Abstract. Monte-Carlo simulations of optical and near-infrared colour-magnitude diagrams (CMDs) in Baade’s Window ($l=1\degree$, $b=-3\degree$) are compared with each other. The morphological structure of the red horizontal branch in those CMDs is likely due to a combination of extinction and age-metallicity of the stars from the bulge/bar. In contrast with the optical (V,I) passbands, the simulations indicate that it is feasible to separate metallicity from extinction with near-infrared data.

1. Introduction

Synthetic Hertzsprung-Russell Diagrams (HRDs) are generated through the population synthesis technique from a homogeneous library of stellar evolutionary tracks (Bertelli et al. 1994). Figure 1 shows a schematic diagram of the HRD-GST (see Ng 1994 and Ng et al. 1995 for details) which uses these diagrams as input for star counts studies. With the HRD-GST the contribution of various stellar populations are decomposed statistically. Through a detailed analysis of the star counts along the line of sight the aim of the study is to obtain constraints on

- the galactic structure;
- the interstellar extinction; and
- the age & metallicity of the different stellar populations.

The results obtained thus far have been reported in the Papers I–III (Ng et al. 1995 & 1996a and Bertelli et al. 1995) and Bertelli et al. (1996).

The distribution of stars along the line of sight is the result of a complex mixture of populations. The ages, metallicities and the spatial distributions of the stars from the various populations contain a wealth of information about the formation and evolution of our Galaxy.
2. Extinction vs Metallicity

Towards the galactic centre there is no consensus about the ages & metallicities of the stellar populations (disc, bulge, bar ...) and the parameterization of the galactic structure. The large variation of the extinction over a relative small area is one of the major causes. Mainly, because it is not easily parameterized. Therefore the CMDs of each field/region needs to be studied separately for its extinction along the line of sight.

In \((V,V-I)\) CMDs the effects of extinction and metallicity are difficult to separate from each other. Because the extinction vector points almost in the same direction as the metallicity gradient, if present, in the HB stars (see figure 1). The tilted clump of red HB stars could be caused by large differential extinction, a large metallicity spread of the HB stars or a combination of both (Catalan & de Freitas Pacheco 1996; Ortolani et al. 1990 & 1995; Ng et al. 1996a,b & c).

This might imply that there are no super-metal rich stars present towards the galactic centre. Patchy extinction might explain the various structures present in the \((V,V-I)\) CMDs. A study of the effects of various forms of extinction towards Baade’s Window (Ng & Bertelli 1996) shows that, if the extinction is not extremely high, patchy extinction will not give results significantly different from a Poissonian type of extinction. The morphology of the red HB stars in Baade’s Window cannot be explained solely by (patchy) extinction and a contribution due to metallicity ought to be taken into account.
3. Optical vs near-IR

Although unlikely, patchy extinction with very special conditions cannot be fully excluded. On the other hand, the near-IR passbands are less sensitive to extinction. The best strategy is probably to determine the extinction (if this is not too high and/or patchy) & the metallicity range of the stellar populations from the optical passbands and verify the results with near-IR photometry.

Baade’s Window is used as an example, because this field has been studied in detail by the OGLE collaboration (Udalski et al. 1993 and references cited therein). Furthermore detailed studies have been made of its CMD (Paczyński et al. 1994, Ng et al. 1996a) and of its extinction (Ng & Bertelli 1996a, Stanek 1996). From the study of the (V,V–I) CMD Ng et al. (1996a&b) found indications for the age-metallicity of the ‘bar’ population along the line of sight. It is not clear though how much the results in those studies are affected by under- or overestimating either the effect of extinction over the field or the metallicity range of the stars from various stellar populations.

Figure 2 shows the simulated (V,V–I) CMD for this window with the normalization reported in Paper III. Note however, that the blue HB stars ($V \approx 17^m$) are slightly too faint with respect to the observed CMD. This is likely due to the lower limit of the metallicity ($Z = 0.0004$) adopted in the current simulation. With an even lower value of the metallicity the blue HB stars will be slightly brighter. The blue edge of the red HB is due to stars with metallicity $Z = 0.003$, while the metallicity of the HB stars
at the red edge could be as high as $Z = 0.06$. The latter value might be considered as an upper limit for Baade’s Window. This figure demonstrates that the reddening vector in the $(V,V-I)$ CMD is indeed almost parallel to the direction in which the metallicity increases.

Figure 3 shows the $(J,J-K)$ CMD. The extinction is scaled from the visual with the ratios $A_\lambda/A_V$ given by Rieke & Lebofsky (1985). It demonstrates that in the near-IR the extinction and metallicity vector are not coupled anymore. The simulation indicates that a more detailed study of the extinction and the metallicity of the stars should be feasible with the DeNIS survey (Epchtein et al. 1993), taking into account the limiting magnitudes $J_{lim} \approx 16^{m}5$ and $K_{lim} \approx 14^{m}5$.

With near-infrared data it is possible to disentangle extinction from metallicity. A well constrained metallicity range would provide important clues about the star formation history of our Galaxy (Ng & Bertelli 1996b). Furthermore, it might provide indications about the presence or absence of super-metal rich stars, which could improve our understanding of the nature of the UV excess in elliptical galaxies (Bressan et al. 1994, Bertelli et al. 1996)

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