The Inner Milky Way Structure with VVV

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Overview

• Red Clump stars as distance indicators
  – Dependence on age and metallicity
• Tracing the bar with RC stars in VVV
• Inner bar flattening and the bar orientation
• The structure behind the bar

• Based on work published in:
Horizontal Branch Stars: Observations and Theory

...(text continues with scientific discussion and references)...
Red Clump in nearby galaxies in near-IR

![Graph showing red clump in different galaxies](Image)

Pietrzynski, Gieren & Udalski 2003

Gonzalez et al. 2011

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...observed in each galaxy (see Table 1). We did this by selecting red clump stars found in our four fields in Fornax (see Table 2). The VLT is identical, which obviously helped us to obtain very homogenous data for all four galaxies discussed. The NTT observing nights were better than 0.03 mag. It is worth mentioning that the data obtained for the Fornax and Carina dwarf Magellanic Cloud data were performed in the same manner as for the data obtained for the Fornax and Carina dwarf galaxies. Basic information on the data is given in Table 1.

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...extinction $E(B-V)$ of that region can be related to that of Baade's Window by the following equation:

$$E(B-V) = 0.55$$

...the diurnal reddening values according to that of a reference field with known extinction. In order to obtain the properties of a reference RC CMD for a 20x20 arcmin region using the final catalog for field after refer to the usual J,H,Ks magnitudes corresponding to the points were used for all the analysis. For this reason, we here correct or saturation and calibrated to 2MASS zero magnitude. This procedure was carried on independently the diurnal magnitude of $K$-band magnitudes indicated by larger errors in the photometry or saturation. This procedure was carried on independently the diurnal magnitude of $K$-band magnitudes indicated by larger errors in the photometry or saturation.
Distance determination: recipe

1. Extinction correction – select the reddening law
   - Nishiyama et al. 2009: \( A_K = 0.528 \times [(J-K_s)_0 - (J-K_s)] \)
   - Mean intrinsic color for RC in Baade’s Window: \((J-K_s)_0 = 0.68\)
2. Make a luminosity function and fit it with a 2nd order polynomial (underlying RGB) + a Gaussian (RC)

\[
N(K_{s0}) = a + bK_{s0} + cK_{s0}^2 + \frac{N_{RC}}{\sigma_{RC}\sqrt{2\pi}} \exp \left[ \frac{(K_{s0}^{RC} - K_{s0})^2}{2\sigma_{RC}^2} \right]
\]

3. The peak of the Gaussian is the \( m(\text{RC}) \)
4. Distance modulus: \((m - M)_{0,\text{target}} = m_{K}^{RC} - M_{K}^{RC} - A_K\)

\(M_{K}^{RC}\) – RC zero point
\(\Delta M_{K}^{RC}\) – population correction with respect to population used to establish the zero point \(M_{\odot}^{RC}\)
Red Clump magnitude variation as a function of longitude at b=+1, -1 deg

Stars are closer to us at positive longitude

Gonzalez et al. 2011, A&A Lett
K-band RC magnitude

Alves 2000; Alves et al. 2002 – 2MASS & CIO + Hipparcos (Solar Neighb.)
Grocholski & Sarajedini 2002 – WIYN Open clusters
Pietrzynski et al. 2003 – LMC, SMC, Fornax, Carina (Araucaria project)
Salaris & Girardi 2002 – population effects (theoretical)
Percival & Salaris 2003 – population effects (empirical + models)
Laney et al. 2012 – SAAO + Hipparcos (Solar Neighbourhood)

Oscar’s Bulge metallicity map

\( M_K = -1.55 \) (solar metallicity, 10 Gyr old isochrone: Pietrinferni et al. 2004)
From RC distances to structure

Gonzalez et al. 2011, A&A Lett
Inner bar flattening

Model: Martinez-Valpuesta & Gerhard 2011
Gerhard & Martinez-Valpuesta 2012
And below the plane...

At $b=-5$, $\sim 750$ pc below the plane the bar flattens much less

Gerhard & Martinez-Valpuesta 2012

Gonzalez et al. 2012, submitted
Still some head scratching ...

Tile: b255  l = 8, b=-6.5
Second clump ~2.5 kpc behind the bar and ~1kpc below the plane!
Summary

• VVV depth and resolution provides ideal dataset for inner Bulge structure studies
• RC, eclipsing binaries, RR Lyr → tracing different components?
• Complexity:
  – patchy extinction (BEAM calculator)
  – Mix of populations – bar/bulge, thin disk and spiral arms, thick disk?
  – Comparison with models