RR Lyrae in Front of the LMC: Implications for Microlensing


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Abstract. The recent suggestion that the microlensing events observed towards the Large Magellanic Cloud are due to an intervening Sgr-like dwarf galaxy is examined. A search for foreground RR Lyrae in the MACHO photometry database yields 20 stars whose distance distribution is not concentrated, and follows the expected halo density profile. Cepheid and red giant branch clump stars in the MACHO database are consistent with membership in the LMC. Since < 0.3% of the RR Lyrae and Cepheids are in the foreground, we conclude that the observed microlensing optical depth is not due to an intervening dwarf galaxy.

1. Search for a Foreground Dwarf Galaxy

Could the observed microlensing towards the LMC be due to an intervening dwarf galaxy? It is difficult to detect overlapping nearby galaxies, as proven by the recent discovery of the Sgr dwarf behind the MW bulge (Ibata et al. 1995). Good distance indicators, like RR Lyrae and Cepheid stars, are particularly useful to search for such structures along the line of sight. For example, we discovered RR Lyrae belonging to the Sgr dwarf in the MACHO bulge database (Alcock et al. 1997). Here we search the MACHO database for evidence of a dwarf galaxy in front of the LMC using RR Lyrae stars as tracers.

2. RR Lyrae and Cepheid Stars in the MACHO LMC Database

The RR Lyrae stars would be easily detected tracers of an intervening dwarf galaxy. Upon inspection of the data presented by Payne-Gaposchkin (1971), Zhao (1997) suggests that there are a few RR Lyrae clustered at 16 to 25 kpc, that may belong to such a dwarf galaxy. Spectroscopic followup of 8 stars by Connoly (1985) and Smith (1985) confirmed that 3 of them are not RR Lyrae, and that 5 of them are MW halo RR Lyrae stars and not LMC members. These 5 halo RR Lyrae have a velocity dispersion $\sigma_{\text{obs}} = 147 \text{ km s}^{-1}$, which is much higher than that expected for an dwarf galaxy (e.g., $\sigma_{\text{Sgr}} = 11 \text{ km s}^{-1}$).

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We have studied the line-of-sight distribution of the RR Lyrae stars in front of the LMC using the MACHO photometric database, which contains $5 \times 10^4$ suspected variable stars in the LMC bar region. We applied cuts in periods, amplitudes, magnitudes and colors to select candidate foreground RR Lyrae. These cuts are optimized to discriminate foreground RR Lyrae from LMC RR Lyrae, blends, or other variable stars. We find 16 RR ab with $A > 0.25$, $0.4 < P < 0.7$ days, $0.2 < V - R < 0.35$, and $V < 18$, and 4 RR c stars with $A > 0.25$, $0.2 < P < 0.4$ days, $0.1 < V - R < 0.25$, and $V < 18$.

The distribution in the sky of these RR Lyrae stars is uniform across the LMC. We also measure their individual distances (accurate to $\sim 10\%$) adopting $M_V = +0.4$ (Reid 1997). The magnitude distribution of the 20 foreground RR Lyrae in the direction of the LMC is plotted in the bottom panel of Fig. 1, showing that there is no significant concentration at any distance. In order to give a direct comparison with what would be expected if there were a dwarf galaxy in the foreground, we arbitrarily shift 0.5% of the LMC RR ab stars to a distance of 25 kpc. This distance is intermediate between the RR Lyrae overdensity suggested by Zhao (1997) at 16-25 kpc, and the 6% clump giant overdensity found by Zaritsky & Lin (1997) at 30-35 kpc. The top panel of Fig. 1 is not consistent with the observations.

Classical Cepheid variable stars are in general less numerous than RR Lyrae stars. However, since they arise from a different parent population (intermediate mass and age), we have also searched for a sequence of brighter Cepheids. The
distribution of about 1500 Cepheids in the 22 bar fields (Alcock et al. 1995) in
the period-magnitude diagram is consistent with membership in the LMC.

RR Lyrae and Cepheid stars represent rare stages of stellar evolution. Core
He-burning clump giants are much more numerous, since many low mass stars
evolve through this phase of evolution. We have constructed a MACHO color-
magnitude diagram for 9 million stars in the LMC bar region, which reveals many
low level features. The clump giants peak near $V - R = 0.45$ and $R = 18.6$. In
addition to clump-clump blends, an extra "bump" is seen near $V - R = 0.55$ and
$R = 17.7$. The redder color of this bump is inconsistent with these stars being
LMC-SMC clump giants located in a tidal stream. If they are clump giants,
they are likely of higher metallicity than the LMC clump giants. However,
the naturally occurring stellar populations of the LMC are the most plausible
explanation for the bump (Alves, 1998).

3. Results and Further Work

1) We found 16 RR Lyrae stars type ab, and 4 RR Lyrae stars type c with
$V < 18$ in front of the LMC.

2) These foreground RR Lyrae show a uniform distribution in the sky, and
are not concentrated along the line-of-sight. The distribution of these stars is
consistent with the density law of the Milky Way halo $\rho \propto R^{-3.5}$.

3) This sample represents 0.3% of the total number of LMC RR Lyrae stars
with similar colors in these fields. This fraction cannot account for the total
microlensing optical depth observed towards the LMC.

4) There is no evidence for a Sgr-like dwarf galaxy in front of the LMC from the
RR Lyrae or Cepheid stars found in the MACHO database.

Further work we will pursue includes a detailed modeling of the RGB clump,
a search for foreground RR Lyrae and Cepheids towards the SMC, and a search
for foreground eclipsing binaries towards the LMC and SMC.

Acknowledgments. This paper is dedicated to the memory of our col-
league Alex Rodgers (1932-1997), who was a pioneer of RR Lyrae and halo
studies, and one of the fathers of the MACHO project.

References

Smith, H. A. 1985, PASP, 97, 1053