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MEASURING THE DISTANCES TO GALAXIES USING THE TIP OF THE RED GIANT BRANCH

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I. INTRODUCTION

Cepheids and RR Lyraes are the well-known primary distance indicators used since early. With an advent of the CCDs in astronomy, another distance indicator joins the primary distance indicator group. It is the tip of the red giant branch. The tip of the red giant branch (called as TRGB hereafter) seen in the color-magnitude diagrams of old stellar populations corresponds to the helium-flash stage in the evolution of low mass stars. It was recognized early by Baade and Sandage that the luminosity of the TRGB can be a potential distance indicator. The TRGB method had been sometimes used for estimating the distances to nearby galaxies since 1980's. However, the accuracy of the TRGB method had not been known until Lee et al. (1993) showed that the luminosity of the TRGB at I-band is an excellent distance indicator for resolved galaxies (Lee et al. 1993).

We present the most updated results based on TRGB method applied for a sample of resolved galaxies for which CCD photometry of the stars are available.

II. METHOD

The TRGB method is basically based on the fact that I luminosity of the TRGB of Pop II is almost constant at $M_I \approx -4.0$ mag for the metallicity range of [Fe/H]< -0.7 dex. Slight correction for the metallicity in determining the absolute I magnitude is applied using the method described in Lee et al (1993).

The I magnitude of the TRGB is measured from the luminosity function of the red giants with the help of the $I-(V-I)$ diagram using the eye estimate or the edge-detector as described in Lee et al. (1993).

III. RESULTS

Figure 1 shows the color-magnitude diagrams of a small sub-sample of the resolved galaxies in the entire sample. The position of the TRGB is clearly seen at the top of the red giant branch of Pop II in Figure 1.

Figure 2 displays the comparison of the distances based on the TRGB method, Cepheids, and RR Lyraes (Lee et al. 1993, Saha et al. 1994, Lee 1995a, b). It shows that there is an excellent agreement among three methods and that the accuracy of the TRGB method is comparable to Cepheids and RR Lyraes.

The TRGB method has several advantages in comparison with Cepheids and RR Lyraes:

- It requires much less telescope time than Cepheids and RR Lyraes.
- It suffers much less extinction problem than Cepheids.
- The luminosity of the TRGB is much brighter than RR Lyraes.

IV. CONCLUSION

In conclusion, the TRGB method is a very efficient and accurate distance indicator. Using the TRGB method, the distances to most galaxies within 3 Mpc can be determined easily from the ground observations. With Hubble Space Telescope observations, it is expected that the distances to the galaxies up to 10–20 Mpc can be estimated using this method.

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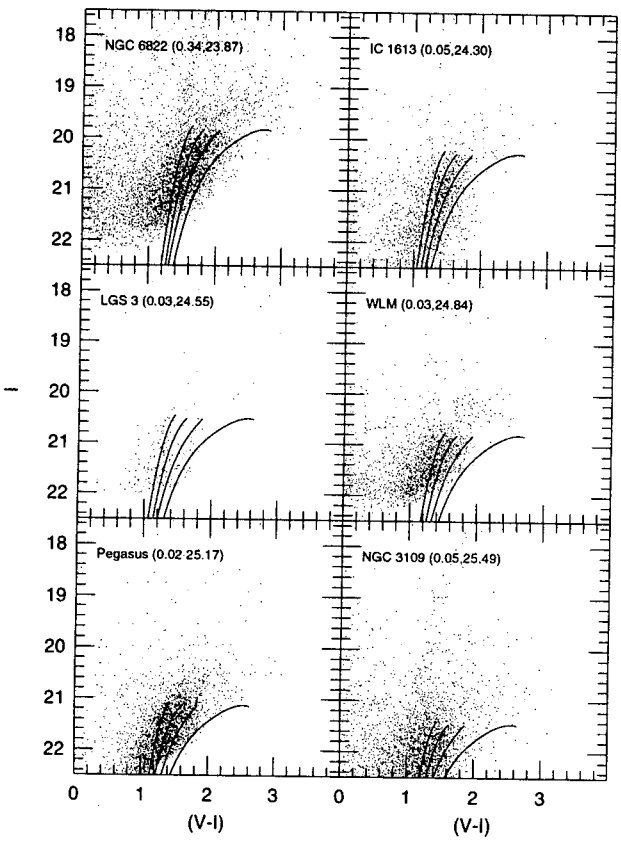

Fig. 1.— $I-(V-I)$ diagrams of the nearby resolved galaxies. The solid lines represent the empirical loci of the red giant branch of the Galactic globular clusters (M15, M2, NGC 1851, and 47 Tuc), shifted according to the reddening and distance of the galaxies (shown by the numbers in the parentheses).

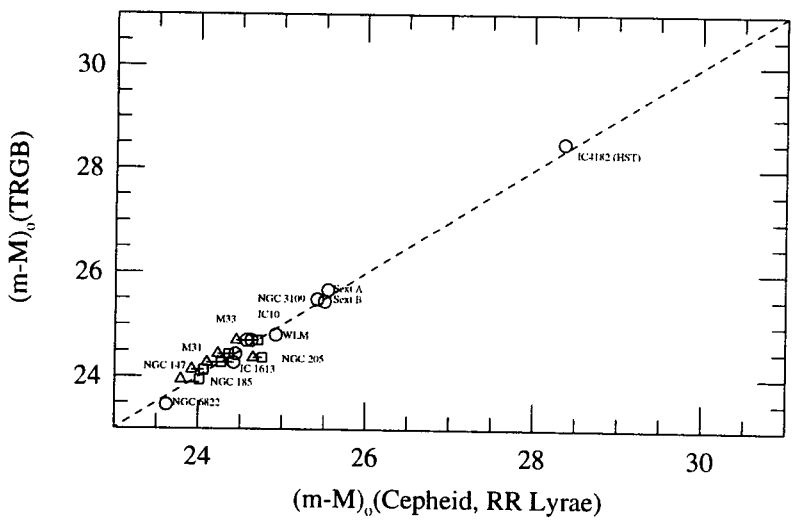

Fig. 2.— Comparison of distances to resolved galaxies based on the TRGB, Cepheids (open circles) or RR Lyrae (open triangles and squares). Note that the scatter about a line of unit slope is remarkably small, ± 0.1 mag. Note that the TRGB distances are based on only one or two epoch observations.