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Disentangling the Galaxy at low Galactic latitudes

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ABSTRACT

We have used the field stars from the open cluster survey BOCCE (Bologna Open Clusters Chemical Evolution), to study three low-latitude fields imaged with the Canada–France–Hawaii telescope (CFHT), with the aim of better understanding the Galactic structure in those directions. Because of the deep and accurate photometry in these fields, they provide a powerful discriminant among Galactic structure models. In the present paper we discuss if a canonical star count model, expressed in terms of thin and thick disc radial scales, thick disc normalization and reddening distribution, can explain the observed colour–magnitude diagrams (CMDs). Disc and thick disc are described with double exponentials, the spheroid is represented with a De Vaucouleurs density law. In order to assess the fitting quality of a particular set of parameters, the colour distribution and luminosity function of synthetic photometry is compared to that of target stars selected from the blue sequence of the observed CMDs. Through a Kolmogorov–Smirnov test, we find that the classical decomposition halo-thin/thick disc is sufficient to reproduce the observations – no additional population is strictly necessary. In terms of solutions common to all three fields, we have found a thick disc scalelength that is equal to (or slightly longer than) the thin disc scale.

Key words: Hertzsprung–Russell (HR) diagram – dust, extinction – Galaxy: disc – Galaxy: stellar content – Galaxy: structure.

1 INTRODUCTION

In order to reconstruct a coherent picture of our Galaxy, star count models typically exploit the colour–magnitude diagrams (CMDs) from several lines of sight. The primary goal is to constrain the structure and relative strength of the various Galactic components. In addition, other quantities such as the star formation rate (SFR), the initial mass function (IMF), the chemical composition and the reddening laws are also tested.

Despite the pioneering successes by Bahcall in the 1980s (see e.g. Bahcall & Soneira 1984) and the extraordinary amount of precise data available today, many aspects of the Galactic structure remain ambiguous. The number of Galactic components (halo, bulge, disc, thick disc etc.), their chemical composition and their origin are widely debated. Recent large-scale surveys [e.g. Sloan Digital Sky Survey (SDSS), Two Micron All Sky Survey (2MASS), QUEST] have detected the presence of substructures in the outer halo, which are taken to be the remnants of disrupted galaxies. For the disc structures, while there is consensus that most of the thin disc population has a dissipative history, the thick disc origin remains contentious. There are (at least) three main processes, which are now proposed to be responsible for thick disc formation: (1) *external origin* – the stars are accreted from outside, during merging with satellite galaxies; (2) *induced event* – the thin disc has been puffed up during close encounters with satellite galaxies; (3) *evolutionary event* – the thick disc settled during the collapse of the protogalactic cloud, before the thin disc formation.

Given this uncertain scenario, it is intriguing to learn about more or less pronounced sequences (see e.g. Conn et al. 2007) crossing the CMDs at low Galactic latitudes. However, fitting these features in a self-consistent scenario is rather challenging. For instance, an incorrect metallicity and a complex reddening distribution can both conspire to bias results. Moreover, in order to detect a possible stellar overdensity, it is essential to have at least a rough idea of the underlying Galactic structure. In other words, one must know how the ‘average’ Galactic CMD should look, especially close to the Galactic plane. A way out could be to observe symmetrical directions relative to the plane (see e.g. Conn et al. 2007): invoking a north–south symmetry, the observed CMDs should indicate the presence of a bona fide overdensity. However, this option is fraught with uncertainties as well: is the Galaxy symmetrical? Is the Galaxy

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(stellar disc) warped (see e.g. López-Corredoira et al. 2007)? Can asymmetrical reddening distributions or stellar chemical gradients mimic asymmetrical star counts?

This paper discusses the capability of a Galactic synthesis model to interpret the star counts at low Galactic latitudes. Typically, star count models create a main-sequence template, and attempt to recover the underlying distribution. We make use of an alternate scheme in which we try to translate the current knowledge of the Galactic populations (thin disc, thick disc and halo) into synthetic CMDs, and see if they are compatible (and at which degree) with the observed CMDs. We try to answer the following question: do the many uncertainties on the Milky Way structure allow to explain the observed CMDs without invoking anomalies? Our method does not produce unique scenarios, and furthermore, we argue that one cannot generally infer unique results.

Taking advantage of the deep and wide-field photometry acquired with the Canada–France–Hawaii telescope (CFHT), whose original targets were open clusters close to the Galactic plane (Kalirai et al. 2001a,b,c, 2008), we are sensitive to disc structures for several kpc before being dominated by the halo. These low-latitude regions are often avoided by star count analyses for their high obscuration. Hence, the published results suffer from a bias: most of the investigations are devoted to the study of the disc scaleheights and the halo structure, information available at intermediate to high Galactic latitudes, whilst the disc scalelengths are often neglected.

The results we find in literature are extremely variable, ranging from 2 to 5 kpc for the thick disc scalelength. Some of these studies provide evidence for a thick disc/thin disc decomposition with similar scalelengths, while others do not. For instance, Robin et al. (1996) and others find 2.5 kpc for the thin disc and 2.8 kpc for the thick disc, Ojha (2001) finds a thin disc scalelength of 2.8 kpc and a thick disc of 3.7 kpc, Larsen & Humphreys (2003) find a thick disc scalelength larger than 4 kpc. From edge-on disc galaxies, Yoachim & Dalcanton (2006) find support for thick discs larger than the embedded thin discs, and Parker, Humphreys & Larsen (2003) argue that the thick disc is not axisymmetrical.

The main issue is whether the thick disc is an independent structure. Although chemical investigations indicate a different α-elements history for the thick disc, suggesting it is a separate component, most of these studies must assume a well-defined kinematical signature, neglecting stars with intermediate kinematics. A marked scaleheight difference between the two discs (250 pc versus 1 kpc), a well-established result, does not exclude a heating origin. The radial scales could in principle distinguish among different formation scenarios: *N*-body simulations suggest that a heating mechanism can increase the scaleheight of a population, but it hardly produces a longer scalelength.

The paper is organized as follows. First, we introduce the data in Section 2. Section 3 gives an overview of the method. In Sections 4 and 5, the star counts in each direction are described in terms of thin and thick disc, and the reddening distribution along the line of sight is determined. In Section 6, we assess the implications of our findings.

2 DATA

The data used in this study are in three low-latitude fields, obtained with the CFHT, corresponding to the location of the open clusters NGC 6819 [$(l, b)^\circ = (73.98, +8.48)^\circ$], NGC 7789 [$(l, b)^\circ = (115.5, -5.38)^\circ$] and NGC 2099 [$(l, b)^\circ = (177.63, +3.09)^\circ$]. For a complete description of the observations and reductions see Kalirai et al. (2001a,b,c). These data, which were originally obtained to study cluster white dwarfs, represent very deep windows in the thin and thick disc. We have selected these three fields out of the 20 currently available from the BOCCE (Bologna Open Clusters Chemical Evolution) project (Bragaglia & Tosi 2006), because they are the deepest, widest and cleanest ones.

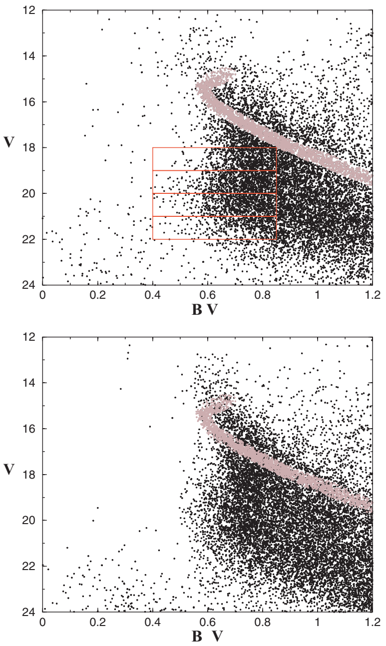

Figure 1. Top panel: the observational CMD in the direction of NGC 6819 [$(l, b)^\circ = (73.98, +8.48)^\circ$] (the cluster main sequence is shown in a lighter colour). The field of view is 0.148 deg^2. The location of the explored subregions is indicated by the boxes. Bottom panel: a synthetic diagram for an acceptable combination of parameters. The thin disc scaleheight is 250 pc, the radial scales for thin disc and thick disc are 2500 and 3700 pc, respectively. The local thick disc normalization is 7 per cent.

To select bona fide field stars, we specifically focus our analysis on the $(V, B-V)$ region below the clusters' main sequences: this region differs for each field (as shown in the upper panel of Figs 1, 2 and 3), due to the various locations of the clusters, reddening distribution etc. To increase the sensitivity to the structural parameters, each region has been further divided into subregions.

The chosen 'grid' is set up keeping several factors in mind: including red stars gives a better counting statistics; a narrow colour range shortens the mass range of the stellar populations, weakening the constraints on SFR and the IMF and focusing only on blue stars preserves the B-magnitude completeness. The bright and faint magnitude limits are chosen to avoid cluster stars, while guaranteeing sample completeness.

In the directions $(l, b)^\circ = (115.5, -5.38)^\circ$ (NGC 7789) and $(l, b)^\circ = (73.98, +8.48)^\circ$ (NGC 6819) the bulk of thin disc stars are close to the cluster, and therefore, share similar CMD positions. Although this is a strong limitation for the thin disc analysis, these data still represent a unique chance to study the thick disc structure. In fact, few, if any, of the sources with magnitude fainter than $V = 18$ (and suitable colours) are likely to be physically associated to the clusters. Again, thanks to the excellent photometry, we can exploit the CMDs as faint as $V = 22$. According to simulations, at this magnitude it is possible to trace the radial scalelength of the thick disc. The situation is different in the anticentre field $(l, b)^\circ = (177.63, +3.09)^\circ$ (NGC 2099). The proximity to the Galactic plane offers a deep snapshot of the outer thin disc, but consequently

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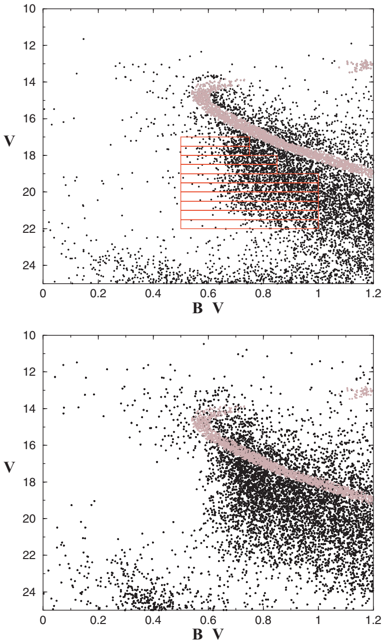

Figure 2. As in Fig. 1, but in the direction of NGC 7789 [$(l, b)^\circ = (115.5, -5.38)^\circ$]. The field of view is 0.104 $\deg^2$. Here the thin disc scaleheight is 250 pc, the radial scales for thin disc and thick disc are, respectively, 2500 and 3500 pc. The local thick disc normalization is 6 per cent.

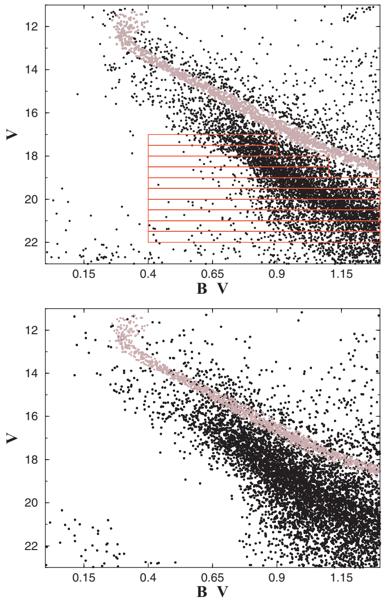

Figure 3. As in Fig. 1, but in the direction of NGC 2099 [$(l, b)^\circ = (177.63, +3.09)^\circ$]. The field of view is 0.155 $\deg^2$. $H_{\rm thin}$ is 250 pc. The radial scales for thin disc and thick disc are, respectively, 2200 and 3300 pc. The local thick disc normalization is 5 per cent.

provides little information about the thick disc. Combining the three lines of sight is an effective test for our Galactic model.

Finally, the CMD density of these stars reflects the matter distribution along the line of sight: the luminosity function is more sensitive to the Galactic structure, while the colour distribution is a major discriminant for age/metallicity/reddening combinations.

Table 1. Model parameters. The X symbol indicates a variable quantity. The SFR is assumed constant in the indicated range.

	Thin disc	Thick disc	Halo
Range of SFR (Gyr)	X-6	10–12	12
Z	0.02	0.001–0.006	0.0004
H-scale (pc)	200, 250, 300	1000	/
Radial scale (pc)	X	X	2600
$[\rho/\rho_{\rm thin}]_\odot$	1	X	0.0015

3 THE MODEL

Both the thin and the thick disc components are shaped as double exponentials, characterized by vertical and radial scales. Because of the low latitude, our lines of sight are less informative about the vertical structure. In our simulations, we make the simplifying assumption that the thick disc scaleheight ($H_{\rm thick}$) is 1 kpc, which is comfortably within the literature range, while the thin disc scaleheight ($H_{\rm thin}$) is tested for three characteristic values, namely 200, 250 and 300 pc. Both the thick and thin disc radial scalelengths are allowed to vary freely. Halo and thick disc local densities are expressed as a fraction of the thin disc density. In particular, the local halo fraction is fixed to be 0.0015 (see e.g. Siegel et al. 2002), while the thick disc value is a free parameter.

The stellar halo is characterized by a De Vaucouleurs density law with a half-light radius of 2.6 kpc. Although our data are marginally sensitive to the halo structure, simulations indicate that this component is required to improve the quality of the fit.

In conclusion, our Galactic model relies on four free parameters, namely the two scalelengths ($L_{\rm thin}$ and $L_{\rm thick}$), $H_{\rm thin}$ and the local thick disc normalization. The complete list of model ingredients is given in Table 1 (for further details see e.g. Castellani et al. 2002; Cignoni et al. 2007). For each component, the SFR is assumed constant. The recent SFR of the thin disc is chosen to reproduce the blue edge of the CMD.

The IMF is a power law with a Salpeter exponent. Masses and ages are randomly extracted from the IMF and the SFR, colours are interpolated using the Pisa evolutionary library (Cariulo, Degl'Innocenti & Castellani 2004). Once the absolute photometry is created, the line of sight is populated according to the density profiles and a reddening correction is introduced. To reduce the Poisson noise, the model CMDs are built from samples 10 times larger than the observed ones. For stars brighter than $V = 22$, photometric errors do not exceed 0.01 mag and the completeness in V is around 80 per cent (Kalirai et al. 2001a,b,c), thus the simulated CMDs can be directly compared with the data without blurring or corrections.

Finally, to decide the match quality of a given model, a Kolmogorov–Smirnov (KS) test was carried out to investigate both the colour distribution in each subregion and the luminosity function of the whole box. Only models giving a KS probability larger than 0.001 for each constraint are selected.

4 RESULTS ABOUT THIN DISC AND THICK DISC STRUCTURE

The lower panels of Figs 1, 2 and 3 show the synthetic diagrams which best reproduce the observed CMD of the top panels.

Fig. 4 shows the allowed region in the parameter space $L_{\rm thick}$ versus $L_{\rm thin}$. It seems clear that our fields at $(l, b)^\circ = (115.5, -5.38)^\circ$ (NGC 7789) and $(l, b)^\circ = (73.98, +8.48)^\circ$ (NGC 6819) are poorly

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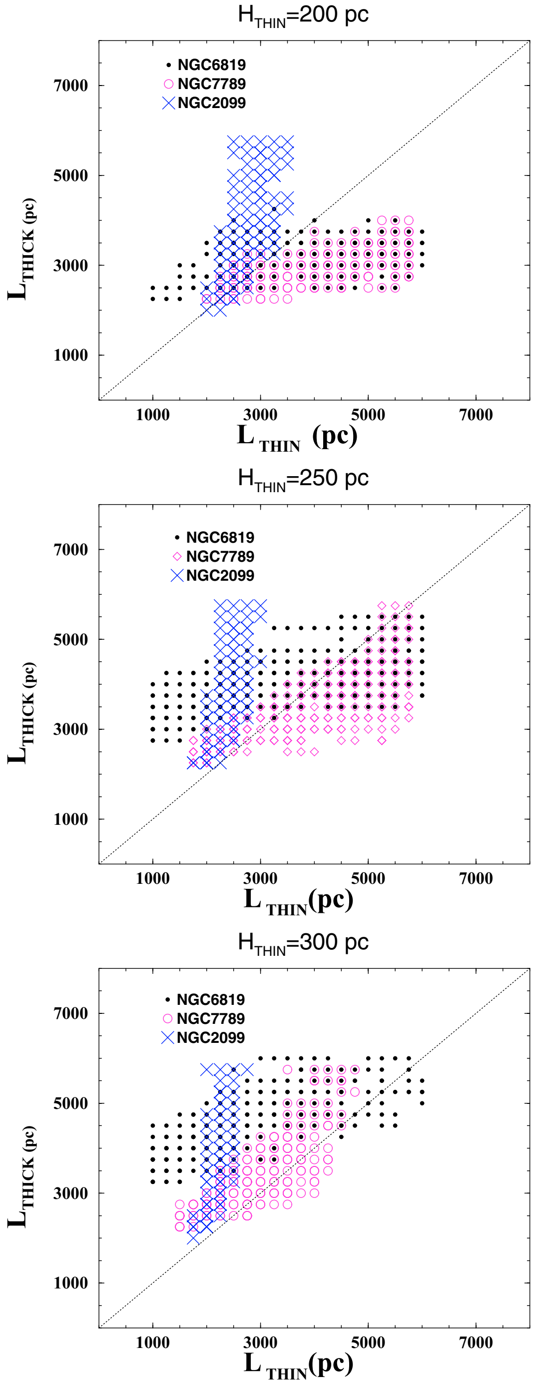

Figure 4. Visual inspection of the acceptable models: different symbols represent different directions. From top to bottom the thin disc scaleheight is assumed as indicated.

suited to constrain the thin disc structure: any thin disc scalelength between 1000 and 6000 pc looks acceptable. Even allowing for different thin disc scaleheights does not actually reduce the parameter space. In these CMDs, cluster and thin disc are partially overlapped, causing the loss of field stars during the already mentioned selection process. In conclusion, there are seemingly insufficient thin disc stars in our selected regions to determine its properties. In contrast, these directions clearly indicate a preferred range for the thick disc scalelength.

The solutions for $(l, b)^\circ = (177.63, +3.09)^\circ$ (NGC 2099) present the opposite situation: in this direction, the $L_{\rm thin}$ values are well constrained, while no preferred solution emerges for $L_{\rm thick}$ (which varies between 2000 and 6000 pc). Evidently, the low latitude of NGC 2099 combined with the intrinsically short vertical scale of the thin disc, implies that a significative portion of the thin disc is included in our field of view. On the other hand, this is not true for the thick disc, whose population density close to the Galactic plain is much lower.

Remarkably, a region exists in the parameter space, which is consistent with the combined directions. The three panels of Fig. 4 explore any dependence of this region on the thin disc scaleheight ($H_{\rm thin}$). For $H_{\rm thin} = 200$ pc the acceptable solutions for $L_{\rm thick}$ do not show any correlation with $L_{\rm thin}$ ($L_{\rm thick}$ versus $L_{\rm thin}$ is flat); for this scaleheight, the thin disc has a negligible influence on the explored CMD region (the thin disc is brighter than $V \sim 17$–18, i.e. the low-magnitude limit). If $H_{\rm thin}$ is increased, the probability of finding thin disc stars fainter than $V \sim 17$–18 increases as well. This implies a kind of degeneracy between $H_{\rm thin}$ and $L_{\rm thick}$. This effect is particularly evident for NGC 6819, the highest latitude field: $L_{\rm thick}$ is strongly correlated with $H_{\rm thin}$.

Regardless of the particular thin disc scaleheight, it is noteworthy that the recovered ratio $L_{\rm thick}/L_{\rm thin}$ never falls below 1 (the straight line in Fig. 4 stands for $L_{\rm thick}/L_{\rm thin} = 1$). Most of the common solutions clump around $H_{\rm thin} = 200$ pc, supporting similar values for $L_{\rm thick}$ and $L_{\rm thin}$. If $H_{\rm thin}$ is increased, the accepted $L_{\rm thick}$ becomes slightly larger than $L_{\rm thin}$.

Fig. 5 shows the acceptable pairs of thick disc normalization and $L_{\rm thick}$. The two parameters influence the luminosity function in a different fashion. The first parameter is the fraction of thick disc stars with respect to thin disc stars in the solar neighbourhood: it controls the ratio between bright (essentially thin disc) and faint (essentially thick disc) stars. On the other hand, the thick disc scalelength is associated both with the ratio bright/faint *and* with the luminosity function decline in the faint end (which is always thick disc dominated).

For each field, the solution space of Fig. 5 demonstrates the strong anticorrelation between $L_{\rm thick}$ and the thick disc local normalization. This effect is related to the fact that the total number of stars subtended by an exponential distribution is proportional to the scale. Hence, when the model scale decreases the local normalization must increase, in order to reproduce the observed star counts. Common solutions exist only for $H_{\rm thin}$ shorter than 250 pc. Beyond this value, the space solutions for the directions to NGC 6819 and NGC 7789 split into two distinct regions and common solutions no longer exist. Summarizing:

(i) the thin disc scaleheight is shorter than 250 pc;
(ii) the thick and the thin disc scalelengths are similar;
(iii) the scalelengths are quite short (2250–3000 pc for the thin disc, 2500–3250 pc for the thick disc);
(iv) a set of parameters ($\rho_{\rm thick}$, $L_{\rm thick}$, $L_{\rm thin}$, $H_{\rm thin}$) can *simultaneously* satisfy the requirements of the three directions;
(v) the thick disc normalization is smaller than 10 per cent.

5 REDDENING AND STAR FORMATION RATE

Together with the spatial structure, the reddening distribution and the thin disc star formation are also constrained. For this task, particularly informative is the blue edge of the CMDs, namely the envelope of the main-sequence turn-offs (vertical or shifted to the red by reddening). Once the model metallicity is assumed, the blue

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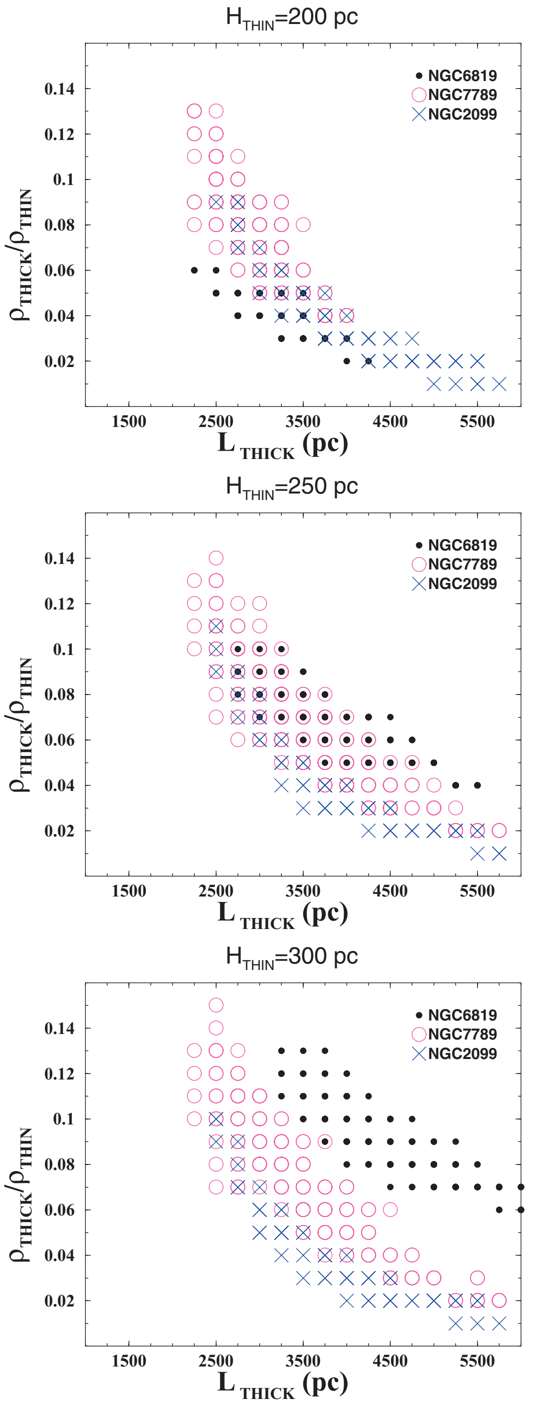

Figure 5. Acceptable pairs of local thick disc normalization and thick disc scalelength.

edge of the CMD is a function of the SFR and the reddening distribution along the line of sight. In particular, the brightest stars of the blue edge (i.e. the blue plume to the left and/or immediately below the cluster turn-off) are ideal candidates to infer information on the thin disc SFR. Given the proximity of these stars, it is reasonable to suppose a low reddening. Figs 1 and 2 show clearly that for NGC 6819 and 7789 the blue edge is quite constant in colour, with $B-V$ ranging between 0.6 and 0.7. This feature is a strong clue that in these directions the reddening is fairly independent of distance. For NGC 2099 the situation is different, with the blue envelope moving from $B-V\sim 0.4$ to $\sim$1.15, so the reddening is expected to vary along the line of sight. In order to infer the thin disc SFR and the reddening distribution, the synthetic diagrams are computed from the following principles.

(i) Given that our data are only weakly constraining the precise star formation law, the SFR is assumed constant and *only the recent SFR cut-off is allowed to vary*.

(ii) The models have been reddened using the standard $R_V = 3.1$ reddening curve of Cardelli, Clayton & Mathis (1989). The distribution of the reddening material is assumed to be a free function of the heliocentric distance. The reddening is increased (with steps of 1 kpc) until the synthetic and the observed blue edge match (according to the KS test for the colour distributions) at any distance.

In general, for a young population like the thin disc, the degeneracy between SFR and reddening is high. In contrast, for an old population like the thick disc (age > 7–8 Gyr) the SFR has a minor impact[1] and the blue edge is a strong indicator of the reddening.

In the following we report our results for each field.

5.1 (73.98, +8.48)° (NGC 6819)

In order to reconcile the theoretical thick disc turn-off with the observed blue edge, our analysis yields a constant reddening $E(B-V)\sim 0.16$, which is roughly the same as that of the cluster (according to Kalirai & Tosi 2004, $E(B-V)$ is 0.1–0.15 and the distance from the Sun $\sim$2.5 kpc), whereas it is lower than Schlegel, Finkbeiner & Davis (1998) estimate, $E(B-V) = 0.2$. This result is a consequence of the relatively 'high' Galactic latitude ($b = 8.5$), which confines the dimming material very close to the Sun.[2]

For a similar reason, we also find that a thin disc star formation which is still ongoing is apparently inconsistent with the observed CMD: indeed, to reproduce the blue edge at magnitudes fainter than $V = 18$, the thin disc activity must be switched off about 1–1.5 Gyr ago: evidently, most of the sampled thin disc stars belong to the old thin disc, while younger objects (age < 1 Gyr), with a typical scaleheight of 100 pc, are severely undersampled[3] in our field. To further examine and verify this hypothesis, we have included in our Galactic model a synthetic young population with an exponential scaleheight of 100 pc. Although the presence of the cluster in the CMD does not allow a quantitative comparison, we have verified that this intrusion has a minimum impact in the range $18 < V < 22$. In other words, ongoing star formation very close to the Galactic plane is not actually ruled out.

5.2 (115.5, −5.38)° (NGC 7789)

As for NGC 6819, a constant reddening correction, namely $E(B-V) = 0.2$ for all the synthetic stars (i.e. independent of the distance), gives the best result. This value, while in good agreement with the cluster estimate,[4] is significantly lower than that quoted

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[1] 7–8 Gyr correspond to turn-off masses below 1 $M_\odot$, whose evolutionary times are very long.

[2] At 3.0 kpc the line of sight is higher than 450 pc over the Galactic plane, thus, exceeding the vertical structure of the disc, it is plausible that most of the extinction occurs before the cluster.

[3] The solid angle and the Galactic latitude conspire to strongly reduce the number of visible stars from the young component.

[4] According to the WEBDA data base, and distance reddening for the cluster NGC 7789 are 2300 pc and $E(B-V) = 0.22$, respectively.

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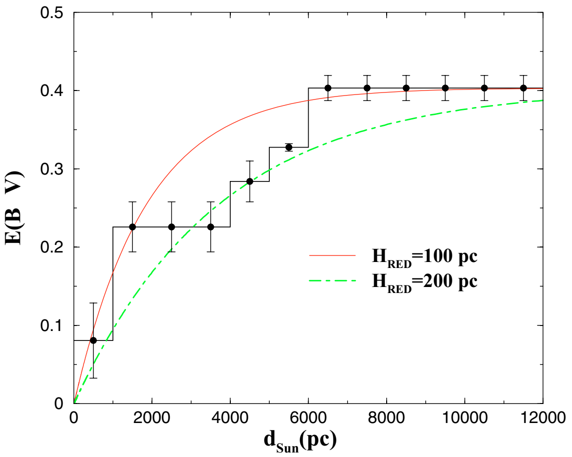

Figure 6. Recovered $E(B-V)$ versus heliocentric distance for the direction of NGC 2099 [$(l, b)^\circ = (177.63, +3.09)^\circ$]. For reference, exponential reddening distributions are also plotted (the scales are 100 and 200 pc, respectively).

on Schlegel's maps [$E(B-V) = 0.4$] in this direction. As with NGC 6819, thin disc star formation seems extinguished about 1–1.5 Gyr ago, but again this is a consequence of the selection effect against young, low-latitude stars.

5.3 (177.63, +3.09)° (NGC 2099)

This field lies in the Galactic plane, and therefore we expect the reddening to be a function of the heliocentric distance. This is indeed clear from the CMD of Fig. 3 (upper panel); while CMDs of the other fields show a quasi-vertical blue edge, as a consequence of the reddening material along the line of sight, the blue edge in this field is redder at fainter magnitudes. According to simulations, this field is thin disc dominated. A constant SFR which is still ongoing is necessary to explain the closest stars. If the same SFR is assumed for the entire thin disc, the reddening law we recover is indicated in Fig. 6 (the error bars indicate the range of acceptable models). For comparison, the same figure shows also the theoretical reddening distribution, for the same direction, expected using an exponentially decaying law perpendicular to the Galactic plane (the asymptotic value is fixed to the recovered one). The recovered distribution is not fitted by any exponential reddening (calculations for H_{RED} = 100 and 200 pc are showed).

6 REMAINING UNCERTAINTIES

Uncertainties in Galaxy modelling due, for example, to the assumed metallicity, binary population and incompleteness, can make our estimates imprecise.

Metallicity – the mean metallicity for both the thin and the thick disc is debated. Recent and old observational studies on the solar neighbourhood provide evidence for a metallicity spread (see e.g. Nordström et al. 2004) at any given age which is not explained in the framework of standard models of chemical evolution. Moreover, the presence of an age–metallicity relation and/or a spatial metallicity gradient further complicate the issue. Ignoring the right metallicity can lead to an incorrect interpretation of the spatial structure. Following the paradigm that a metal-rich system appears underluminous with respect to a metal-poor one, if the data are metal poor compared to the model, the inferred scalelength will be too short.

Binaries – the inclusion of binaries increases the luminosity of the population. Our model adopt only single stars, thus, if the binary fraction is conspicuous, the retrieved scale will turn out to be too short.

Completeness – losing faint stars lead to spuriously short scalelengths (especially for the thick disc).

Halo component – standard Galactic halo parameters have been used. However, the literature also documents very different prescriptions. A different choice could affect the thick disc distribution.

Structure – our findings make sense within the context of our parametrization: exponential profiles, whose radial and vertical scales are constant within the Galaxy. Introducing new features, such as an increase of the scaleheight (flare) or a warp of the Galactic plane, may produce a very different picture. Nevertheless, our parametrization is sufficient to reproduce the observations. In addition, our Galactic model is axisymmetrical. Therefore, any variation with Galactic longitude is missed. Finally, the thick disc scaleheight is assumed to play a minor role (because of the low latitude), hence it is fixed at a canonical 1 kpc. However, sporadic strong variations from this value are reported in the literature. In order to explore also this parameter, additional and preferably higher latitude fields would be needed.

7 CONCLUSIONS

We have carried out preliminary modelling of the observations in three deep and low-latitude Galactic fields imaged at the CFHT. Using a population synthesis method we gain information about the spatial structure, the thin disc star formation and the reddening distribution along the lines of sight. The directions $(l, b)^\circ = (73.98, +8.48)^\circ$ (NGC 6819) and $(l, b)^\circ = (115.5, -5.38)^\circ$ (NGC 7789) are very sensitive to the thick disc scalelength, whereas the line of sight $(l, b)^\circ = (177.63, +3.09)^\circ$ (NGC 2099) is sensitive to the thin disc scalelength. We decompose the Galaxy into halo, thick disc and thin disc. Solutions common to all lines of sight do exist and require that the thin disc has a vertical scale shorter than about 250 pc. The inferred radial scales are consistent with the thick disc equally extended or slightly larger than the thin disc. Our results support a typical scale of 2250–3000 pc for the thin disc and 2500–3250 pc for the thick disc. Similar scales for the thin disc are basically found by Ruphy et al. (1996) ($L_{\mathrm{thin}} \sim 2.3 \pm 0.1$ kpc) and Robin, Creze & Mohan (1992) ($L_{\mathrm{thin}} \sim 2.5$ kpc). It is noteworthy that the Robin et al. (1992) field is in the same direction of NGC 2099, giving an independent support to our result (they use a different statistical procedure). However, these authors argue for a thin disc cut-off at 15 kpc, whereas our determination invokes a reddening effect. In fact, the only acceptable solutions for the direction to NGC 2099 *requires* a structured reddening distribution, which seems to differ from simple exponential laws, revealing the inadequacy of classical distributions close to the Galactic plane.

Concerning the thick disc, our recovered scalelength is perfectly compatible with Robin et al. (1996) ($L_{\mathrm{thick}} \sim 2.8 \pm 0.8$ kpc), Buser, Rong & Karaali (1999) ($L_{\mathrm{thick}} \sim 3 \pm 1.5$ kpc) and Cabrera-Lavers, Garzon & Hammersley (2005) ($L_{\mathrm{thick}} \sim 3.04 \pm 0.11$ kpc). Ojha (2001) finds a thick disc scalelength ($L_{\mathrm{thick}} \sim 3.7 \pm ^{0.8}_{0.5}$ kpc) longer than ours, but the mean metallicity they adopt is higher ([Fe/H] ~ -0.7). Likewise, the very extended thick disc ($L_{\mathrm{thick}} >$ 4 kpc) quoted by Larsen & Humphreys (2003), may be due to adopting the luminosity function of 47 Tucanae ([Fe/H] $\sim -0.7/-0.8$), and could be reconcilable with our findings as well. Moreover, our

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conclusion about the thick disc normalization in the solar vicinity is consistent with the results obtained by the above-mentioned papers.

Searching for common solutions, the results presented here depict a thick disc scalelength that may be only slightly longer (∼20 per cent) than the thin disc one. If the two discs are really decoupled, the task for the future will be to understand the underlying mechanisms which have promoted very different scaleheights, while preserving similar scalelengths.

Clearly, this is only a pilot study showing what could be achieved by combining deep high-quality photometric fields with appropriate models for the Galaxy's components. To reach a better understanding of the Galactic structure, more fields of this kind should be studied, possibly including symmetrical locations.

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