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STELLAR POPULATIONS IN THE CALÁN-ESO CATALOGUE. THE LUMINOSITY FUNCTION AND KINEMATICS OF DWARFS

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RESUMEN

A partir del catálogo CALAN-ESO (CE) (Ruiz et al. 2001a) limitado en movimiento propio $\mu \geq 0.2$ arcsec año^{-1} y magnitud aparente $m_R \lesssim 19.5$ mag, estudiamos la función de luminosidad (LF) con sus errores, para diferentes latitudes y longitudes Galácticas de 14 areas distribuidas en el cielo usando simulaciones Monte Carlo, para determinar si existen variaciones significativas de la LF en cada zona. A la vez, estudiamos la cinemática de las diferentes poblaciones coexistentes ajustando los parámetros cinemáticos a partir de la función de distribución de estrellas en distancia.

ABSTRACT

From the CALÁN-ESO (CE) catalogue limited in proper motion $\mu \geq 0.2$ arcsec yr^{-1} and aparent magnitude $m_R \lesssim 19.5$ mag (Ruiz et al. 2001a), we studied the luminosity function (LF) with its errors in different galactic latitude and longitude for 14 areas distributed on the sky using Monte Carlo simulations to determine if there are variations in the LF for each zone. Also we studied the kinematics of diferent coexistent populations by fitting kinematical parameters of the distribution function of stars on the distance.

Key Words: **GALAXY: DISK — SOLAR NEIGHBORHOOD — STARS: KINEMATICS — STARS: LUMINOSITY FUNCTION, MASS FUNCTION**

1. GENERAL

Proper motion catalogues allow us to select very interesting populations of stellar objects. The cut in proper motion biases the sample toward objects with extreme kinematical characteristics, like old disk, thick disk, and halo populations. We use the CE catalogue to study the kinematical propeties and LF of dwarf population in the solar vicinity.

The CE catalogue has 542 stars selected from 14 areas of the sky each area covering $5° \times 5°$. Proper motions were estimated from ESO-Schmidt red IIIa-F plates with 6-16 yr baseline time. The 14 areas of the southern hemisphere were selected avoiding high galactic latitudes ($|b| \lesssim 40°$), in order to obtain sufficient background stars that serve as references to detect and calculate proper motions. The sample was cut in proper motion to include stars with $\mu \geq 0.2$ arcsec yr^{-1}, and $m_R \leq 19.5$ mag, where the sample is statistically complete. Errors in proper motion were estimated to be $\sigma_\mu \approx 0.03$ arcsec yr^{-1} and in position angle, $\sigma_\theta \approx 12°$.

2. THE OPTICAL LUMINOSITY FUNCTION

2.1. *Photometric distances*

The first step for our study was to calculate the distances from photometric data. We used the color $(V-I)$ that is less affected by errors with respect to other available colors. M_V vs. $(V-I)$ calibration for main sequence stars was obtained from available data for 140 stars with BVRI photometry and trigonometric parallaxes of REsearch Consortium On Nearby Star (RECONS). White dwarfs in the sample were already found and published (Ruiz & Bergeron 2001b), and the giant and sub-giant stars are estimated to contribute a very tiny fraction in the sample (2 giants and 1 sub-giant found in the sample). These stars were not taken in account for this study. The only other population that could "contaminate" our dwarf stars sample corresponds to metal poor dwarf stars (sub-dwarfs and extreme sub-dwarfs), some part of this population was detected by using spectral indices given by Gizis (1997). Also proper motion reduced diagram can help to distinguish this population of solar metallicity dwarf stars. Distances were corrected for reddening and absorption. Distance (D) and absolute magnitude (M_V) errors were estimated using Monte Carlo simulations (Costa & Méndez 2003), they were estimated to be $\sigma_{M_V} \sim 0.2 - 0.4$ mag and $\sigma_D \sim 0.1 - 0.2 \times D$.

2.2. *LF and the $1/V_{max}$ method*

To obtain the LF we used the $1/V_{max}$ method, with the limits in proper motion $\mu_{min} = 0.2$ arcsec yr^{-1}, and in apparent magnitudes $7.5 \text{ mag} < R < 19.5$ mag. Correction due to a non-homogeneous

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density profile was applied (Méndez 2002), but they were less than 10%. Absorption and reddening also were included, although they were very small. Malmquist bias correction and unresolved binaries effects were calculated, but they didn't have relevant effects over the LF. Kinematical bias was ignored, as each area cover a too small solid angle of the sky as to have an important effect. Monte Carlo simulations over LF were computed to study the effect of the observational errors, photometric and proper motion errors, and a "cosmic" dispersion in metalicity, propagated over the calculated LF. It was compared with the typical statistical poissonian errors used in $1/V_{max}$ method given by Felten (1976). Both sources of errors have different origin, and their effects are comparable in magnitude, so it is necessary to take attention with respect to the uncertainty introduced in LF by observational errors and "cosmic" dispersion, in addition to purely statistical errors. The areas of the CE sample were separated in two different zones, first by Galactic longitude grouping those areas near to $l \sim -90°$ in one group and those areas near to $l \sim -40°$ in another group, and second by Galactic latitude grouping those areas with $|b| < 20°$ in one group and those areas with $|b| \gtrsim 20°$ in another group. The idea was to determine whether there is variation in LF for different places of the sky in the solar neighborhood, but no significant variation were found within the errors.

3. STELLAR DENSITY PROFILE AND VELOCITY DISPERSION

3.1. *Scale factor H_Z vs. velocity dispersion*

We wanted to study the density profile as a function of the distance. There are a series of parameters that determine their form, apparent magnitude limit, the LF, Galactic density scale factors H_R and H_Z, local density, and the limit in proper motion. In our sample the steepness of the density profile could be determined mainly for the height scale factor H_Z, and the kinematics of the populations, given the limit in proper motion. We tray to determine how both characteristics affect over the density profile, by modeling the kinematics of stars in the CE sample using a Schwarzchild distribution, characterized for a median velocity and the velocity dispersion of the modeled population. The proper motion cut was applied over the distribution, integrating the Schwarzchild distribution in radial velocity, positional angle and proper motion with $\mu \geq \mu_{min}$. Median velocities in the solar reference frame were calculated taking into account the peculiar solar motion, the local standard of rest and median Galactic velocities of the population modeled. Including this distribution to the Galactic density approximated by $\rho(Z) \approx \rho_0 \exp(-Z/H_Z)$, the density profile is modeled by $\rho_{\mu\ lim}(Z) = \rho_0 \exp(-Z/H_Z)\ f(\vec{V}, <\vec{V}_{pop.}>, \sigma_{\vec{V}}, Z, l, b)$, where f corresponds to the function obtained from Schwarzchild distribution integrated. No strong dependency in H_Z was found in the density profile, so in practices the kinematics determines its form.

3.2. *Fitting velocity dispersion*

Since the slope of the density profile has in practices a only dependency in the kinematics of the stellar populations, we can use it to study the velocity dispersion of the stars of our sample. It was necessary to include in addition to a thin disk population, a halo population (and a thick disk population), to give account of the density profile at distances $\gtrsim$ 100 [pc], where there are still objects in the sample. Areas near Galactic longitude $l \sim 270°$ don't have relevant "contamination" of no-thin disk components for distances less than 100 [pc], and it is possible to use a thin disk model to calculate the thin disk velocity dispersion and density by fitting our model up to 100 [pc]. We obtain a velocity dispersion of $\sigma_U = 30$ km s^{-1} and a local density of $\rho_0 = 0.10 \pm 0.01$ stars pc^{-3} for M dwarfs. On other areas with $l \sim 320°$ and $l \sim 0°$ there is a strong presence of thick disk and halo component, so it was not possible to separate these stellar components from the thin disk stars. It would be necessary a good metallicity estimation for stars in the sample to determine a better density profile for halo stars (and thick disk stars). From simulated synthetic catalogue it was observed that the thick disk component can not be distinguished and separated from the thin disk in the density profile as it could be possible for halo stars component. A simple Schwarzchild kinematical model appears like an interesting method to predict star counts and to study the LF and the kinematical parameters of coexisting populations from proper motion catalogues.

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