FIRST ESTIMATE OF THE THICK DISC MASS FUNCTION

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Abstract. A large set of star counts at high and intermediate galactic latitudes, in the visible and the near infrared, is used to determine the density law and the mass function of the thick disc population, by comparing the data with simulations of a population synthesis model. The combination of shallow fields dominated by stars at the turnoff with deep fields having smaller mass stars allows the first determination of the thick disc initial mass function in the mass range 0.2–0.8 M\(_\odot\).

Keywords: Galaxy: structure, stellar content, initial mass function

1. Introduction

The thick disc has probably been formed by a merging event on the thin disc of the Milky Way early in the age (Sommer-Larsen and Antonuccio-Delogu, 1993; Robin et al., 1996). However the physical conditions in which these stars have been formed are not known. One can reasonably model the thick disc density law by a double exponential but the determination of the scale height and the local density is problematic due to a degeneracy between these two parameters. Moreover no accurate determination of the local density has ever directly been done, even with Hipparcos, due to the small proportion of the thick disc locally with regard to the thin disc. The determination of the initial mass function (IMF) is an important issue in the recent controversy about the universality of the IMF. Until now no direct measurement of the thick disc IMF has been done. Using a large set of stellar samples, we investigate the thick disc density law together with its IMF by comparing the data with simulations of a model of stellar population synthesis.

2. Data Sets

The data sets used in this analysis are described in Reylé and Robin (2001). They combine shallow and deep star counts in the visible. We also used near infrared data from DENIS (Epchtein et al., 1999) reduced at the Paris Data Analysis Center. The fields are distributed at high and medium galactic latitudes, where the disc population is not yet dominant.
3. Model of Population Synthesis

We used a revised version of the Besançon model of population synthesis. Previous versions are described in Bienaymé et al. (1987), Haywood et al. (1997). A revised IMF for the disc has been used, tuned with the most recent Hipparcos results: the age-velocity dispersion relation (Gomez et al., 1997) and the local luminosity function (Jahreiss and Wielen, 1997). The scale height has been self-consistently computed using the potential obtained from the constraints on the local dynamical mass (Crézé et al., 1998). The density law and IMF of the spheroid was determined from deep star counts by Robin et al. (2000). The thick disc population is modeled as originating from a single epoch of star formation, with an age of 14 Gyr and a metallicity of \(-0.7 \pm 0.25\) dex. We used Bergbush and VandenBerg (1992) oxygen enhanced evolutionary tracks. The density law is defined by the scale height, the scale length and the local density. The IMF follows a power law \(dN/dm \propto m^{-\alpha}\).

Population synthesis simulations have been computed in every observed field and are compared using a maximum likelihood test (see appendix C in Bienaymé et al., 1987). The likelihood has been computed for a set of models, with varying thick disc parameters. In place of the local density we used the parameter \(df = \text{local density} \times \text{scale height}^2\) to try to overcome the degeneracy between these two parameters. The confidence limits of the estimated parameters are determined by producing a series of simulated random samples. The dispersion of the likelihood about the mean of this series gives an estimate of the likelihood fluctuations due to the random noise.

4. Results

The IMF slope is best constrained when separately studying the fields, as the data do not cover the same mass range of thick disc stars and give constraints on different parts of the luminosity function. Thick disc stars in DENIS fields have masses greater than 0.6\(M_\odot\). The mass range of thick disc stars in deep counts is 0.2 to 0.6\(M_\odot\). The field SA57 is the deepest one. It is complete and free from significant galaxy contamination up to \(V=24\). It is dominated by stars with masses between 0.2 and 0.4\(M_\odot\). Figure 1 shows iso-contour likelihoods as a function of scale height \(h\) and density \(df\) for different IMF slopes, for DENIS fields, deep fields, and SA57, separately. An IMF slope \(\alpha \geq 1.25\) does not allow an acceptable solution for all the fields. However, a lower IMF slope, \(\alpha = 0.5\), gives an agreement for all three magnitude intervals. Although the deepest bin 22–24 in SA57 contains thick disc stars with masses from 0.2 to 0.4\(M_\odot\), this field alone does not give enough constraints to determine if an IMF with a change of slope around 0.3\(M_\odot\) or a lognormal distribution such as in globular clusters of similar abundance (Paresce and De Marchi, 2000) would give a better agreement.