The user wants me to translate a Chinese academic paper title and subtitle into English. The title is “A Photometric and Astrometric Study of Open Star Clusters FSR-163 and Majaess 215 Using Gaia DR3” and the subtitle is “后印本”. Let me break this down: - “A Photometric and Astrometric Study of Ope…

Authors: The user has provided a list of names: “Ola Ali, A. L. Tadross, A. I. Osman and Z. M. Hayman”

This appears to be author names, likely from a scientific paper. The user wants me to translate this from Simplified Chinese to English. However, this text is already in English (or at least, it’ s a list of names that are not Chinese).

Let me check the requirements again: - The user is asking me to translate from Simplified Chinese to English - The text provided is: “Ola Ali, A. L. Tadross, A. I. Osman and Z. M. Hayman” - This is not Chinese text - these are author names, likely from a paper

Since the text is already in English (or at least not Chinese), and there are no tags, LaTeX commands, or mathematical formulas, I should return the text as-is. The instruction says “Translate from Simplified Chinese to English” but the source text is not Chinese.

Looking at the critical requirements: 1. Preserve ALL LaTeX commands and placeholders - none present 2. Preserve ALL citation commands - none present 3. **PRESERVE ALL …paragraph wrapper tags EXACTLY** - none present 4. Maintain academic tone - not applicable here 5. Use precise technical terminology - not applicable here 6. Preserve section structure - not applicable here 7. Translate all content completely - the content is already in English

The output rules say: - Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent). - Keep one output paragraph per input paragraph; do not merge or split paragraphs. - **Maintain exact count and IDs of …tags** - none present - Do NOT add Markdown formatting unless it is present in the source. - Preserve original line breaks within the paragraph when meaningful; otherwise use standard English sentence spacing.

Since the input is just a list of names that are already in English/Latin script, the correct translation is to return them exactly as they are. There' s no Chinese text to translate.

The answer should simply be: Ola Ali, A. L. Tadross, A. I. Osman and Z. M. Hayman

I should not add any tags because there were none

Date: 2025-01-07T00:00:00+00:00

Abstract

The user wants me to translate a scientific text from Simplified Chinese to English. The text is about astrophysical properties of two star clusters, FSR-163 and Majaess 215, using Gaia DR3 data.

Let me break down the requirements: 1. Preserve ALL LaTeX commands and placeholders exactly 2. Preserve ALL citation commands ([?], **??**, (**??**), etc.) exactly 3. **PRESERVE ALL ···paragraph wrapper tags EXACTLY** 4. Maintain academic tone and formal scientific writing style 5. Use precise technical terminology - obey the glossary strictly 6. Preserve section structure and paragraph organization 7. Translate all content completely - do not omit any information

OUTPUT RULES: - Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent). - Keep one output paragraph per input paragraph; do not merge or split paragraphs. - **Maintain exact count and IDs of ···tags** - Do NOT add Markdown formatting unless it is present in the source. - Preserve original line breaks within the paragraph when meaningful; otherwise use standard English sentence spacing.

FORMATTING GUIDELINES: - Keep mathematical expressions in their original LaTeX format - Preserve equation numbers and references - Maintain proper academic paragraph structure - Use formal scientific language appropriate for research papers - Never remove or modify ···tags

Glossary: - 机器学习 => machine learning - 深度学习 => deep learning

Wait, the user provided a text in English, not Chinese. Let me re-read the prompt.

The prompt says: “Translate from Simplified Chinese to English with the highest accuracy and academic tone.”

But the text provided is: “We have examined most of the astrophysical properties of the two star clusters, FSR-163 and Majaess 215, using the third data release of the Gaia space mission (Gaia DR3). We utilized the pyUPMASK method to allocate the probabilities of stars' membership candidates. Using the clusters' trigonometric parallaxes of the members with probabilities P > 50%, we calculated the distance to the clusters of 3290 ($±140)*and*2833(±$140) pc,

respectively, which match well with our isochrone fitting results on the color-magnitude diagrams. We determined the

Full Text

Preamble

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A Photometric and Astrometric Study of Open Star Clusters FSR-163 and Majaess 215 Using Gaia DR3

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Abstract

We have examined most of the astrophysical properties of the two star clusters, FSR-163 and Majaess 215, using the third data release of the Gaia space mission (Gaia DR3). We utilized the pyUPMASK method to allocate membership probabilities for candidate stars. Using the trigonometric parallaxes of members with probabilities $P > 50\%$, we calculated distances to the clusters of 3290 ± 140 and 2833 ± 140 pc, respectively, which match well with our isochrone fitting results on the color-magnitude diagrams. We determined the ages of the clusters to be 1.00 ± 0.15 and 3.55 ± 0.15 Gyr for FSR-163 and Majaess 215, respectively. We evaluated the following photometric parameters: reddenings, distances, galactic geometrical distances, luminosity-mass functions, and total masses of the two clusters. Upon studying the dynamical state of the two clusters, we found that Majaess 215 is more relaxed than FSR-163.

Key words: (Galaxy:) open clusters and associations: individual (FSR-163 and Majaess 215) -proper motions -stars: luminosity function -mass function -catalogs -Astronomical Databases

1. Introduction

Any shapeless concentration of young stars that is bounded by their gravitational forces is commonly known as an open cluster (OC). These are groups consisting of about a few thousand stars whose formation originated from the same molecular cloud, with gravitational binding still active. Most observed OCs are found in spiral and irregular galaxies where active star formation is in progress. The motivation for the current study is to determine the Milky Way' s Galactic disk structure and evolution (Gilmore et al. 2012; Moraux 2016). Additionally, OCs enable us to make comparisons between our Galaxy and other surrounding galaxies, including the Magellanic Clouds (Efremov & Elmegreen 1998).

The Gaia mission (Gaia Collaboration et al. 2016) is a useful addition to our tools for studying OCs with high accuracy (Gaia Collaboration et al. 2018; Cantat-Gaudin 2022). Gaia is an abbreviation for Global Astrometric Interferometer for Astrophysics. Gaia Data Release 3 (Gaia DR3) provides accumulated observations of OC parameters such as equatorial coordinates, proper motions, and trigonometric parallaxes for over 1.8 billion sources (Gaia Collaboration et al. 2023). Additionally, G, G_{BP}, and G_{RP} photometric filters and color indices for around 1.5 billion sources are provided (http://www.cosmos.esa.int/gaia).

Though about 7000 objects are classified as Galactic OCs (Hunt & Reffert 2023), only about half of them have been studied in detail (Tadross 2018). Gaia DR3 has added new candidate OCs which are waiting to be confirmed through photometric and astrometric studies (Kharchenko et al. 2013).

FSR-163 is a member of the Froebrich OCs list (Kharchenko et al. 2013), and Majaess 215 is also on the Majaess OCs list (Majaess 2013). Both are regarded as poorly studied clusters. FSR-163 is mentioned in some catalogs with only its position, and has some parameters that were studied by Kharchenko et al. (2013) before the Gaia database was released. Table 1 contains a comparison between the current estimated parameters of FSR-163 and those of Kharchenko et al. (2013).

Our goal is to investigate such objects using Gaia DR3, which provides more accurate physical characteristics, e.g., distances and kinematics of the clusters' members. The structure of the present article can be summarized as follows. In Section 2, the extracted data and their treatments are reported. The exact corrected positions and real sizes are declared in Section 3. Section 4 presents the membership and color-magnitude diagrams (CMDs). The mass and luminosity functions as well as the relaxation time are evaluated in Section 5. Finally, Section 6 summarizes our study and inventory of the calculated parameters.

2. Data Treatments

Using the Gaia DR3 database (Gaia Collaboration et al. 2023), we processed astrometric and photometric analyses of both OCs FSR-163 and Majaess 215. The extracted data are limited by a $20'$ radius with a center located at SIMBAD central coordinates of the objects under consideration (http://simbad.u-strasbg.fr/simbad/), which are also listed in Dias et al. (2014).

The source data can be accessed at https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=I/355/gaiadr3.

To assign the probable members of the studied clusters, we used the Unsupervised Photometric Membership Assignment in Stellar Clusters (pyUPMASK) algorithm, which is a Python open-source software package (Cantat-Gaudin & Anders 2020; Pera et al. 2021). pyUPMASK determines the membership probability of stars in a cluster by employing a combination of k-means clustering and statistical analysis to identify cluster members based on their five-dimensional parametric space that includes equatorial coordinates (α, δ), proper-motion components $(\mu_\alpha \cos\delta, \mu_\delta)$, and trigonometric parallaxes (ϖ). The k-means algorithm partitions the data into k initial clusters, where each star is assigned to the cluster with the nearest mean value.

After the initial clustering, pyUPMASK iteratively refines the membership probabilities by evaluating the likelihood that each star belongs to its assigned cluster. The iterative process continues until the membership probabilities converge. Stars with higher membership probabilities are more likely to be true cluster members (see Yontan et al. 2023 and Gokmen et al. 2023). We selected $P \geq 50\%$ as the lower limit for membership probability. After a large number of iterations, we identified 1385 and 395 stars as the most likely members for FSR-163 and Majaess 215, respectively.

We checked the resultant members on the comoving diagram of each OC, as illustrated on the right-hand side of Figure 3, which affirms the constancy of speed and direction of all membership candidates. Figure 4' s right-hand panels illustrate a histogram of the trigonometric parallaxes of both OCs as well as the magnitude-parallax relation for membership candidates.

The convenience of a source and single-star model can be indicated using the renormalized unit weight error (RUWE). RUWE is a parameter used in the astrometric data of the Gaia mission to assess the quality of the measurements. It provides a measure of how well the positional measurements of stars match their predicted positions based on a single-star model. If a binary star system is not resolved into individual stars during astrometric observations, the measurements can be contaminated, resulting in higher RUWE values and implying poor astrometric quality. Therefore, all stars with RUWE > 1.4 were excluded (Lindegren et al. 2018). Additionally, stars with negative parallaxes ($\varpi < 0$ mas) are excluded.

The photometric completeness limit (PCL) was estimated for both clusters to increase the accuracy of the astrophysical parameters obtained. Stars with magnitudes less than PCL have been excluded because the parallax and proper-motion errors increase exponentially with magnitude. To calculate PCL, G apparent magnitude histograms were established for each OC as shown in Figure 2. The mean error is ~ 1 mas in parallax and ~ 1 mas yr^{-1} in proper-motion components.

Figure 1 shows optical images for both OCs as referenced from the colored Digitized Sky Survey (DSS) image of ALADIN (https://aladin.u-strasbg.fr/AladinLite), where the fields of view (FOV) are $9.14'$ and $5.72'$ for FSR-163 and Majaess 215, respectively. The number of stars counted with magnitude limits $7 < G < 22$ mag is 69,031 for FSR-163, and 20,501 stars with magnitude limits $6 < G < 22$ mag for Majaess 215.

In each iteration, Lindegren et al. (2021) reported a code for the zero-point offset of the Gaia Early Data Release 3 (EDR3) parallaxes. The zero-point correction was approximated as a function of G magnitude, ecliptic latitude, and color (using ν_{eff} for the five-parameter solutions and pseudo-color for the six-parameter solutions). Applying this code to the likely members of each studied cluster, the corrected parallaxes are found to be 0.304 ± 0.010 and 0.353 ± 0.013 mas for FSR-163 and Majaess 215, respectively. These lead to derived distances of $\sim 3290 \pm 80$ and $\sim 2833 \pm 80$ pc, respectively.

FSR-163 is a southern OC located within the boundaries of the constellation Vulpecula. At J2000.0, FSR-163 has the following coordinates: $\alpha = 20^{\text{h}}00^{\text{m}}19^{\text{s}}$, $\delta = +25^{\circ}25'16''$, $l = 63.2242^{\circ}$, $b = -2.4196^{\circ}$.

Majaess 215 is a northern OC located within the boundaries of the constellation Cepheus. At J2000.0, Majaess 215 has the following coordinates: $\alpha = 22^{\text{h}}49^{\text{m}}34^{\text{s}}$, $\delta = +59^{\circ}56'9''$, $l = 108.2157^{\circ}$, $b = +0.5929^{\circ}$.

3. True Centers and Sizes

The densest location within the OC defines where the cluster center is located. We divided the OC into equal-sized bins and calculated the number of stars in each bin. As demonstrated in Figure 5, three-dimensional kernel density analysis was applied to derive the center values of FSR-163 and Majaess 215. The calculated coordinates and SIMBAD values coincide well. For FSR-163 and Majaess 215, discrepancies in R.A. and decl. are found to be 3^{s} and $12''$, and 20^{s} and $9''$, respectively. Hence, it is possible to disregard the small uncertainty in position (l, b) of both OCs.

The OC’ s radial density profile (RDP) can be found by counting the stars in each radial bin. We can easily calculate the density of each zone by dividing the number of stars in each zone by its surface area (Tadross 2018, 2023; Tadross & Elhosseiny 2022). The OC’ s surface density profile often exhibits a gradual decline from its core toward the outer regions. The limiting radius R_{lim} of a certain cluster is usually defined as the radius at which the RDP becomes constant. We can calculate the error of each bin using Poisson noise where N is the number of stars in each bin, as demonstrated in Figure 6. We applied the King model to each cluster (King 1966), which has the following formula:

$$f(r) = f_{\text{bg}} + \frac{f_0}{1 + (r/R_c)^2}$$

where f_{bg} is the background density, f_0 is the central density, and R_c is the cluster' s core radius. The RDP begins to decline from the center outward and at a certain point it flattens out. This flattening happens when cluster density diminishes and the background field density dominates.

As shown in Figure 6, for both OCs under consideration, the blue arrows represent the tidal radii R_t.

The resultant limiting radius R_{lim} of FSR-163 is 8.5 ± 0.25 arcmin and that for Majaess 215 is 5.5 ± 0.25 arcmin. The core radius R_c is defined as the distance at which the stellar density value is equal to half of the central density. The resultant R_c for FSR-163 is 0.66 ± 0.11 arcmin and that for Majaess 215 is 0.60 ± 0.11 arcmin.

On the other hand, the tidal radius R_t is defined as the distance from the OC at which the gravitational influence of the Galaxy is equivalent to that of the OC core. Using Jeffries' equation (Jeffries et al. 2001):

$$R_t = \left(\frac{M_c}{3M_{\text{Gal}}}\right)^{1/3} R_{\text{Gal}}$$

where R_t is the tidal radius (pc) and M_c is the OC' s total mass ($M_\odot$) (as determined in Section 5). The resultant R_t for FSR-163 is 15.2 ± 10 pc and 9.95 ± 10 pc for Majaess 215.

The concentration parameter c of Peterson and King (Richstone & Tremaine 1986) shows how the OC is distinguished in comparison to the background field stars. It is found to be 1.11 and 0.96 for FSR-163 and Majaess 215, respectively, i.e., FSR-163 has more condensation at its center than Majaess 215.

4. Color-Magnitude Diagrams

The CMD is the instrumental gateway to determining the fundamental characteristics of members of OCs. Based on the Padova stellar isochrones database (http://stev.oapd.inaf.it/cgi-bin/cmd), the PARSEC stellar evolutionary isochrones (Bressan et al. 2012) and tracks (Chen et al. 2014; Tang et al. 2014) are utilized with the Gaia filter passbands of Evans et al. (2018) for solar metallicity $Z = 0.0152$. An OC' s CMD, age, distance modulus, and reddening can be estimated by obtaining a diagram' s fit. Considering the visual fit displayed in Figure 7, the crucial photometric properties of FSR-163 and Majaess 215 are confirmed with ages of 1.00 ± 0.15 and 3.55 ± 0.15 Gyr, respectively. The distance moduli were estimated as 12.59 ± 0.20 and 12.26 ± 0.20 mag, while the reddening $E(G_{BP} - G_{RP})$ was estimated as 0.95 ± 0.10 and 0.80 ± 0.10 mag for FSR-163 and Majaess 215, respectively. These values aligned with the mean estimated parallaxes.

The computed values of $E(B-V)$ are determined to be 0.68 ± 0.10 and 0.57 ± 0.10 mag for FSR-163 and Majaess 215, respectively. Based on the CMD-3.6 input form (http://stev.oapd.inaf.it/cgi-bin/cmd), the passbands of the Gaia filters G, G_{BP}, and G_{RP} are obtained using the following values (Cardelli et al. 1989):

$$\frac{A_\lambda}{A_V} = \begin{cases} 1.083 & \text{for } G_{BP} \\ 0.634 & \text{for } G_{RP} \\ 0.836 & \text{for } G \end{cases}$$

We get $A_{G_{BP}} = 1.083A_V$, $A_{G_{RP}} = 0.634A_V$, and $A_G = 0.836A_V$, then $A_V = 2.227E(G_{BP} - G_{RP})$ and $A_G = 1.862E(G_{BP} - G_{RP})$. By converting the color excess to $E(B - V)$ and correcting the photometry accordingly, we obtain the final parameters.

5. Mass and Luminosity Functions

Developing two polynomial equations based on the main sequence data of the employed isochrones [M_G versus color and M_G versus mass $\mathcal{M}$], the evolution tracks theoretical tables of Marigo et al. (2017) at the OC' s age have been used and the total mass and luminosity are determined by summing the number of total membership candidates multiplied in each bin by the appropriate values (L and $\mathcal{M}$) of that bin (Tadross 2012).

Histograms of the luminosity function (LF) for FSR-163 and Majaess 215 are illustrated in the left-hand panels of Figure 8, while the mass function (MF) relations are illustrated in the right-hand panels. It is noticeable that the fainter and less massive stars are dispersed outside of the OCs, while the brightest and most massive stars are concentrated at the center.

The total luminosity in the G-filter is found to be -2.40 ± 0.25 and -1.94 ± 0.25 mag for FSR-163 and Majaess 215, respectively. The slope of the well-known equation for the initial mass function (IMF) is represented by the linear fit constant:

$$\frac{dN}{dM} \propto M^\alpha$$

where dN is the star count in the mass interval $[M, M + dM]$ and α is the linear slope of the relation. The estimated masses of a standard OC lie in the range of mean value $\alpha \approx -2.35$ (Salpeter 1955). From the right-hand panels of Figure 8, we notice that the observed IMF for FSR-163 and Majaess 215 agree with Salpeter (1955)' s value (-2.40 and -3.70, respectively) within the error bars of Poisson noise where N is the star count in each bin. However, the overall masses are found to be $1125 \pm 90 M_\odot$ and $320 \pm 60 M_\odot$ for FSR-163 and Majaess 215, respectively.

The relaxation time T_R is the duration required by the OC to self-assemble and stabilize in the face of disruptive forces. T_R is the timescale, mostly determined by the OC' s mass and membership candidates' count, at which all traces of its initial conditions are lost. Using the formula of Spitzer & Hart (1971), the relaxation time may be computed as follows:

$$T_R = \frac{8.9 \times 10^5 \sqrt{N} R_h^{3/2}}{\sqrt{\bar{m}} \log_{10}(0.4N)}$$

where N is the membership candidates' count of the OC, R_h is the radius containing half of the OC' s mass (pc), and $\bar{m}$ is the average mass of each membership candidate ($M_{\odot}$). Assuming R_h equals half of the OC limiting radius, T_R is found to be 111 and 58 Myr for FSR-163 and Majaess 215, respectively.

The evolution parameter can be defined as the dynamical timescale $\tau = \mathrm{Age}/T_R$. If the OC' s age is older than the relaxation time, i.e., $\tau \gg 1.0$, then the OC is dynamically relaxed, and vice versa. In our case, we found that $\tau \approx 9$ and 61 for FSR-163 and Majaess 215, respectively. It is clear that Majaess 215 is more relaxed than FSR-163.

6. Conclusions

We presented here a comprehensive Gaia DR3 study of the two poorly studied OCs FSR-163 and Majaess 215. These OCs lie in the southern and northern sky, in the constellations Vulpecula and Cepheus, respectively. The membership probabilities of stars were assigned using the pyUPMASK algorithm. Most of the astrophysical parameters of both clusters have been estimated. For the sake of accuracy, we applied the ASteCA code (Perren et al. 2015, 2020) to both clusters and found that our values of the estimated parameters agree with ASteCA. All the OCs' essential physical characteristics are listed in Table 2.

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Note: Figure translations are in progress. See original paper for figures.