Mon. Not. R. Astron. Soc. **322**, 426–432 (2001)

Radial scalelengths of the galactic thin and thick disc with 2MASS data

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Accepted 2000 October 20. Received 2000 September 22; in original form 2000 July 24

ABSTRACT

This paper presents a global analysis of the 2MASS (Two Micron All Sky Survey) data as observed in seven fields at different galactic latitudes in our Galaxy. The data allow the preliminary determination of the scale parameters, which lead to strong constraints on the radial and vertical structure of the galactic thin and thick disc. The interpretation of star counts and colour distributions of stars in the near-infrared with the synthetic stellar population model gives strong evidence that the galactic thin disc density scalelength (h_R) is rather short (2.8 ± 0.3 kpc). The galactic thick disc population is revisited in the light of new data. We find the thick disc to have a local density of 3.5 ± 2.0 per cent of the thin disc, exponential scaleheight (h_z) of 860 ± 200 pc and exponential scalelength (h_R) of $3.7\pm^{0.8}_{0.5}$ kpc.

Key words: surveys – stars: statistics – galaxies: stellar content – galaxies: structure – infrared: stars.

1 INTRODUCTION

The release of 2MASS data is intended to enable the community to carry out scientific investigations with a near-infrared data set for the first time. The deep near-infrared Two Micron All Sky Survey (2MASS) survey offers an unprecedented view of the Milky Way, nearly free of the obscuring effects of interstellar dust, which will reveal the true distribution of luminous mass, and thus the largest structures, over the entire length of the Galaxy.

This paper is part of a global analysis of near-infrared star counts to constrain the galactic structure parameters. The central tool of this approach is the 'Besançon' model of stellar population synthesis. The population synthesis model used here permits a global analysis of the data, since observational data can be simulated in each field with the true observational conditions (photometric system, errors and selection effects).

The scalelength and radial structure of galactic discs are rather poorly known at present. For the Milky Way, published values for the scalelength of a thin disc range from 1.8 to 6 kpc. Star counts from deep charge-coupled device (CCD) photometry and Schmidt plate data in the anticentre by Robin, Crézé & Mohan (1992a,b) and Ojha et al. (1994a, 1996) lead to the conclusion that the exponential scalelength is only 2.5 kpc, compared to the estimate of 5.5 ± 0.5 kpc from *Pioneer 10* surface photometry of the Galaxy (van der Kruit 1986). Deep near-infrared star counts from DENIS (DEep Near-Infrared Survey of the Southern Sky) in the anticentre show that the disc scalelength is rather short ($h_R = 2.3 \pm 0.1$ kpc; Ruphy et al. 1996).

It is now apparent that a thick disc does indeed exist in the Galaxy (Gilmore, Wyse & Kuijken 1989; Reid & Majewski 1993; Ojha et al. 1996; Robin et al. 1996). However, details of the physical parameters and the formation of the thick disc are incomplete. For example, the density scalelength of the thick disc is poorly known at present. It can be a major discriminant in theories of thick disc formation, being about 50 per cent larger than that of the thin disc in some merger models (Quinn, Hernquist & Fullager 1993), but approximately equal to the thin disc in models where the thick disc is simply part of a quasi-static settling of material to the plane (Burkert, Truran & Hensler 1992).

Robin et al. (1996) and Ojha et al. (1994a,b, 1996) have combined photometric and kinematic data from their own surveys with data from a number of other surveys to determine physical parameters of the thick disc more accurately. Robin et al. (1996) concluded that the thick disc has a scalelength of $2.8\pm^{0.8}_{0.5}$ kpc, a scaleheight of 760 ± 50 pc, a local density of 5.6 ± 0.8 per cent of the thin disc density, and a metallicity of -0.7 ± 0.2 dex with no detectable gradients.

The 2MASS deep near-infrared star counts on a large scale, allow for the first time, a quantitative comparison with the model of stellar populations, which constrain the radial and vertical structure of the galactic discs. In this paper, we present J and K_s star counts in seven directions as observed by the 2MASS survey at different galactic latitudes in the inner and outer part of the Galaxy. We describe the analysis used to obtain the density scalelengths of the galactic thin and thick disc of the Milky Way, using the whole data set and the model of stellar population synthesis.

2 DATA

We have used the public release of the 2MASS sampler and first incremental data of point source catalogues in J- (1.25 μm),

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H- (1.65 μm) and K_s-band (2.17 μm) in our analysis. The data are drawn from observations obtained at the Northern 2MASS facility at Mt Hopkins, AZ. 2MASS uses two new, highly-automated 1.3-m telescopes, one at Mt Hopkins, AZ, and one at Cerro Tololo Inter-American Observatory (CTIO), Chile. The data are complete to 16.0 mag in J, 15.5 mag in H and 15.0 mag in K_s. The 2MASS point source catalogues contain position and brightness information of the objects.

Seven 2MASS fields at different galactic latitudes in our Galaxy were chosen, which cover an approximately 68 deg^2 area. With these first 2MASS public release data sets, the galactic disc populations are revisited. This new infrared data allow the preliminary determination of the scale parameters of galactic discs.

The selected fields used in this paper are towards the galactic anticentre direction at median latitudes, towards the antirotation direction at low and median latitudes, and towards the galactic pole. The choice of the fields towards the anticentre and antirotation directions was made because they constrain the galactic structure parameters towards the outer part of the Galaxy. The fields towards the antirotation direction also give evidence of the relative motion of the intermediate populations. The fields at low and intermediate latitude give a strong constraint on the scalelengths of the galactic discs while the galactic pole field constrains only the scaleheight and not the scalelength. Our investigations are based on the combined data from seven 2MASS fields which have been used in the global match. The position of the fields covered by the observations are listed in Table 1.

3 THE MODEL FOR STELLAR POPULATION SYNTHESIS

We have used a revised version of the Besançon model for stellar population synthesis to interpret the 2MASS near-infrared counts. The previous versions of the model were extensively described in Robin & Crézé (1986), Bienaymé, Robin & Crézé (1987), Haywood (1994) and in Haywood, Robin & Crézé (1997a,b). The Besançon model is a self-consistent model of the Galaxy, in the sense that the model parameters are forced to follow physical laws (physical links between the density, velocity, and metallicity distribution are taken into account). The model involves four populations: thin disc, thick disc, halo and bulge.

3.1 Thin disc

A standard evolution model is used to produce the disc population, based on a set of usual parameters: an initial mass function (IMF), a star formation rate (SFR), a set of evolutionary tracks (see Haywood et al. 1997a,b and references therein). In this model, the galactic thin disc in the z-direction is represented by a sum of seven isothermal components with different scaleheights and ages, from 0 to 10 Gyr. The z velocity dispersion–age relation is used for the distribution of stars along the z-axis (except for the youngest one, which can not be considered as relaxed). Then, the Boltzmann equation is used to convert z velocity distributions into z density. This model is dynamically self-consistent, in the sense that the potential used in the Boltzmann equation is the one generated by the total mass distribution of stellar populations. The self-consistency is established iteratively. This model employs a constant star formation rate, a three-slope IMF and a 21 km s^{-1} maximum velocity dispersion. The model also gives the thin disc a vertical metallicity gradient according to age–metallicity and age–scaleheight relations. In this model, the key parameter is the density law of the galactic thin disc, which is an Einasto (1979) density law for $R \leqslant R_{\max}$ (radial cut-off), and is equal to 0 beyond $R_{\max}$. The Einasto law is close to a sech^2 law in the vertical direction (see Bienaymé et al. 1987, for details), and close to an exponential law in the radial direction, in such a way that the parameter h_R is similar to a radial exponential scalelength.

Table 1. Fields in the sampler and first incremental data as observed by 2MASS.

Field	α_{2000}	δ_{2000}	$l_{\rm cen}$	$b_{\rm cen}$	area (deg^2)
I	$23^h02^m36\overset{s}{.}0$	$+27°03'40''$	$94\overset{\circ}{.}9$	$-29\overset{\circ}{.}8$	17.72
II	$02^h43^m22\overset{s}{.}8$	$+27°03'54''$	$151\overset{\circ}{.}6$	$-29\overset{\circ}{.}5$	9.64
III	$02^h52^m40\overset{s}{.}6$	$+27°04'01''$	$153\overset{\circ}{.}7$	$-28\overset{\circ}{.}5$	11.83
IV	$07^h05^m36\overset{s}{.}0$	$+20°49'30''$	$195\overset{\circ}{.}7$	$+12\overset{\circ}{.}3$	5.96
V	$08^h50^m28\overset{s}{.}8$	$+09°02'02''$	$218\overset{\circ}{.}5$	$+30\overset{\circ}{.}5$	5.32
VI	$08^h59^m40\overset{s}{.}8$	$+14°53'24''$	$213\overset{\circ}{.}3$	$+35\overset{\circ}{.}0$	10.47
VII	$13^h20^m11\overset{s}{.}8$	$+26°54'11''$	$32\overset{\circ}{.}6$	$+83\overset{\circ}{.}6$	6.69

3.2 Thick disc

The thick disc is also modelled as being radially and vertically exponential above the plane. The thick disc population is modelled as originating from a single epoch of star formation. The model uses Bergbush & Vandenberg (1992) oxygen enhanced evolutionary tracks. The IMF is modelled by a simple power law with a slope of about $\alpha = 1$–2. The luminosity function used for the thick disc is similar to that of 47 Tuc. A detailed analysis of the thick disc population from *UBV* photometric and astrometric star counts has been given elsewhere (Ojha et al. 1994a,b, 1996, 1999; Robin et al. 1996). The thick disc metallicity is chosen as -0.7 dex, following *in situ* spectroscopic determination from Gilmore, Wyse & Jones (1995) and photometric star count determinations (Robin et al. 1996; Buser, Rong & Karaali 1999).

3.3 Interstellar matter

In the model a disc of absorbing layer (interstellar matter) with a double-exponential density law is added to the stellar components. The distribution of A_V (r, l, b) of diffuse absorbing matter is assumed to be the same as the density law of the young disc, with an equivalent scale height of 140 pc, a scalelength of 5000 pc and an adjustable normalization. The default normalization in the model, 0.7 mag kpc^{-1} in the V-band, is suitable for median and high latitudes. These values have been obtained by fitting the total extinction in four galactic directions to observed values (Robin 1983). At low latitudes this value may be adjusted to each field. Extinction in other passbands is derived from A_V using a standard reddening law (see Robin & Crézé 1986). In addition to this smooth distribution of diffuse absorbing matter, absorbing clouds of given reddenings and distances can be introduced as well along the line of sight.

3.4 Method

Since we are dealing with fields at different galactic latitudes, the effect of extinction along the line of sight must be investigated. The effect of extinction on K_s star counts is limited. However, J–K_s colour distributions are significantly sensitive to the extinction. We have adjusted the extinction in each direction by comparing the model-predicted and observed J–K_s distribution. A grid of models with various values for the coefficient of the local diffuse visual extinction (A_V) has been studied in each direction. Then, the fit of the position of the observed and model-predicted J–K_s colour distribution peaks allows the adjustment of the spatial extinction law in the model. By comparing the observed and predicted J–K_s distribution peaks, we find the best value of $\sim 0.7\,\mathrm{mag\,kpc^{-1}}$ in the *V*-band for the coefficient of the local diffuse visual extinction for the intermediate and high galactic latitude fields. The fit gives a value of $\sim 0.25\,\mathrm{mag\,kpc^{-1}}$ in the *V*-band for the lower galactic latitude field (Field IV in Table 1).

A brief summary of the revised Besançon model for population synthesis is described in Robin, Reylé & Crézé (2000). While examining the various parameters for the galactic discs, we have started with the best fit revised Besançon model (as in Robin et al. 2000).

4 ANALYSIS

4.1 Fitting method: maximum likelihood

Population synthesis simulations have been computed in each observed field using photometric errors as close as possible to the true observational errors, with photometric errors generally growing as a function of the magnitude and are assumed to be Gaussian. Monte Carlo simulations are performed in a solid angle much larger than the data in order to minimize the Poisson noise. Then we compare the number of stars produced by the model with the observations in the selected region of the plane (magnitude, colour) and we compute the likelihood of the observed data being a realization of the model following the method as described in Bienaymé et al. (1987).

Let q_i be the number of stars predicted by the model in bin i, and f_i be the observed number. In case the deviations of f_i's with respect to q_i just reflect random fluctuations in the counts, each f_i would be a Poisson variate with mean q_i. The probability that f_i will be observed is

$$\mathrm{d}P_i = \frac{q_i^{f_i}}{f_i!}\exp(-q_i).$$

The likelihood of a set of q_i's given the relevant f_i is

$$L = \ln \sum \mathrm{d}P_i = \sum_i (-q_i + f_i \ln q_i - \ln f_i!).$$

When searching for models that maximize L, it is convenient to use the reduced form

$$L - L_0 = \sum_i f_i \left(1 - \frac{q_i}{f_i} + \ln \frac{q_i}{f_i}\right),$$

where L_0 is constant and $L - L_0 = 0$ for a model which would exactly predict all f_i's.

4.2 Confidence interval

The confidence interval of our fit comes from the estimation of the variation of the likelihood resulting from the Poission noise on the simulated data. We estimated the confidence interval of our fit by computing the Poisson noise using several simulations (at least 25 simulations for each of the models) of similar models. The likelihood for the realizations of the same model differing just by the Poisson statistics, gives the value to be added to the maximum likelihood in order to obtain the confidence level.

4.3 Thin disc scalelength

A grid of models with various disc scalelengths has been studied. For each of these models, we determine the best value of the density scalelength using a maximum likelihood technique, applied on a set of bins of K_s and J–K_s to the whole set of data from seven fields, for stars brighter than 15 mag in K_s. The data are binned with a step of 1 mag in K_s and 0.1 in J–K_s. To avoid large Poission noise in the Monto Carlo simulations, we computed at least 10 simulations of $50\,\mathrm{deg}^2$ for each of the models tested in our analysis.

Fig. 1 shows the maximum liklehood curve for different values of the scalelength (h_R) of the thin disc from the combined data set from seven fields. The maximum likelihood is obtained with a scalelength of 2.8 kpc. We obtained an uncertainty of ± 0.3 kpc in the determination of h_R from the estimation of the variation of the likelihood resulting from the Poisson noise on the simulated data.

4.4 Thick disc local normalization, scaleheight and scalelength

After comparison with model simulations and the data, we selected the magnitude (K_s) and colour (J–K_s) range, where the thick disc stars are in a majority. We restricted our analysis to the domain defined by $13 < K_s < 15$ and $0.2 < J$–$K_s < 1.0$. Most of these are G-, K- and M-type stars ($M_V < 9$) and peak around 0.5 mag in J–K_s.

We produced simulated catalogues for an array of thick disc properties with different parameters for local density, scaleheight and scalelength. Binned K_s and J–K_s diagrams are made of stars. Thick disc properties are found by fitting the best statistical matches between the simulated and the observed colour–magnitude diagrams using the maximum likelihood method.

First, we constrained the local normalization of the thick disc. Simultaneously, we also checked for the scaleheight for the thick disc, which was however rather insensitive with the 2MASS data. This is borne out by the relatively flat distribution of the maximum

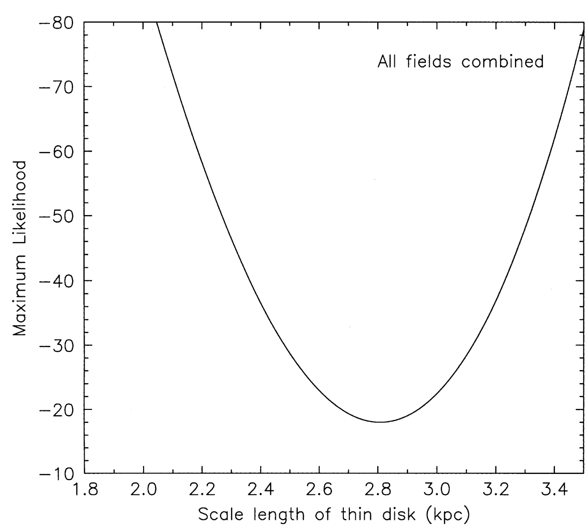

Figure 1. Maximum-likelihood curve for the density scalelength (h_R) of the thin disc, derived from the combined set of data from seven fields.

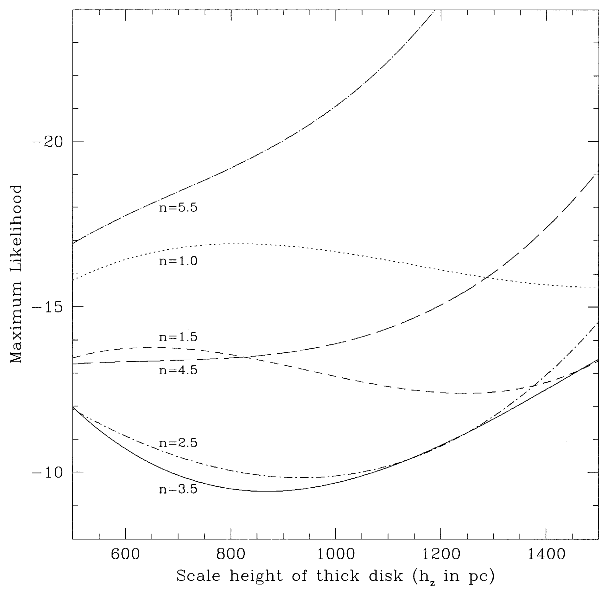

Figure 2. Maximum-likelihood curves for the scaleheight (h_z) of the thick disc, derived from the combined set of data from seven fields. The sequence of curves from bottom to top corresponds to values of the thick disc normalization (in per cent of thin disc).

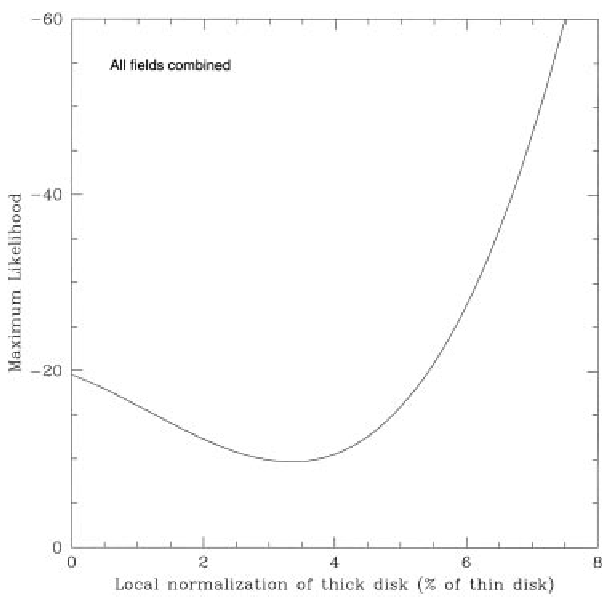

Figure 3. Maximum-likelihood curve for the thick disc local normalization, derived from the combined set of data from seven fields.

likelihood values, within most of the variation range. Fig. 2 shows the maximum likelihood curves for the thick disc scaleheight (h_z) derived from the combined set of data from seven fields. In Fig. 2, the sequence of curves from bottom to top corresponds to values of the thick disc local normalization from 1.0 to 5.0 (per cent of the thin disc). Fig. 3 shows the maximum likelihood curve obtained for different values of thick disc local normalization. The best fit value of 3.5 ± 2.0 (per cent of the thin disc) was obtained for the thick disc local normalization with a scaleheight (h_z) of 860 ± 200 pc.

Finally, after obtaining the best-fit values for the local density and scaleheight of the thick disc, we constrained the thick disc

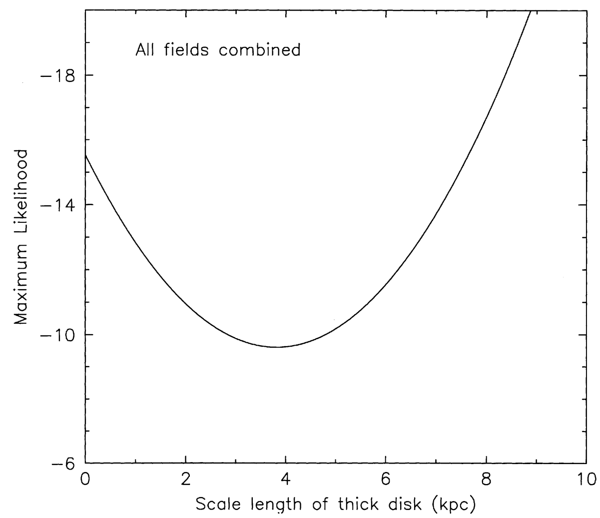

Figure 4. Maximum-likelihood curve for the density scalelength (h_R) of the thick disc, derived from the combined set of data from seven fields.

scalelength (h_R) parameter. The best fit value came out to be $3.7\pm^{0.8}_{0.5}$ kpc for the thick disc scalelength. Fig. 4 shows the likelihood obtained as a function of the thick disc scalelength.

5 MODEL AND DATA COMPARISON

In Fig. 5, the observed apparent K_s magnitude distribution is compared with the model predictions with thin disc scalelengths of 2.8 and 3.5 kpc, thick disc scalelength of 3.7 kpc, scaleheight of 860 pc and the local density of 3.5 per cent of the thin disc. The total observed counts are in good agreement with the model predictions assuming the thin and thick disc scalelengths, h_R, of 2.8 and 3.7 kpc, respectively. Fig. 6 shows J–K_s distributions in seven fields, along with model predictions for two different thin disc scalelengths, $h_R = 2.8$ kpc and $h_R = 3.5$ kpc. The excess of stars seen on Figs 5 and 6 for $h_R = 3.5$ kpc, is significantly reduced with the new value of h_R. The model fit with data is not, however, completely satisfactory in J–K_s, which might be improved by a slight change of star formation rate history in the model. It is expected that the galactic evolution parameters will be better known after the analysis of the *Hipparcos*, Tycho and DENIS catalogues. The Besançon model will be further improved using the data from *Hipparcos*, Tycho and DENIS (Robin et al., in preparation).

6 DISCUSSION

6.1 Thin disc

There have been several determinations of the thin disc density scale length of the Milky Way either from a photometric or a kinematic approach. They range between 1.8 to 6 kpc in the literature. Most determinations based on photometry or star counts give possible values in a large range between 2.5 and 5 kpc (Kent, Dame & Fazio 1991 gave a recent review; see also Robin et al. 1992b), but part of these measurements are model dependent and require assumptions. To add to this apparent confusion, many published density scalelengths are deduced from kinematic data using the asymmetric drift relation, but generally the expressions used for the asymmetric drift are simplified without any strong

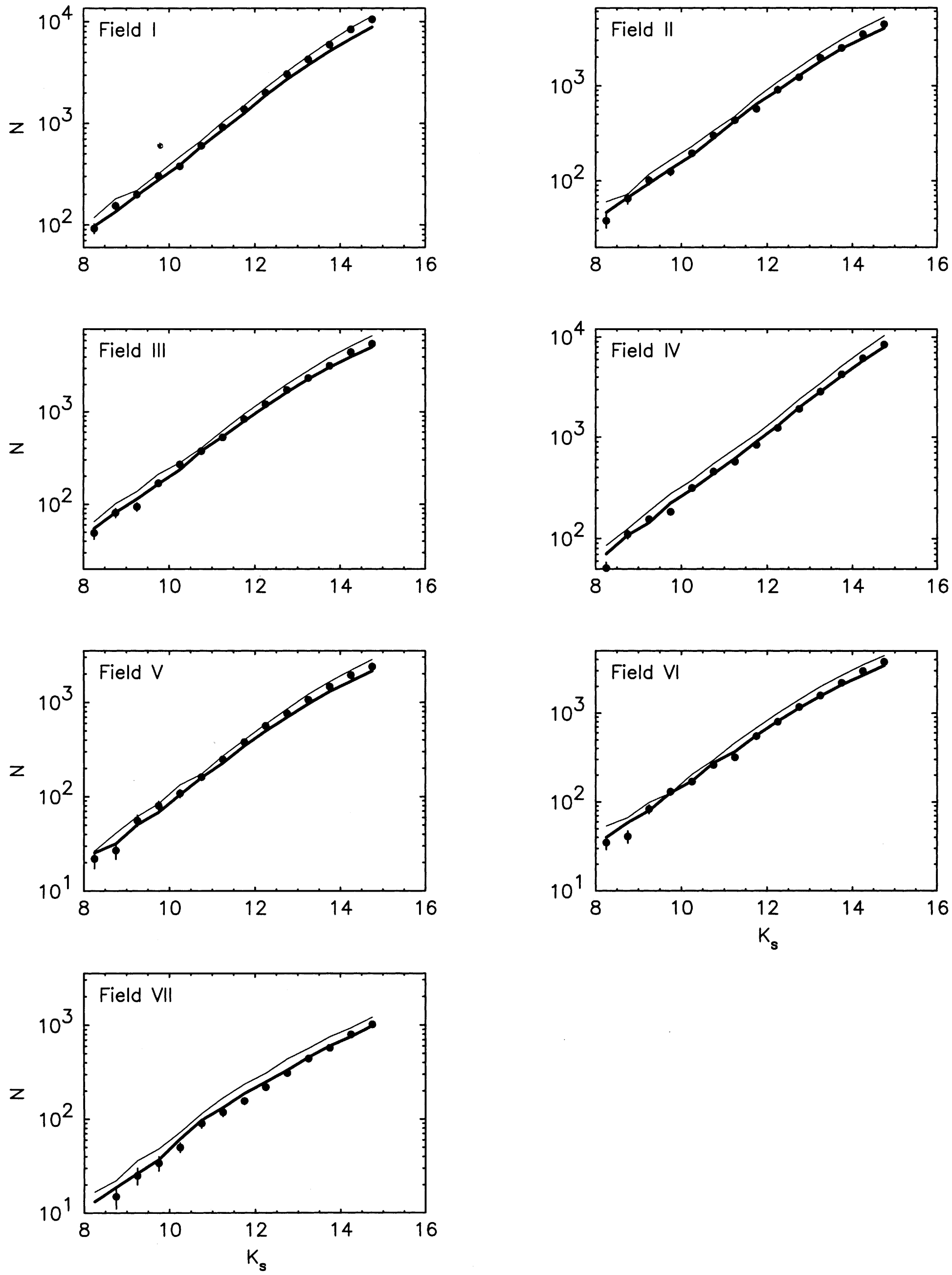

Figure 5. K_s star counts in seven fields. Filled circle: observed counts with 1σ error bars (Poisson noise only). Thick line: predicted counts assuming a density scalelength (h_R) of 2.8 kpc. Thin line: predicted counts with h_R of 3.5 kpc.

theoretical support. For example, it is frequently assumed that the kinematic and density scalelengths are equal. Only in a recent contribution (Fux & Martinet 1994), the term including the shape (spherical, cylindrical…) of the potential was adjusted.

It is possible that the discrepancy between photometric determinations of h_R arises from the assumption of constant scaleheight. A scalelength of 5.5 kpc has been obtained from the *Pioneer 10* background experiment by van der Kruit (1986). *Pioneer* data does not directly constrain the scale length, but the radial to vertical scale ratio (h_R/h_z) is such that the results depend on the assumed scaleheight. They assumed a scaleheight of $h_z = 325$ pc (that is the value of old disc dwarf), while one would expect that old disc giants would dominate the light in *Pioneer* data (Lewis & Freeman 1989). Adopting the recent determination of $\sim$250 pc for h_z (Kuijken & Gilmore 1989; Kroupa 1992; Haywood et al. 1997b), the radial scalelength deduced from *Pioneer 10* data would be closer to 3.9 kpc. It should be noted that the Einasto disc models used by the Besançon model (Robin et al. 1986) have an increasing scaleheight of about 15 pc kpc^{-1} for those representing the old disc stars. This may explain why the scalelengths ($h_R \sim 2.5$–2.8 kpc) deduced by Robin et al. (1992a,b) and this paper are so much smaller than the one obtained from the *Pioneer 10* data with constant scaleheight (h_z). Lewis & Freeman (1989) determined the radial scalelength $h_R = 4.4$ kpc from the velocity dispersions of disc K giants on the assumption that the scaleheight is independent of R. They found a different

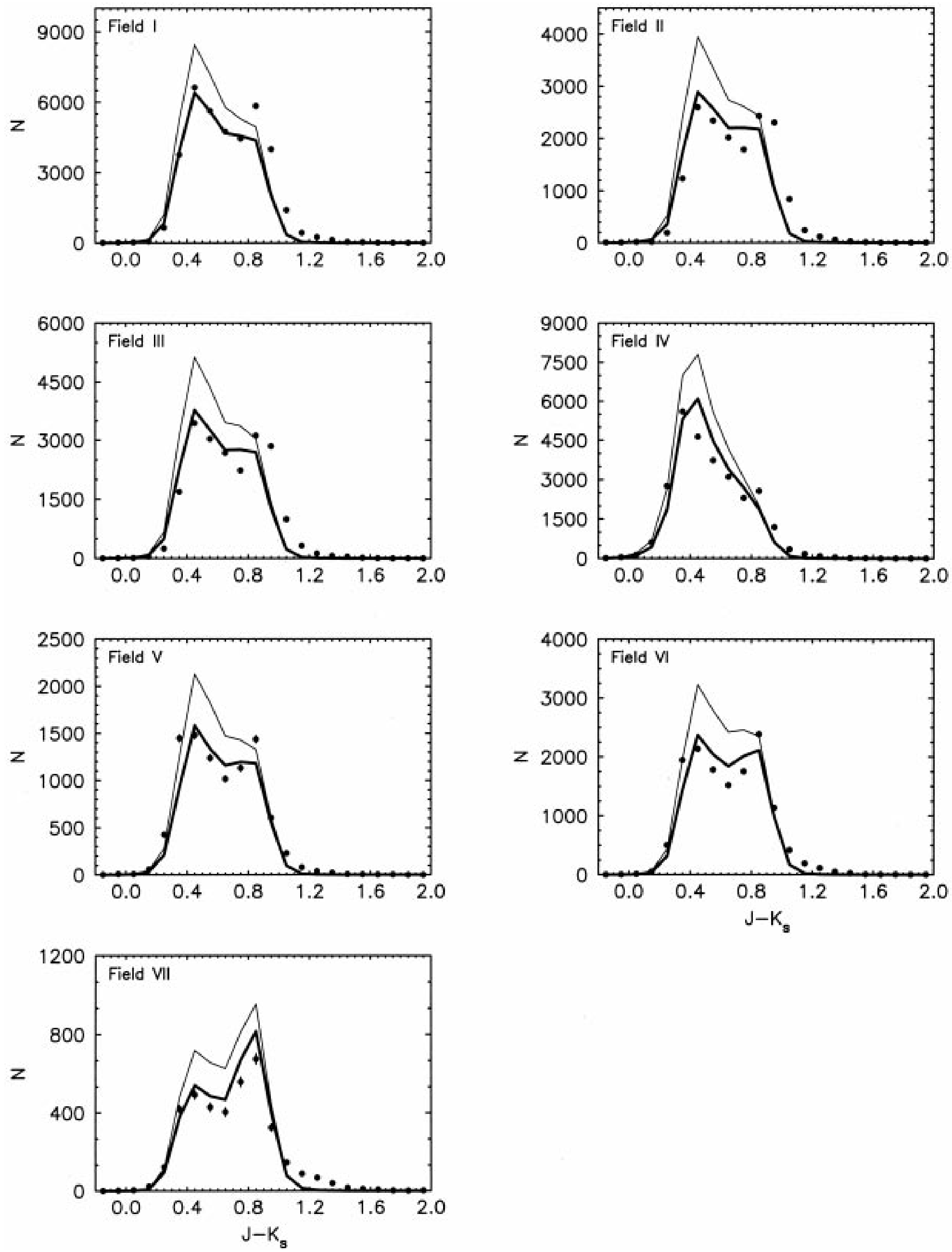

Figure 6. *J*–K_s distributions of sources brighter than $K_s = 15$ mag in seven fields. The symbols are as in Fig. 5.

scalelength $h_R = 3.4$ kpc from density (σ_R) determination. The kinematic determination of the radial scalelength obtained by Fux & Martinet (1994) is $h_R = 2.5$ kpc, assuming a radially constant scaleheight h_z, and $h_R = 3.1$ kpc with a positive local h_z gradient of 30 pc kpc^{-1}. Their analysis is based on the asymmetric drift equation and on moments of the Boltzmann equation. More recently, Feast (2000) has obtained the scalelength of the thin disc $h_R = 3.3 \pm 0.6$ kpc by reanalysing the radial velocity data of different variables. They also assume that the disc scaleheight and the ratio of the axes of the velocity ellipsoid (σ_R/σ_z) do not change with *R*.

Here, we have presented a direct measurement of density scalelength of the thin disc by analysing the data using a synthetic model, reproducing observable quantities (magnitude and colour counts). This method is expected to avoid systematic bias which can be encountered on inverting the process. The resulting density scalelength of 2.8 ± 0.3 kpc has to be compared to some recent works: the value of 2.3 ± 0.1 kpc obtained by Ruphy et al. (1996) by analysing the DENIS near-infrared data towards the anticentre direction; Robin et al. (1992a,b): 2.5 ± 0.3 kpc, from optical star counts towards the galactic anticentre; Fux & Martinet (1994): $h_R = 2.5^{+0.8}_{-0.6}$ kpc, based on a rigorous analysis of the asymmetric drift relation; Porcel et al. (1998): 2.1 ± 0.3 kpc, from the near-infrared *K*-band counts from the TMSG (Two Micron Galactic Survey); Freudenreich (1998) finds $h_R = 2.6$ kpc by fitting *COBE* data to a galactic model. Bienaymé (1999) finds that the density scalelength of the galactic disc is 1.8 ± 0.2 kpc, using the neighbouring stars in the *Hipparcos* catalogue.

We also notice that an increase of h_R (by $\sim$0.7 kpc) predicts a significant excess of stars (in Figs 5 & 6). It follows that the present 2MASS data are clearly incompatible with the larger values of h_R for the thin disc, such as those found by van der Kruit (1986) ($h_R = 5.5 \pm 1$ kpc) and Lewis & Freeman (1989) ($h_R = 4.4 \pm 0.3$ kpc).

6.2 Thick disc

There are several recent determinations of galactic thick disc properties, which are based on analyses of data from the survey of the North Galactic Pole and also several fields at intermediate latitudes of the Galaxy: Reid & Majewski (1993) analysed the deep star count data towards the NGP. They claimed the gradient in the thick disc properties ranged from 2–11 per cent for the local normalization of the thick disc (to the local thin disc), 700–2000 pc for the scaleheight (h_z) and scalelength (h_R) of 3.5 kpc. A recent determination by Robin et al. (1996) gives $h_z = 760 \pm 50$ pc, with a local density of 5.6 ± 1.0 per cent relative to the thin disc and scalelength (h_R) of 2.8 ± 0.8 pc. Their studies make use of broad-band multicolour photometric and proper motion data, and they provide analysis of the data in terms of an appropriately consistent combination of stellar population synthesis models, including the kinematics, space density distributions, star formation histories and chemical evolution of the galactic stellar populations. Spagna et al. (1996) used a *BVR* star count and proper motion data towards the NGP. They found the thick disc to have a scaleheight of $h_z = 1137 \pm 61$ pc, with a local density of 4.3 per cent. Ng et al. (1997) determined the thick disc properties using the *BV* star counts: $h_z = 1000 \pm 100$ pc, with a local density of 5.3 per cent and scalelength (h_R) of 4.5 kpc. More recently, Buser et al. (1999) analysed the *RGU* star count data towards the NGP. They found the galactic thick disc to have a local density of 5.9 ± 3 per cent of the local thin disc density, exponential scalelength of 3.0 ± 1.5 kpc and exponential scaleheight of 910 ± 300 pc.

Some degeneracy seems to remain between the exact determination of the local stellar thick disc density, its scaleheight and scalelength (at least from the divergence of the published results summarized above). Nevertheless, it can be shown that star counts when restricted to a small number of galactic directions and a small magnitude range do not give a strong constraint on the scaleheight, but rather on the parameter: (local density) $\times$ (scaleheight)^2 (Robin et al. 2000). At present, there is no accurate determination of the thick disc density in the solar neighbourhood, independent of the scaleheight. Reasonable values range between 700 to 1200 pc for the scaleheight and 1 to 4 per cent for the local density relative to the thin disc.

7 CONCLUSION

We have analysed the 2MASS near-infrared data observed in seven fields with the help of a model of stellar population synthesis. The preliminary result confirms that the thin disc has a relatively short scalelength of 2.8 ± 0.3 kpc. We conclude that the thick disc population can be described by a radially exponential density law with a scalelength of $3.7\pm^{0.8}_{0.5}$ kpc, a scaleheight of 860 ± 200 pc, and a local normalization of 3.5 ± 2.0 per cent of the thin disc. Additional information will be gained when much more extensive sampling of the sky in different directions of the Galaxy are analysed.

ACKNOWLEDGMENTS

This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center, funded by the National Aeronautics and Space Administration and the National Science Foundation. We thank Dr Annie Robin for letting us use their model of stellar population synthesis and for giving her useful comments on the first version of the paper. We thank the anonymous referee for useful comments on the manusscript. This research paper has made use of the DEC-ALPHA system of the Optical CCD astronomy programme of TIFR.

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