Searching for the Galactic Bar with Near- and Mid-Infrared

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Abstract

Bars have an important role in the galaxy evolution and structure. It has long been known that the Milky Way has a long bar. However, authors have given different values for the structural parameters such as position angle, half length. In this study, we investigate the structure of the Galactic bar using the red clump giants (RCGs) with 2MASS and *WISE* photometries. In order to separate the RCGs in the direction of the Galactic bar, we used the Galaxia model and calculated the extinctions and distances of the RCGs in each star field. We computed the half length and the position angle of the bar using Markov Chain Monte Carlo simulation 4.1±0.1 kpc and 39.4±0.8 degrees, respectively.

Data

The RCGs used for the calculation of the structural parameters of the bar are taken from the *WISE* catalogue [1]. The catalogue has not only the *WISE* data, but also the 2MASS data. 2MASS provides J, H, K_S data in the near-infrared, while *WISE* has $W1$, $W2$, $W3$, and $W4$ data in the mid-infrared. We used the data of near plane fields in the inner Galaxy ($27 \geq l$ (deg) ≥ -8, $5 \geq b$ (deg) ≥ -5).

Separation of the RCGs

We used the extinction law in [2] to separate the RCGs from the ($W1$, $J-W1$) plane:

$$\rho(R,z) = \frac{\rho_0}{k_{fl}} \times \exp\left[\frac{R_0 - R}{h_R} - \frac{z - z_w}{k_{fl} h_z}\right], \quad (1)$$

where $\rho(R,z)$ is the dust density in terms of distance and Galactic coordinates, $R_0 = 8$ kpc, h_R (4.2 kpc) and h_z (88 pc) are the scale-length and the scale-height of the dust, $\rho_0 = 0.54$ mag kpc^{-1}, and k_{fl} and z_w describe the flaring and warping of the gas, respectively [2]. The extinction can be evaluated by the following equation:

$$E_r(B-V) = E_\infty(B-V) \times \frac{\int_0^r \rho(s)ds}{\int_0^\infty \rho(s)ds}, \quad (2)$$

where $E(B-V)$ is colour excess. By using the estimated extinction and $M_{W1} = -1.635 \pm 0.026$ mag [3], the most probable RCGs in the CMD were found.

References

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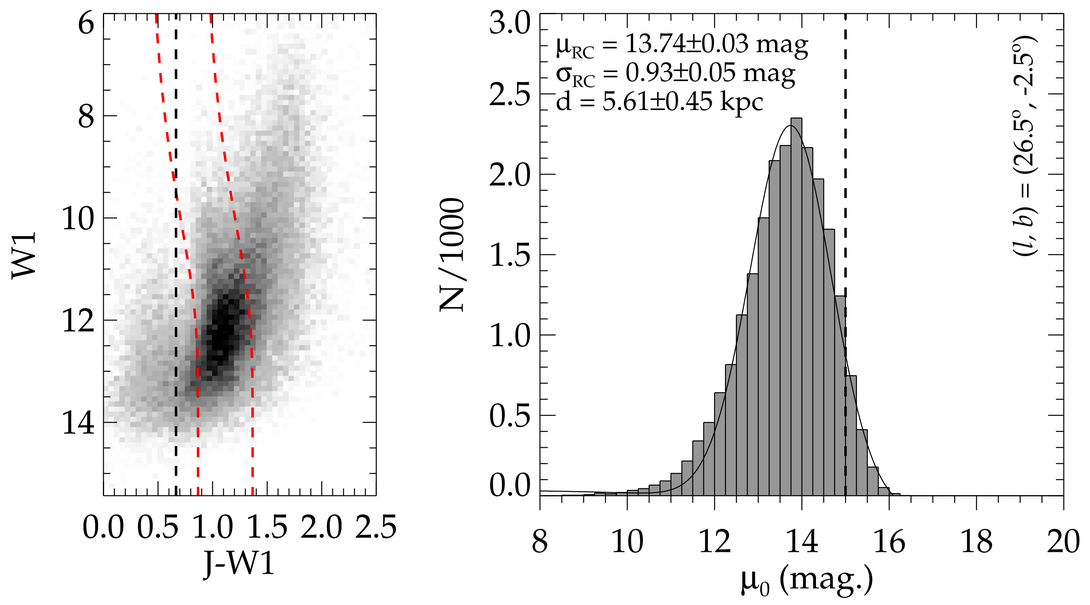
Acknowledgements

This study has been supported by the Scientific and Technological Research Council (TÜBİTAK) 112T120. This research has made use of NASA's Astrophysics Data System Bibliographic Services, the VizieR catalogue access tool, CDS, Strasbourg, France and NASA/IPAC Infrared Science Archive and Extragalactic Database (NED), which are operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Distances of the RCGs

The red clump giants (RCGs) are evolved stars that burn helium in their cores. They are located in a discrete place relative to the main-sequence stars in the H-R diagram. Since these stars have a small scattering of their luminosity function, they have been used as a standard candle which allows to calculate the distances of the stars accurately. As shown in the following figure on the left, the RCGs are separated using the Galaxia model. The model predicts that the most probable RCGs are located between the two dashed red lines. The true colour of the RCGs is also indicated in the figure as the black dashed line which is $(J-W1)_0 = 0.665$ [3]. On the right, the distance module distribution of the selected RCGs is plotted. The vertical dashed line denotes the completeness limit of the data.



Results

We calculated the distances of the RCGs for each direction and plotted the distance distribution below. In this figure, filled circles and filled squares represent the bar and the bulge, respectively. The open diamond symbols shows the directions that have no reliable distance determination due to incompleteness effect. In order to estimate the structural parameters of the bar and the bulge, we used Markov Chain Monte Carlo simulation. The simulation results are given in the lower panels as histogram plots. Half lengths of the bar and the bulge are 4.1 ± 0.1 kpc and 3.0 ± 0.2 kpc, respectively. Position angles of the bar and the bulge are found to be $\phi = 39.^\circ4 \pm 0.^\circ8$ and $\phi = 27.^\circ3 \pm 2.^\circ7$, respectively.