Boletim da Sociedade Astronômica Brasileira, **36**, no. 1, 135-136

Determination of the intersterllar medium components towards the Open Cluster UFMG 4

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Abstract. The determination of the astrophysical parameters of open clusters requires improved knowledge of the interstellar reddening towards the cluster. The goal of this work is two-folded: (*i*) determine the structural parameters of the Open Cluster UFMG 4 using Gaia DR3 data; (*ii*) investigate the interstellar medium components in its direction, specially the dark cloud obscuring it. The method involves isochrone fitting using decontaminated color-magnitude diagrams and analysis of Color Excess vs. Distance Diagrams. The cluster revised parameters are ($E(B-V)$, $(m-M)_o$, $[Fe/H]$ (dex), $log(t)$, r_c, r_t) = (1,50 ± 0,03, 10,90 ± 0,3 , 0.0152 ± 0,010, 8,65 ± 0,05, 134 ± 14 , 927 ± 134). Three interstellar components have been identified: (a) starting at 280pc, with $E(b-y)$ increasing from 0.08 to 0.22 mag, maybe related to the backside of the Loop I Bubble; (b) the second at (800 ± 100) pc with $E(b-y)$ from 0.35 to 0.60 mag; the last one at (1150 ±50 pc) and $E(b-y)$ = 0.60 to 1.44 mag, identified as the cloud screening UFMG 4.

Resumo. A determinação dos parâmetros astrofísicos de aglomerados abertos requer um conhecimento das componentes do meio interestelar ao longo de sua direção. As metas deste trabalho são: (*i*) determinar os parâmetros estruturais do aglomerado aberto UFMG 4 usando dados do Gaia DR3; (*ii*) investigar as componentes do meio interestelar em sua direção, especialmente a nuvem que o obscurece. O método envolve o ajuste de isócronas em diagramas cor-magnitude descontaminados e análise de diagramas de excesso de cor por distância. Os parâmetros revisados são:($E(B-V)$, $(m-M)_o$, $[Fe/H]$ (dex), $log(t)$, r_c, r_t) = (1,50 ± 0,03, 10,90 ± 0,3 , 0.0152 ± 0,010, 8,65 ± 0,05, 134 ± 14 , 927 ± 134). Três componentes interestelares foram identificadas: (a) iniciando em 280pc e $E(b-y)$ de 0.08 a 0.22 mag, talvez devido ao fundo da Bolha Loop I; (b) outra em (800 ± 100) pc com $E(b-y)$ de 0.35 até 0.60 mag; a última em (1150 ± 50 pc) e $E(b-y)$ = 0.60 to 1.44 mag, identificada como a nuvem em frente de UFMG 4.

Keywords. (Galaxy:) open clusters and associations: individual: UFMG4 – Galaxies: ISM – (Galaxy:) open clusters and associations: general – ISM: bubbles – ISM: clouds – (ISM:) dust, extinction

1. Introduction

The unprecedent quality of the astrometric data of the Gaia mission has allowed to identify open clusters hindered by very dense dark clouds in the Galactic Plane (Ferreira et al. 2019, 2020, 2021). In this sense, to precisely determine the astrophysical parameters of clusters requires improved knowledge of the interstellar reddening towards the cluster.

The goal of this work is two-folded: (*i*) determine the structural parameters of the Open Cluster UFMG 4 using Gaia DR3 data (Eyer et al. 2023) ; (*ii*) investigate the interstellar medium (ISM) components in its direction, specially the dark cloud obscuring it. The cluster coordinates are (RA, DEC) = (18h11m58.32s; -22d58'51.6"), that corresponds to the Galactic coordinates (l, b) =(8.116°; -2.157°) (Ferreira et al. 2020).

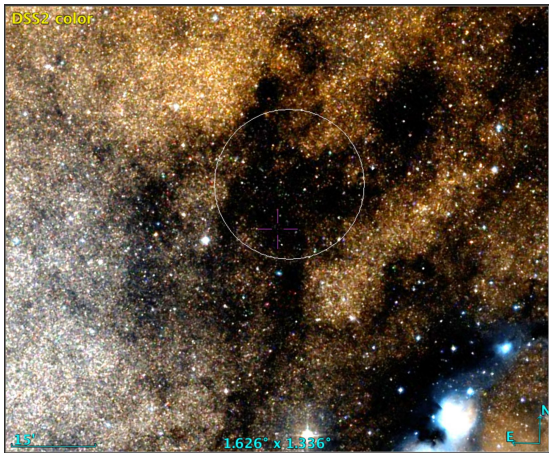

Figure 1. UFMG4 (white circle) in the DSS2 image. The cluster coordinates are (RA, DEC) = (18h11m58.32s; -22d58'51.6"), that corresponds to the Galactic coordinates (l, b) =(8.116°; -2.157°)

2. Methodology

The applied method involves: (1) Astrometric decontamination of the Color-Magnitude Diagram (CMD) through the to determine the cluster's membership Angelo et al. (2019); Ferreira et al. (2019); (2) Isochrone fitting to obtain distance, age ($\log(t)$), metallicity ($[Fe/H]$) and interstellar redenning ($E(B-V)$) (Ferreira et al. 2020, 2021). (3) King Profile fitting to determine core and tidal radii. (4) Analysis of the color excess $E(b-y)$ vs. Distance Diagrams and the reddening spatial maps. A sud-

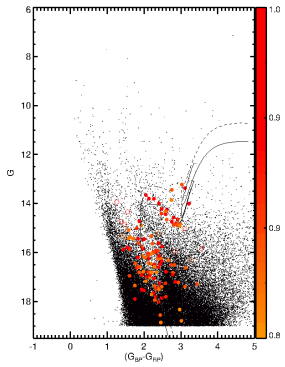

Figure 2. CMD of UFMG4 representing probability od membership and determination of isocrone using data from Gaia DR3

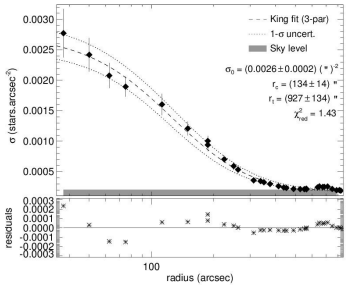

Figure 3. King fit (3 parameters) for UFMG4, using data from Gaia DR3

Table 1. Astrophysical parameters of the cluster **UFMG4**

$E(B-V)$	$(m-M)_o$	$[Fe/H]$	$\log t$
(mag)	(mag)	(dex)	(t/ano)
1,50 ± 0,03	10,90 ± 0,3	0.0152 ± 0,010	8,65 ± 0,05
Distance (pc)	r_c (arcmin)	r_t (arcmin)	
1995 ± 100	134 ± 14	927 ± 134	

den increase in the color excess at certain distance indicates the location of the interstellar cloud (Corradi et al. 1997; Reis & Corradi 2008).

3. Key Results

The structural parameters analysis has made use of GAIA DR3 (Eyer et al. 2023). Figure 2 shows the astrometrically decontaminated CMD, superimposed with the results of the isochrone fitting with metallicity 0.152 dex.

The core and tidal radii have been obtained through a King Profile fit, as shown in Fig. 3. The resulting cluster parameters are given in Tab. 1.

To investigate the cloud in front of UFMG 4 the distances and absorpions were taken from Starhorse2 (Anders 2022). To obtain the Strömgren $E(b-y)$ Colour Excess, the relation of Crawford & Mandewewala (1976) $E(b-y) = A_V/4.3$ has been used. The data covered a radius of 30 arcmin with the exclusion criteria applied: Distance $\leq$ 2 kpc, the flags Fidelity $>$ 0.5 and FlagOut $<$ 1. One must notice that $E(b-y) = 0.70 \times E(B-V)$.

The spatial reddening maps (Figure 4) to regions with and without the clouds allow us to identify that. The color excess $E(b-y)$ vs. Distance Diagrams and the reddening spatial maps can be seen in Figure 5. For comparison, the same diagram is shown for a region without the cloud.

Towards UFMG4 it can be noticed that from 280pc the $E(b-y)$ reaches values of 0.05-0.10 mag. According to Reis & Corradi (2008); Reis et al. (2011); Santos et al. (2011); Corradi et al. (2004) this corresponds to interface of the Local and Loop I bubbles. A slight increase in $E(b-y)$, up to 0.20 mag, is believed to be the backside of the Loop I Bubble, consistent with Pelgrims et al. (2020).

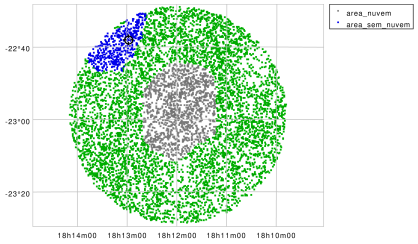

Figure 4. Skymap of the areas around UFMG4 being analysed

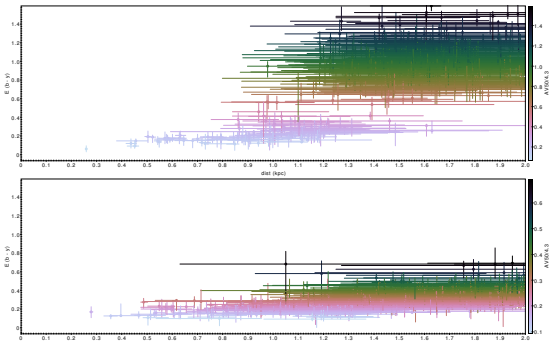

Figure 5. The Color Excess $E(b-y)$ vs. Distance Diagram

Another two abrupt changes in the color excess occur at the distances of (800 ± 100) pc, where $E(b-y)$ goes from 0.2 to 0.4 mag, and at (1150 ± 50) pc where $E(b-y)$ goes from 0.6 up to 1.4 mag. For comparison, in the area free of dust clouds, the $E(b-y)$ levels remains low up to at least 1.2 kpc. The component at (800 ± 100) indicated a more diffuse component, while the one at (1150 ± 50) pc can be identified as the cloud in front of UFMG 4.

4. Conclusion

The reddening obtained by isochrone fitting and through colour excess vs. distance diagrams are consistent with each other. In the near future polarimetric data collected at OPD/LNA will help to refine these findings.

Acknowledgements. The authors wish to acknowledge the support from CNPQ, CAPES, UFRJ, CEFET-MG, FAPEMIG, FAPERJ and LNA.

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