PPMXL photometric study of two newly discovered open clusters (SAI 19 and SAI 23)

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Abstract. In our research, we studied the characteristics of two newly discovered open star clusters. Their structural (core radius, limiting radius, etc) and the astrophysical parameters (reddening, distance, age, etc) have been investigated using 2MASS database and PPMXL database extracted from VizieR web site for the studied clusters. The studied newly discovered clusters are SAI 19 and SAI 23 were not studied before, they have ages of 0.4 Gyr and 0.3 Gyr respectively. The luminosity and mass functions as well as the total masses have been determined.

1. Introduction

Stellar clusters can be classified into two environmental classes depending on their association with interstellar matter [1]. Exposed clusters are clusters with little or no interstellar matter within their boundaries. Almost all clusters found in standard open cluster catalogs fall into this category. Embedded clusters are clusters which are fully or partially embedded in interstellar gas and dust. They are completely invisible at optical wavelengths and best detected in the infrared. Koposov et al [2] and Glushkova et al [3] published new surveys through searching for new open star clusters. They have discovered 168 new clusters among them 26 are embedded clusters. We have selected two open star clusters; SAI 19 and SAI 23 from the new survey, especially the embedded clusters in the galactic disk. Table 1 lists the centres coordinates and the diameters of the two selected clusters as given in the survey of ref. [3]. The current work is the first study for clusters SAI 19 and SAI 23. This paper is organized as follows ; the clusters center and clusters structure are given in section 2, clusters membership is introduced in section 3, the color magnitude diagram and the obtained physical parameters are discussed in section 4, and the cluster’s luminosity and mass functions are introduced in section 5. Finally, the conclusion is devoted to Section 6.

2. The Clusters Center and Clusters Structure

We determine the center of the two clusters; SAI 19 and SAI 23 by building histograms of star counts along $\alpha$ and $\delta$ using 2MASS extracted data. Then, the histograms were fitted by Gaussian function to obtain the location of the maximum number density in $\alpha$ and $\delta$, which represents the cluster’s center. The new values of centers for the two clusters are given in table 1 and presented in figure 1. Radial Density profile (RDP) is defined as the number of stars per unit area at different values of radius from the cluster’s center to outward [4]. It enables us to determine the cluster structural parameters such
as core radius, limiting radius...etc. The RDP is constructed by counting stars inside concentric rings outward from the cluster center. The observed surface radial density profile was fitted using the King Model [5], in the form:

\[
\rho (r) = f_{bg} \frac{f_0}{1 + \left(\frac{r}{r_{\text{core}}}\right)^{1+x}} ,
\]

(1)

where \( r_{\text{core}} \), \( f_0 \) and \( f_{bg} \) are the core radius, the central surface density and background surface density, respectively. The cluster limiting radius, \( r_{\lim} \), was calculated by comparing \( \rho(r) \) to the levels of the background density and it is defined as:

\[
r_{\lim} = r_{\text{core}} \left( \frac{f_0}{f_{bg}} - 1 \right)^{1/2} ,
\]

(2)

where \( \sigma_{bg} \) is an uncertainty of \( f_{bg} \).

Table 1. Equatorial, Galactic coordinates and the apparent diameters of the candidate clusters obtained from SAI open cluster catalog.

| Cluster | \( \alpha \) (h:m:s) | \( \delta \) (°:′:″) | G. Long. (°) | G. Lat. (°) | D.′ |
|---------|---------------------|------------------|-------------|-------------|-----|
| SAI 19  | 02:26:31.9          | +61:59:33       | 133.846     | 1.153       | 6.0 |
| SAI 23  | 02:54:05.0          | +60:39:52       | 137.404     | 1.286       | 2.0 |

Figure 1. The Gaussian fitting profiles of star counts across \( \alpha \) and \( \delta \) for the cluster center for SAI 19 and SAI 23 open clusters.

Figure 2 shows the RDP from the new centers of the clusters. The core radius and limiting radius are shown for each cluster in table 2.

3. Clusters Membership
To remove the field stars (non-member stars) from the cluster region, we applied the kinematical method. First by building two histograms; one for the component of the proper motion in \( \alpha \) and the other
for the component of the proper motion in $\delta$. The highest count of stars represents the cluster member stars, because they share nearly the same proper motion values, then by selecting a range for both pmRA and pmDE around the histogram peak, the stars within this range could be considered as members of the cluster as. Then cleaning the cluster data from the rest stars (field stars) to obtain cleaned CMDs for each cluster for further data analysis.

**Figure 2.** Radial density profile for SAI 19 (left) and SAI 23 in (right).

### 4. Clusters Physical Parameters

The cleaned CMDs are used to derive physical parameters (age, reddening and distance) as shown in table 2. Figure 3 presents the observed CMDs; J versus J-H and Ks versus J-Ks for our targets fitted with the suitable isochrones. These isochrones cover an age range from 4 Myr to 14 Gyr with step of 0.05 in the logarithm of age and for a metallicity of $Z = 0.017$ [6].

**Figure 3.** Isochrone fitted to the observed CMD of SAI 19 and SAI 23.

### 5. Clusters Luminosity and Mass Functions

We have used the cleaned cluster data after the field stars decontamination to construct the luminosity (LF) and mass functions (MF). We present the observed LFs in J band for the stars fainter than zero absolute magnitude, these LFs are given in absolute magnitude scales after applying the distance modulus derived in the previous section, at J band LF lies in the luminosity range (-2 to 4), with a maximum at round 3.25 mag for SAI 19, while J band lies in the luminosity range (-2.5 to 4), with a maximum at around 3 mag for SAI 23. This absolute magnitude are determined using a suitable bin size.
The LFs are transformed to the MFs using the mass-luminosity dependency according to the adopted isochrones. Scale [7] gave the distribution per mass interval by the relation:

\[ \frac{dN}{dM} \propto M^{-\alpha}, \]

where \( \alpha \) is the power index equals to 2.35 according to the original Salpeter value [8]. It is noted that the investigated MF slope ranging of the clusters under consideration are found to be - 2.59 and 2.42, which are found to be around the Salpeter’s value.

### Table 2. The astrophysical parameters of the candidate clusters.

| Parameter                  | SAI 19          | SAI 23          | Parameter                  | SAI 19          | SAI 23          |
|----------------------------|-----------------|-----------------|----------------------------|-----------------|-----------------|
| Center (Ra. h: m: s)       | 02: 26: 46.32   | 02 :53 :52.18   | E(J-H) (mag.)              | 0.354± 0.02     | 0.199±0 .02     |
| (Dec. : : : )              | +62:8:13.2      | +60:37:16.32    | m-M (mag.)                 | 10.89± 0.04     | 11.352±0.17     |
| \( r_{lim} \) (arcmin.)   | 7.20 ± 1.1      | 14.32 ± 2.3     | Distance (pc.)             | 1509 ± 33       | 1863 ± 150      |
| Core radius (arcmin.)      | 2.15±0.31       | 4.17 ± 0.62     | Membership                 | 81 stars        | 108 stars       |
| Log(age)                   | 8.6 ± 0.05      | 8.5 ± 0.05      |                            |                 |                 |

6. Conclusion
In this research, we present a photometric and kinematic study for two selected open clusters from the 26 embedded clusters discovered by Glushkova et al [3], through their automatic sky survey. For these embedded clusters and many other newly discovered clusters, the coordinates of their centers and diameters are only given in this survey. This is the first study that has been done for our target SAI 19 and SAI 23 to determine the structure and the physical parameters. In our study, we used the near-infrared JHKs data from 2MASS Point Source [9] and PPMXL [10] Catalogs.

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