Mon. Not. R. astr. Soc. (1987) **227**, *Short Communication*, 13P–17P

Density normalization of the thick disc of the Galaxy

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Accepted 1987 May 19. Received 1987 May 19; in original form 1987 April 27

Summary. The conflict between the normalization values for the thick disc found by Gilmore & Reid (2 per cent) and Sandage & Fouts (10 per cent) is resolved.

1 Introduction

Recent work has shown that the thick disc has a normalization with respect to the thin disc of 10 per cent (Sandage & Fouts 1987; Sandage 1987). This value is then directly compared with Gilmore & Reid's (1983, GR) value of 2 per cent and various explanations are put forward to account for this difference. In this work it is shown that there is no conflict between these values and that the difference lies entirely in the density laws used. Gilmore's galaxy model, using both Sandage's and GR's density laws and normalizations, is then compared with star counts in the Hazard 8-Hour Field.

2 The density law perpendicular to the plane of the Galaxy

In Sandage (1987) the density distribution perpendicular to the plane is derived from the velocity dispersions, $\sigma(W)$, and an adopted gravitational acceleration perpendicular to the plane, $g(Z)$. These density laws (one for each component) are shown in table 1 and fig. 1 of Sandage (1987). These density laws are approximately exponential away from the plane, but are flatter close to the plane. He then fits these density laws to star count data from the North and South Galactic Poles. The thick disc normalization is calculated from the difference in intercepts of the density laws after the fitting has been accomplished. In Sandage & Fouts (1987) no density laws are used in the normalization calculation and almost all the stars in this sample lie within ~300 pc of the Sun. The thick disc normalization calculated in this paper is for the *local* neighbourhood.

In GR the density laws for both the thick and thin discs are assumed to be exponential. These laws are then fitted to South Galactic Pole star count data with the difference in the intercepts giving the thick disc normalization. It is important to note that this paper assumes the density law to be exponential near the plane of the Galaxy. If this is not the case, the value given by this technique will not apply to the local neighbourhood. Even so, this value can be used in conjunction with exponential density laws and star counts since they are not greatly affected by the number of stars in the solar neighbourhood. It should be noted that within 1 kpc of the plane of

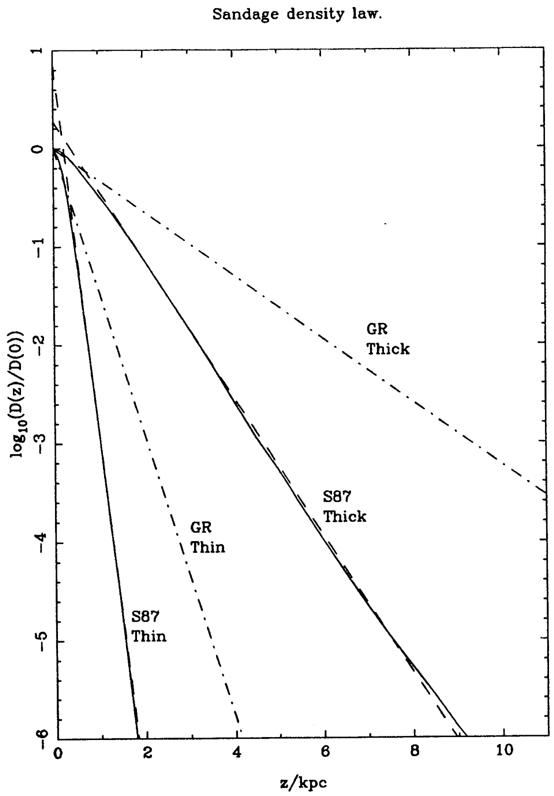

Figure 1. The solid line shows the density laws for the thick and thin discs used in Sandage (1987). The dashed lines are linear approximations (equivalent to exponential density laws) to these density laws. For the straight lines drawn, the difference in intercepts can account for a factor of $3.8[=10^{(0.85-0.27)}]$ between an exponential density law normalization and that found by Sandage. Also drawn are the density laws used in GR (dot-dashed lines).

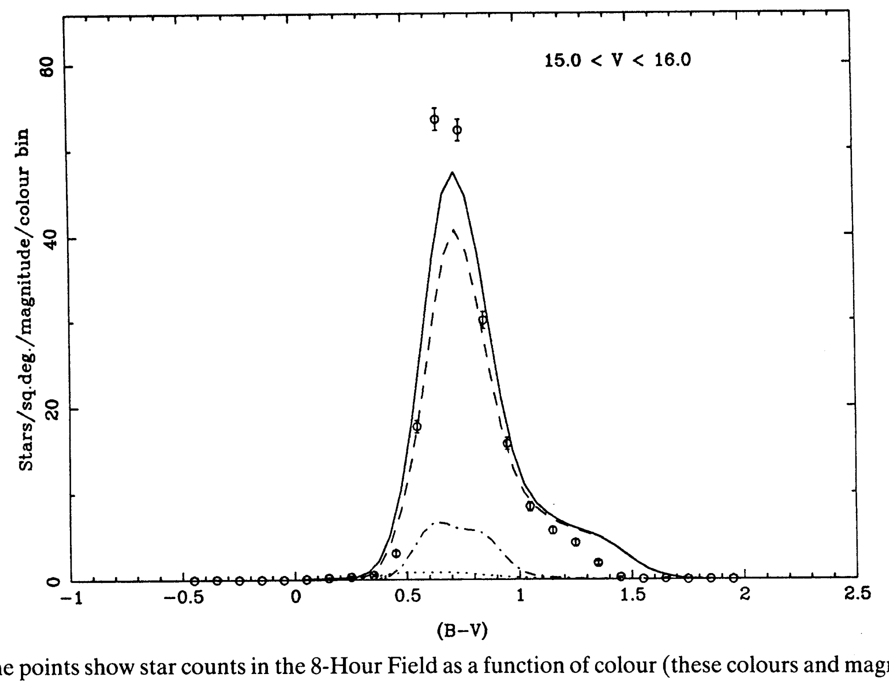

Figure 2. The points show star counts in the 8-Hour Field as a function of colour (these colours and magnitudes have been transformed from O and E) for the magnitude range $15<V<16$. The lines drawn are the predicted star counts from Model 1 (see text) with the unbroken line representing the total counts; dashed line, thin disc; dot-dashed line, thick disc; and dotted line, spheroid.

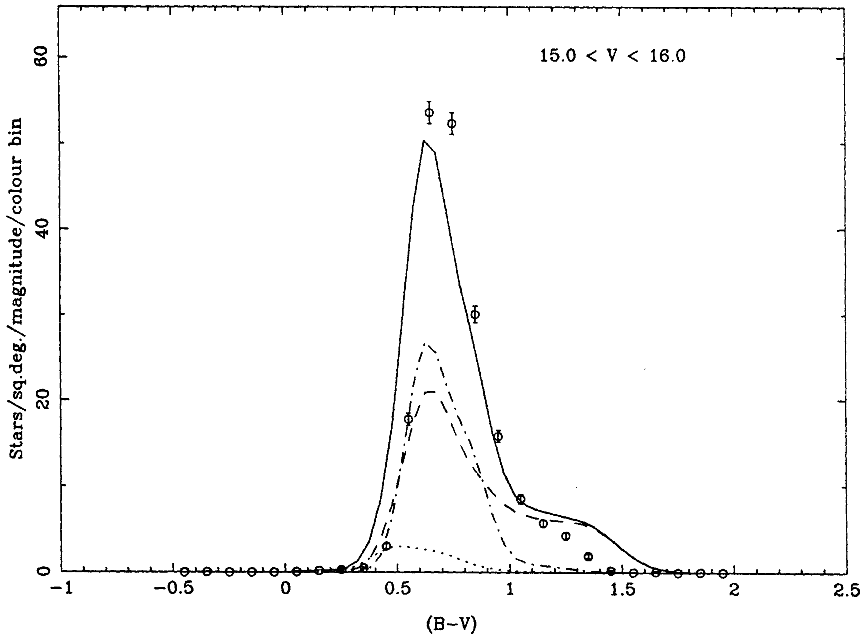

Figure 3. As Fig. 2, for Model 2.

the Galaxy, star counts are dominated by the thin disc, therefore no data on the true density law for the thick disc are possible from just star counts. Thus, one must be careful in comparing GR's normalization directly with that obtained by Sandage.

The difference in normalization values can be accounted for by the difference in the density laws. Firstly, this can be seen by drawing straight lines (exponential density laws) through Sandage's density laws (fig. 1 of Sandage 1987) and comparing the intercepts. Since these laws are only approximately linear on a log–linear plot, a variety of intercepts can be found depending on the distance above the plane that is given the most weight in finding the linear 'fit'. Using these intercepts a factor of between 3 and 7 can be calculated to convert from an exponential density law normalization of the thick disc to Sandage & Fouts' local value. Fig. 1 illustrates this point.

Also drawn on Fig. 1 (dot-dashed lines) are the density laws used in GR which have exponential scaleheights of 300 and 1350 pc for the thin and thick discs respectively. These have quite different exponential scaleheights to those of Sandage's density laws and this difference could also account for some of the difference between the normalization in GR and that of Sandage (1987). It should also be noted that the scaleheights quoted in Sandage (1987) for his density laws are $\exp(-1)$ folding lengths *counted from* $Z=0$, which is the curved part of the density law, and should therefore not be compared with scaleheights which are determined from purely exponential density laws such as in GR.

3 Observations

To test these ideas, Gilmore's galaxy model was altered to include Sandage's density laws and normalizations. This was then compared with star count data in the Hazard 8-Hour Field ($l=210°$, $b=35°$). These data are part of a proper motion survey in four fields and the plates have been measured using the APM at Cambridge. The plates used to provide the colour information were the blue and red Palomar Observatory Sky Survey plates, O62 and E62. The photometry was then calibrated using CCD data taken on the 1-m telescope at SAAO, Sutherland and the transformation between $(B–R)$ and $(B–V)$ was calculated using the stars in the Cousins E-region lists. This

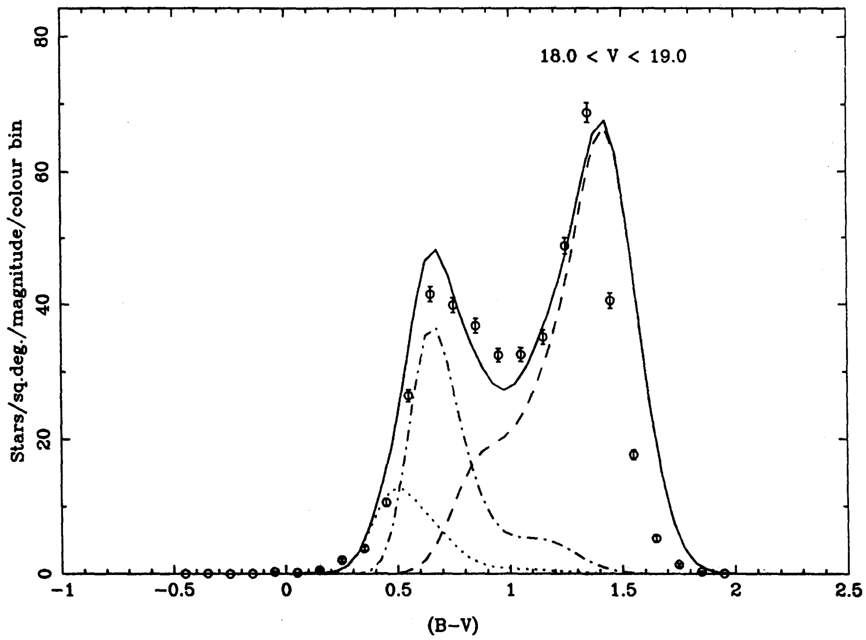

Figure 4. As Fig. 2 except the magnitude range is $18<V<19$.

transformation will only be approximate for the red stars (B–V>1.4) due to the difference between the E pass-band and the Kron–Cousins R pass-band which has an extended red tail.

Model 1 is the Gilmore–Reid model with exponential density laws and a thick disc normalization of 2 per cent. Model 2 has the Sandage derived density laws and a 10 per cent thick disc normalization. Both models are reasonably consistent with the data down to about $V=16$ mag. Figs 2 and 3 show these models in comparison with the star count data. Fainter than this and Model 2 becomes inconsistent with the data, whereas Model 1 shows a reasonable agreement (see Figs 4 and 5).

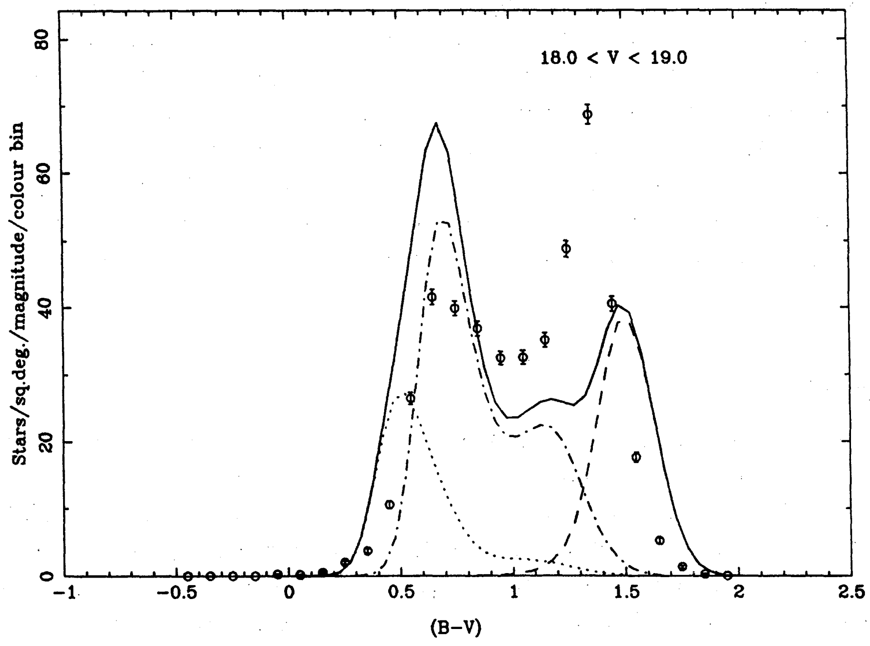

Figure 5. As Fig. 4, for Model 2.

4 Conclusions

Sandage's density laws (Sandage 1987) in combination with a thick disc normalization of 10 per cent are inconsistent with star count data in the Hazard 8-Hour Field. It is also shown that a *local* thick disc normalization of 10 per cent is compatible with GR's *exponential density law* normalization of 2 per cent. Considering the results in Sandage & Fouts (1987), it is probable that Sandage's density laws are incorrect, in that they overestimate the contribution of the thick disc a few kps from the plane.

Acknowledgments

I thank Dr Gerry Gilmore for useful discussions and the APM group, in particular Dr Mike Irwin, for assistance in measuring and processing the plates.

References

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