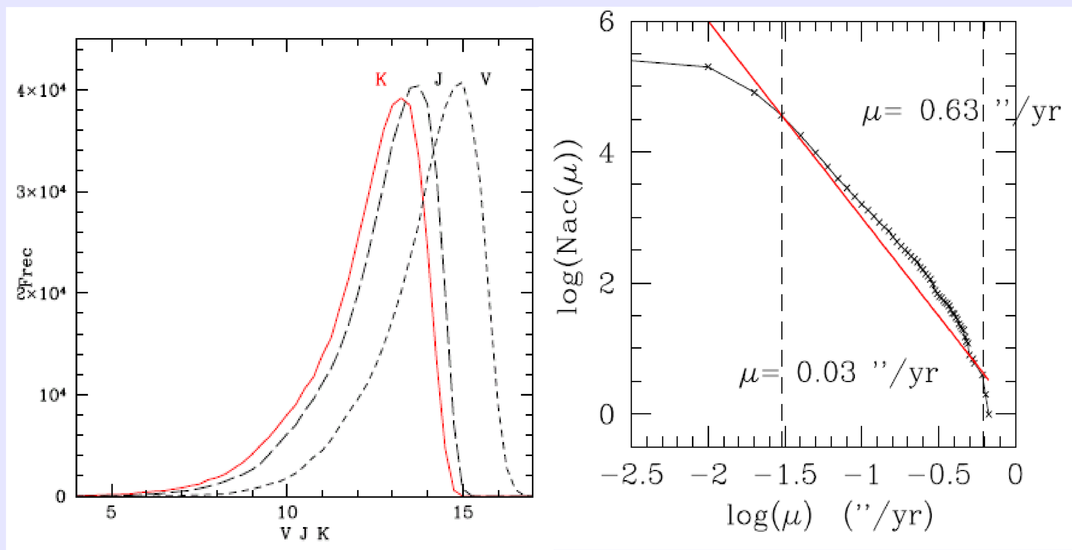

Fig. 1

(a) Magnitude distribution of the CdC-SF stars.

(b) Proper motion distribution of CdC-SF. Densities follow the law N (μ) ~ μ^{-3}. We consider completeness 0.03 "/year ≤ μ ≤ 0.63"/year.

MEAN ABSOLUTE MAGNITUDES METHOD

The parameter **H, reduced proper motion** (Luyten 1938), defined similarly to the absolute magnitude M, it is used as a statistical estimator M:

$$\left.\begin{aligned} M_\lambda &= m + 5 - 5\log d \\ H_\lambda &= m + 5 + 5\log\mu \\ \mu &= \frac{V_t}{4.74\, d} \end{aligned}\right\} \Rightarrow M = H_\lambda + 3.38 - 5\log V_t$$

Proper motion is directly related to the absolute magnitude M, **if Vt is independent of M**. So, with a sample of stars with the same distribution we have

Vt = a + b <M> H

Determined the relationship <M> = a + b H with calibration stars, we can obtain absolute magnitudes for all stars in our sample.

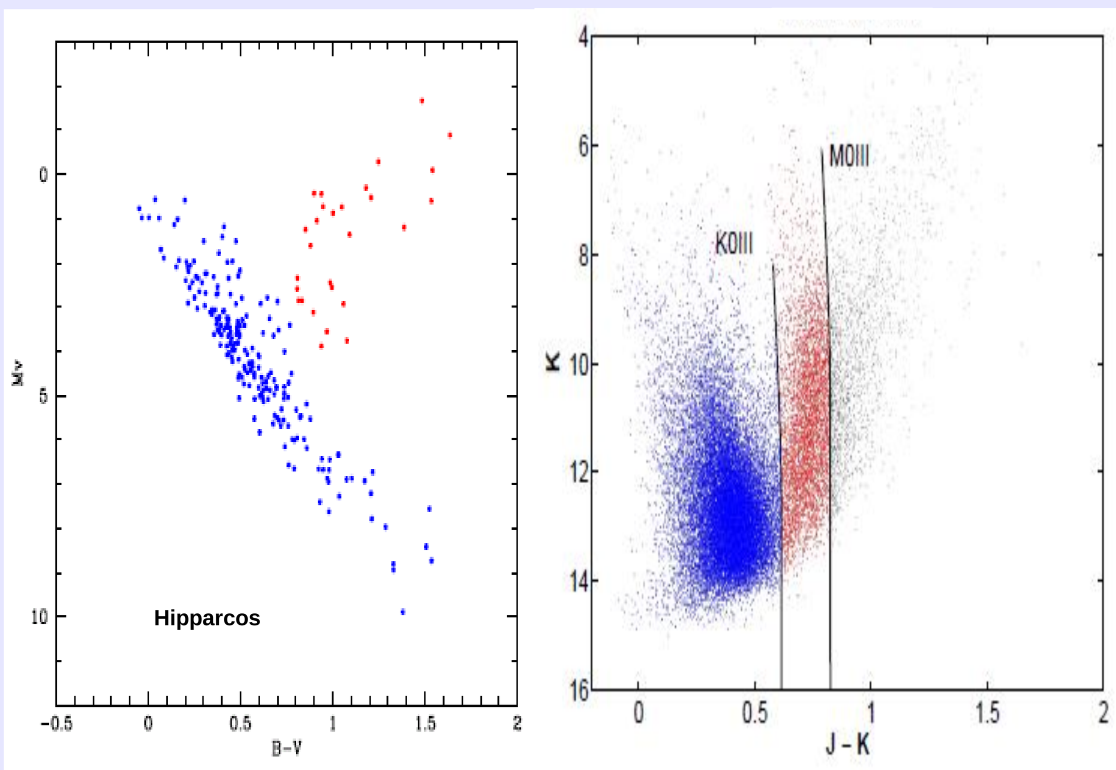

Fig. 2 Photometric separation of populations with similar kinematic: dwarf (blue) and giants (red):

(a) Hipparcos HR diagram and manual stellar classification.

(b) Color-magnitude diagrams of CdC-SF and dividing traces in a field near the galactic plane as example.

PROCEDURE

Luminosity Function: number of stars Φ (M) per unit of magnitude and volume.

The application of the Luyten's method to transform apparent magnitudes into absolute required to have a group of stars that share the same velocity distribution.

This separation of populations with similar kinematics performed following the photometric criteria, because dwarfs and giants have a different cinematic history:

- Separation of the calibration stars of Hipparcos has done manually (Fig. 2a)

- In our sample, the separation is done using theoretical traces given by the SKY model (Wainscoat et al. 1992). An example is shown in Fig. 2b.

RESULTS

We obtained the calibration equations to relate the proper motion reduced with the absolute magnitude (Fig. 3), and are as follows:

$$DWARFS:\quad M_K = -2.91(\pm 0.45) + 0.74(\pm 0.06) H_K\ ;\ \sigma_M = 0.97$$
$$GIANTS:\quad M_K = -5.27(\pm 0.67) + 1.33(\pm 0.20) H_K\ ;\ \sigma_M = 0.67$$

Malmquist bias and Lutz-Kelker corrections were found to be negligibles.

We have determined the Luminosity Function up to 200 pc (Fig. 4). It agrees perfectly with the transformation, in the K band, calculated by Mamon & Soneira (1982) from the semi-empirical Luminosity Function of Bahcall & Soneira (1980).

In case of dwarfs stars (Fig. 4a), there is a deficit of faint and near stars that are not included in our catalogue CdC-SF due to its construction itself (Fig. 5). In the future, we will add high proper motion catalogs to solve this problem.

For giant stars (Fig. 4b), not just our data agree very well, but extending to the current observations.

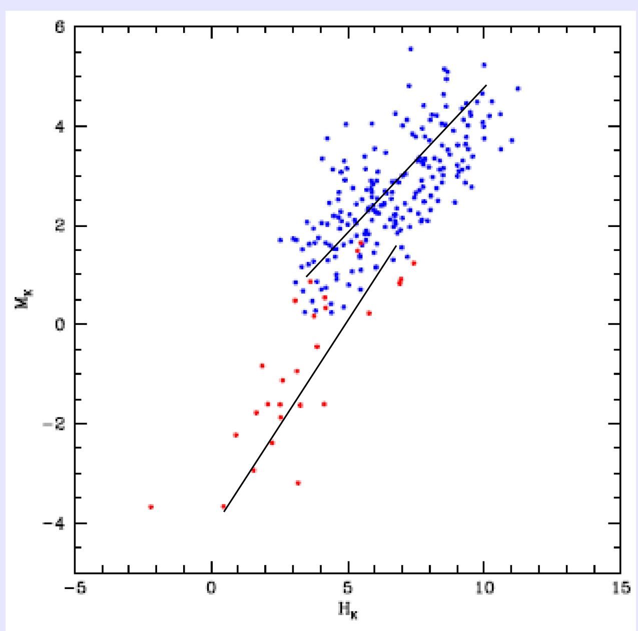

Fig. 3 H-M linear relations used for calibration, different for each type of population. Fitting has been made by least squares weighted according to the observational errors.

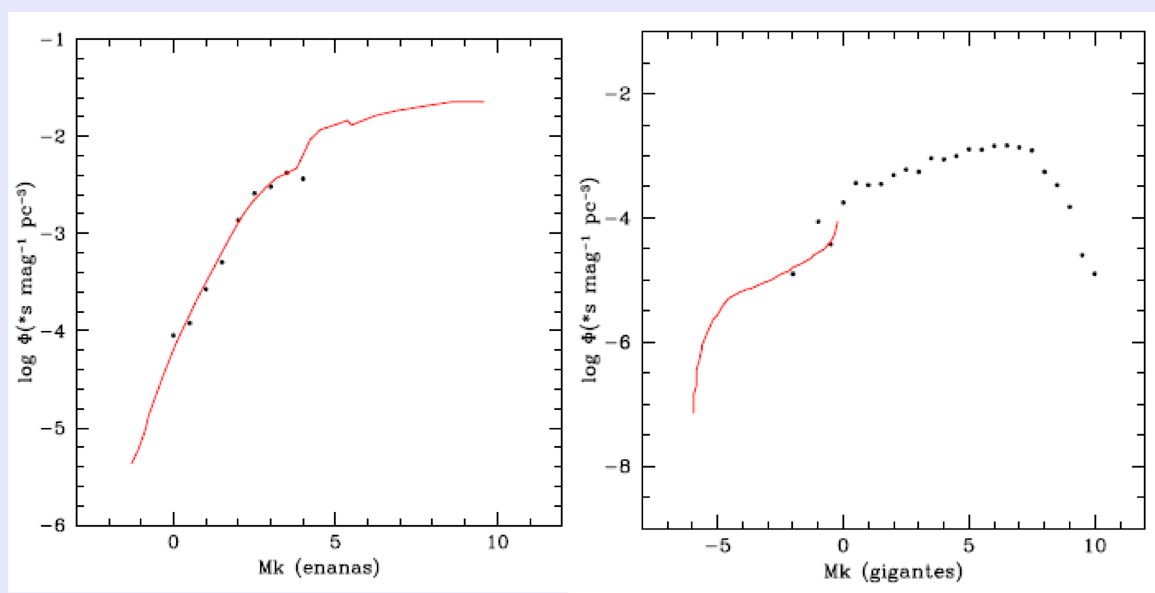

Fig. 4 Transformation of stellar luminosity function into JHK band (Mamon & Soneira 1982) of the analitical function determinated visual band (Bahcall & Soneira 1980), for giants (left) and dwarfs (right).

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