Boletim da Sociedade Astronômica Brasileira, **35**, no. 1, 141-142


# Analysis and characterization of the open clusters UFMG 100 and NGC 2360

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**Abstract.** The present work aims to study the open star clusters NGC 2360 and UFMG 100, as well as a possible cluster UFMG101. We have applied the methods for determining structural parameters by Ferreira et al. (2019; 2020) and astrometric decontamination by Angelo et al. (2019). Using GAIA EDR3 data, we have obtained structural parameters for UFMG 100: (RA, DEC) = (109.906°; -15.931°), limiting radius $R_{lim}$ = 700 arcsec, proper motion ($\mu_\alpha$, $\mu_\delta$)= (-2.625; 3.025) mas/year and parallax $\varpi$ = 0.276 mas. With the isochrone fitting, we have obtained color excess $E(B-V)$ = 0.02 mag, distance modulus $(m-M)_o$= 11.4, corresponding to a distance $d$ = 1852 pc, and $\log[t(years)]$ = 8.80, which corresponds to (0.63 Gyr). Furthermore, a King profile fitting was performed, in which the core radius and central density were determined as $r_c$ = 500 arcsec and $\sigma_0$ = 0.00008 $arcsec^{-2}$, respectively. Analyzing the cluster region, the presence of a possible cluster in the area has been noticed, provisionally named UFMG101. Its preliminary structural parameters are: (RA, DEC) = (109.615°; -15.654°), $R_{lim}$ = 400 arcsec, ($\mu_\alpha$, $\mu_\delta$)= (-1.223; 2.375) mas/year and $\varpi$ = 0.143 mas.

**Resumo.** O presente trabalho se propõe a estudar os aglomerados estelares abertos NGC 2360 e UFMG 100 e um possível aglomerado UFMG101. Aplicando os métodos de determinação de parâmetros estruturais de Ferreira et al. (2019;2020) e de descontaminação astrométrica de Angelo et al. (2019). Utilizando os dados do GAIA EDR3, obtivemos parâmetros estruturais para UFMG 100: coordenadas equatoriais (RA, DEC) = (109,906°;- 15,931°) , raio limite $R_{lim}$ = 700 arcsec, movimento próprio ($\mu_\alpha$, $\mu_\delta$)= (-2,625; 3,025) mas/ano, paralaxe $\varpi$ = 0,2755 mas. Com o ajuste de isócronas obtivemos excesso de cor $E(B-V) = 0,02$ mag, módulo de distância $(m-M)_o$= 11,4, que correspondem a distância $d$ = 1852 pc e $\log[t(anos)]$ = 8,80 o que corresponde a (0,63 Ganos). Ademais, foi realizado um ajuste do perfil de King, no qual foram determinados os parâmetros raio do core e densidade central, respectivamente, $r_c$ = 500 arcsec e $\sigma_0$ = 0.00008 $arcsec^{-2}$.Analisando a região dos aglomerados, nota-se a presença de um possível aglomerado na região, provisoriamente denominado UFMG101. Os parâmetros estruturais preliminares são: (RA, DEC) = (109,615°;-15,654°), $R_{lim}$ = 400 arcsec, ($\mu_\alpha$, $\mu_\delta$)= (-1,223; 2,375) mas/ano e $\varpi$ = 0,143 mas.

**Keywords.** (Galaxy:) open clusters and associations: individual: NGC 2360 – (Galaxy:) open clusters and associations: individual: UFMG 100 – (Galaxy:) open clusters and associations: general

## 1. Introduction

Star clusters are groups of stars that are gravitationally connected and born from the same molecular cloud. That is, these stars have similar distance, proper motion, age and chemical composition. The determination of its astrophysical parameters allows us to better understand the star formation and the stellar evolution, as well as the structure and evolution of our Galaxy. While attempting the characterize the open cluster NGC5999 using parallax and proper motion data from GAIA DR2, Ferreira et al. (2019) have discovered the clusters UFMG 1, UFMG 2 e UFMG 3 and, in the sequence other 69 new objects in 2020 and 2021 (Ferreira et al., 2020 and 2021). Also, it has been discovered a possible open cluster, UFMG 100, in the area of NGC 2360.

## 2. Research Goals

Study the Open Clusters UFMG 100 and NGC 2360 by applying methods of structural parameters determination and astrometric Colour-Magnitude Diagram (CMD) decontamination

## 3. Methodology

The analysis has made use of GAIA DR3 data (Eyer, L., Audard, 2023). The applied method is composed of the following steps:

- Visual analysis of the CMD and the GAIA astrometric and photometric data. Through it we have generated diagrams that allow to visually extract preliminary astrometric parameters;
- Determination of precise structural and astrometric parameters of the clusters, by aplying the method developed by our group as described in Ferreira et al (2019, 2020). In this method one looks for the maximum central density of the profile in order to determine these parameters (Ferreira et al., 2019).
- Establishment of the membership probabilities to be used in conjunction with the isochrone fitting to determine the age, metallicity, distance modulus and reddening. The astrometric decontamination method developed by our group (Angelo et.al 2019) has been applied.
- Determination of the tidal and core radius of UFMG 100

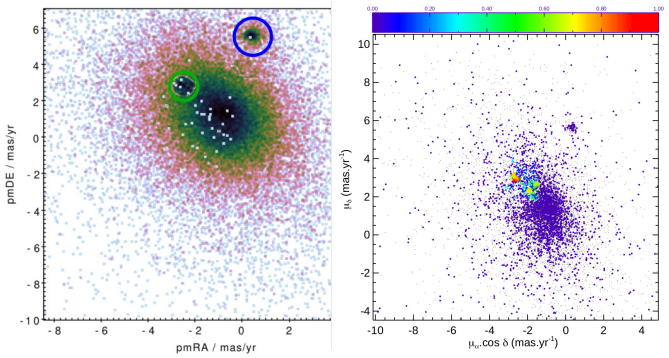


**Figure 1.** (left) VPD containing NGC 2360 and UFMG 100. (right) Expanded UFMG 100 VPD with membership indicated

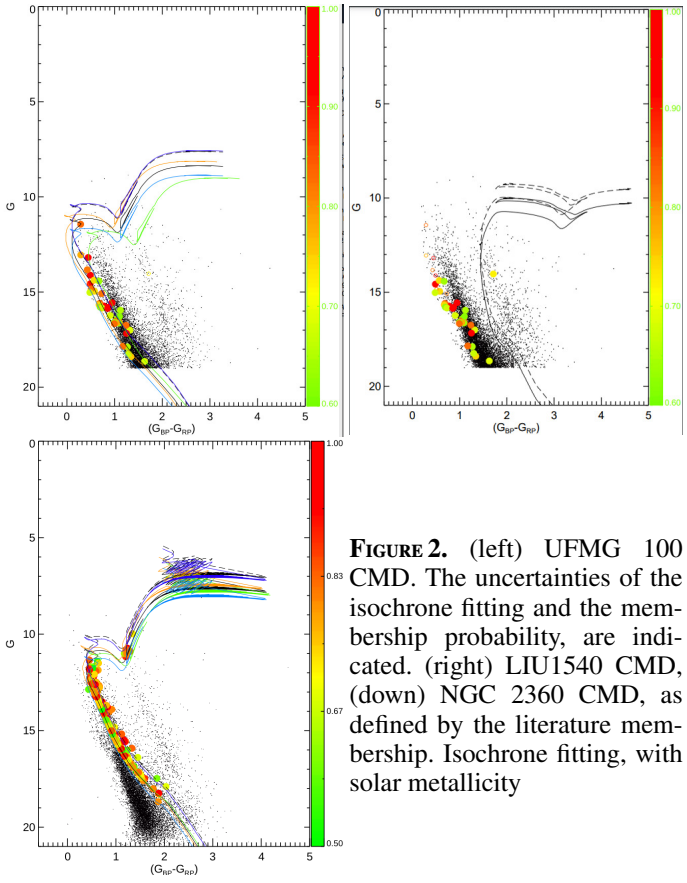


**Figure 2.** (left) UFMG 100 CMD. The uncertainties of the isochrone fitting and the membership probability, are indicated. (right) LIU1540 CMD, (down) NGC 2360 CMD, as defined by the literature membership. Isochrone fitting, with solar metallicity

## 4. Key Results

The VPD of UFMG 100 can be seen in Figure 1.

Isochrone fitting, with solar metallicity has been performed to determine the cluster parameters as shown in Figure 2. The data from Liu et. al (2022) (Table 1) are shown in Figure 2.

After, the King Profile (3 parameters) fitting has been made to determine the tidal and core radius, as can be seen in Figure 3.

Since the radii found were bigger than expected for a cluster in such position, a comparison of the parallax and the dispersion in proper motion with other clusters has been made, to see if the cluster follows the general tendencies (Figure 4).

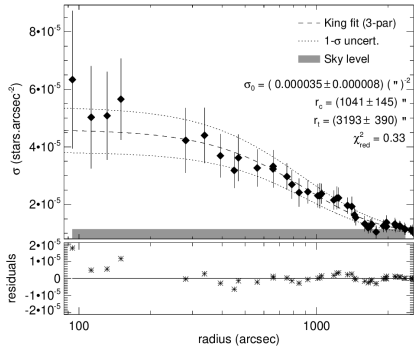


**Figure 3.** King Profile fitting (3 parameters) for UFMG 100

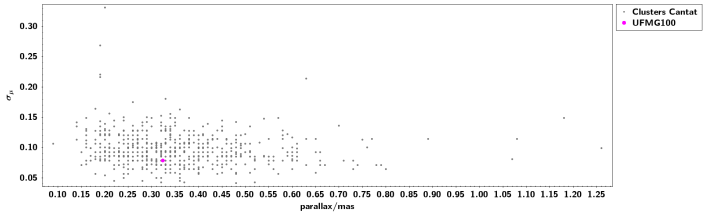


**Figure 4.** Parallax and dispersion in proper motion for UFMG 100, as compared to other clusters

**Table 1.** Structural and Astrophysical parameters of the clusters NGC 2360 and UFMG 100

| Cluster | RA(°) | DE(°) | $R_{lim}$(") | PMRA (mas/yr) | PMDE (mas/yr) | PLX (mas) |
|---|---|---|---|---|---|---|
| NGC 2360 | 109,441 | -15,626 | 950 | 0,390 | 5,590 | 0,9072 |
| UFMG 100 | 109,906 | - 15,931 | 550 | -2,625 | 3,025 | 0,276 |
| | $E(B-V)$ (mag) | $(m-M)_o$ | d (pc) | logt | | |
| NGC 2360(Lit) | 0,08 ± 0,03 | 9,96 ± 5,6 | 982 ± 132 | 8,95 ± 0,05 | | |
| NGC 2360(Work) | 0,08 ± 0,06 | $10,1^{+0.4}_{-0.6}$ | $934^{+242}_{-225}$ | 9,00 ± 0,05 | | |
| UFMG 100 | $0,02^{+0.25}_{-0.09}$ | $11,4^{+0.5}_{-0.8}$ | $1852^{+479}_{-571}$ | 8,80 ± 0,05 | | |
| LIU1540 | 1,25 ± 0,05 | 12,35 ± 0,05 | 5248 ± 122 | 7,60 ± 0,05 | | |

## 5. Conclusions

Table 1 summarizes the structural and astrophysical parameters of the clusters. The results obtained for NGC 2360 are consistent with the literature and have similar precision, validating the applied methodology . Also, it has been possible to conclude that the candidate, UFMG 100, really consists of a cluster. However, searching the literature we have found that the cluster Liu 1540, which has just been reported (Liu et. al, 2022) has similar parameters ($\varpi$ = 0.313 ± 0.029 mas, $\mu_\alpha$ = -2.616 ± 0.066, $\mu_\delta$= 2.935 ± 0.069 mas/yr). This fact leads us to the conclusion that the discovery was simultaneous, although they, published it first. However, our results allowed us to better characterize the cluster.

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

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