Reddening-Free Indices for the **VISTA Filter System**

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The X-Shaped Galactic Bulge

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Using RC distances thus derived, and taking into account the change in extinction law for |b| < 1, the VVV *JHK*_S photometry was used to infer the detailed structure of the Galactic bulge. Our bulge's X-shaped structure (McWilliam & Zoccali 2010) is thus confirmed, as shown in Figs. 4-6 (Saito et al. 2011).

l~−0.5 (tiles b207−389)

Introduction

Reddening-Free Indices

Even in the near-IR, extinction levels can be very significant, particularly towards the inner and very obscured regions of the Milky Way. Here we present a series of reddening-free indices (Catelan et al. 2011), derived specifically in the VISTA ZYJHK_S system, along with some first applications.

The VISTA Filter System



This leads to the following set of reddening-free indices (Catelan et al. 2011):

$m_1 = K_S - 1.08(Z - Y)$	$c_1 = (Y - J) - 1.14(J - H)$
$m_2 = H - 1.13 \left(J - K_S \right)$	$c_2 = (Z - Y) - 0.99(Y - J)$
$m_3 = J - 1.03 \left(Y - K_S \right)$	$c_3 = (J - H) - 1.47(H - K_S)$
$m_4 = K_s - 1.22(J - H)$	$c_4 = (J - K_S) - 1.50(Z - Y)$

Towards the Galactic center, the coefficients change somewhat. In particular,



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$$\begin{pmatrix} 0 \\ g^{o}p \\ -5 \\ -10 \end{pmatrix}$$

Fig 4. Density map for $\ell \sim 0.5$ (tiles b207-389) showing the structures traced by RC stars in the (X, b) plane, based on $(m-M)_4$. A cross marks the Galactic center ($R_{GC} = 8$ kpc); the Sun is at (X, b) = (0,0). The color scale has been normalized in each horizontal strip. The lower part of an X-shaped structure is clearly seen at b < 0.

 $b \sim -1.0$ (tiles b 313 - 326)







Relative Extinctions

- Standard extinction law from Cardelli et al. (1989), with R = 3.09 (Rieke & Lebofsky 1985).
- Near-IR extinction law for the central regions of the Galaxy





Fig 5. Density map showing the structures traced by the RC stars near the Galactic plane (i.e. as seen from above, $b \sim -1.0$, tiles b313-326), based on $(m-M)_4$. Individual lines of sight, at a given longitude, are represented by vertical strips. The cross marks the Galactic center, assuming $R_{GC} = 8$ kpc.

 $b \sim -1.0$ (tiles b 313 - 326)



Fig 6. As in Fig. 5, but normalized in each

from Nishiyama et al. (2009; see also Schödel et al. 2010).

Filter	λ _{eff} (μm)	A _X /A _{Ks} (standard)	A _x /A _{Ks} (Gal. center)
Ζ	0.878	4.23	
Y	1.021	3.31	
J	1.254	2.37	3.02 ± 0.04
Н	1.646	1.56	1.73 ± 0.03
K _s	2.149	1.00	1.00

0	0.5	1	G.1	<i>C</i>	-0.2	0	0.2	0.4	0.0	0.0	
		$(J-K_s)$						m4			

Fig 3. Original (*left*) and reddening-free (*right*) CMDs for VVV area #09, corresponding to 15 tiles covering $-2.75 < \ell < -10.07$, -4.70 < b < -1.32, with 12 M stars.

Distances

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The reddening-free pseudomagnitudes m_i are especially useful to derive distances, since (Saito et al. 2011):

$$m-M\big)_{i=1\ldots 4}=\big(m-M\big)_0$$

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vertical strip, as in Fig. 4.

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In the case of red clump (RC) stars, $M_4 = M_{K_S} - (J-H)_0$ can be computed on the basis of a combination of models (e.g., Salaris & Girardi 2002) and empirical calibrations (Cox 2000).