

Characterization of a Young Open Cluster G144.9+0.4 in Cam OB1 Association



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Abstract

Open clusters (OCs) are good laboratories to study stellar evolution and dynamical interaction among member stars. We are carrying out a program to identify uncharted OCs using sky-survey data. Our preliminary result is from the 2MASS point source catalog in Galactic latitude $|b| < 50$ degrees. One such density peak (G144.9+0.4) located in Cam OB association, is a young star cluster at $(l,b)=(144.9,+0.4)$, first recognized but not well characterized, by Glushkova et al. (2010). We used the PPMXL proper motions to constrain the membership. Our analysis shows a distance of 1.0~kpc, hence G144.9+0.4 is physically related to Cam OB1 association. Based on the 2MASS and WISE colors, seven Classical T-Tauri Star (CTTS) candidates are found within the cluster, however, three of those with larger proper motions may be non-members. Nonetheless, one of these candidates is not only a kinematic member but also a CTTS which is confirmed by spectrum. The spectral energy distribution fitting also shows that these stars are very young which is indicative of a young age of the cluster.

Open Cluster : G144.9+0.4

- First recognized, but not well characterized by Glushkova et al. (2010). Figure 1 demonstrates the spatial distribution of the Cam OB1 association (Straizys & Laugalys 2007).
- The density map shows a peak at $(l,b)=(144.904,+0.434)$ as shown in Figure 2a.
- The diameter is estimated $\sim 8'$ (Figure 2b).

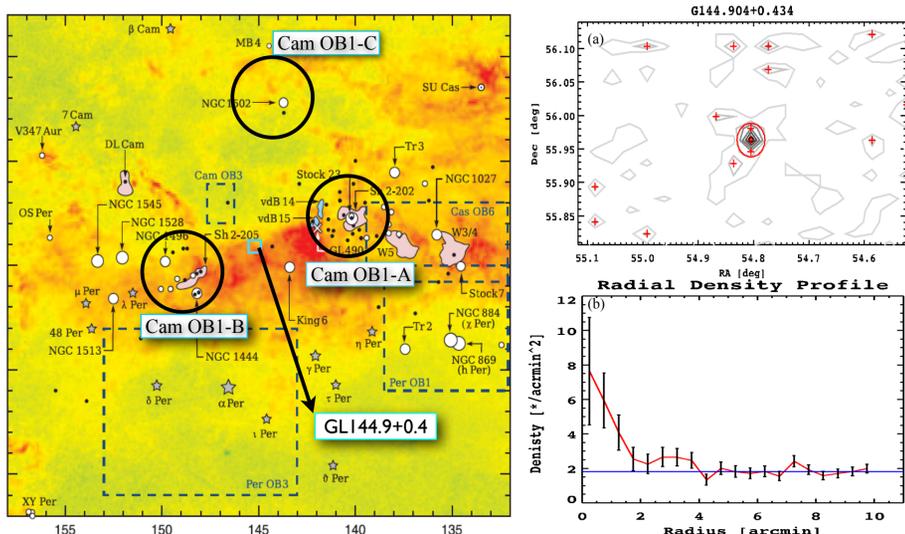


Figure 1. Dust clouds in Camelopardalis and the nearby regions taken by Straizys & Laugalys (2007)

Figure 2. (a) The density map. (b) The radial density profile.

Classical T-Tauri Stars (CTTS) Candidates

- Figure 3 shows seven CTTS candidates in the 2MASS color-color diagram. The four cyan triangles mark the young stars identified by the WISE colors.
- Our H α imaging observation suggested that star E is strong H α emitter. Table 1 lists archival data of our candidates and the last 3 columns are stellar parameters obtained from the SED fitting (Robitaille et al. 2006). The SED fitting (see Figure 4) indicates that these candidates are very young (< 1 Myr).

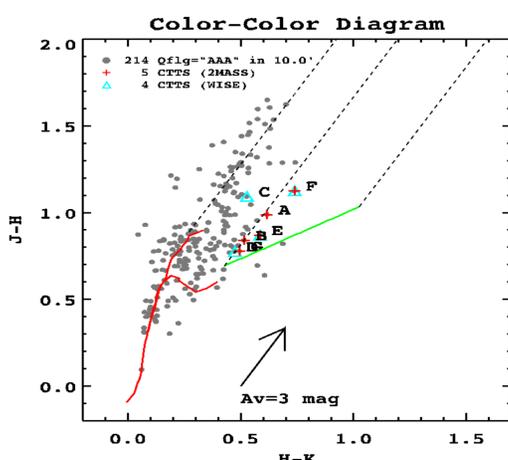


Figure 3. Red lines are giants and dwarfs locus by Bessel & Brett (1988). Green line is intrinsic Classical T-Tauri Stars locus by Meyer (1997). All of the loci are converted into 2MASS system. The black arrow and dashed lines represent the interstellar reddening direction. Red crosses and cyan triangles are CTTS candidates from 2MASS and WISE, respectively.

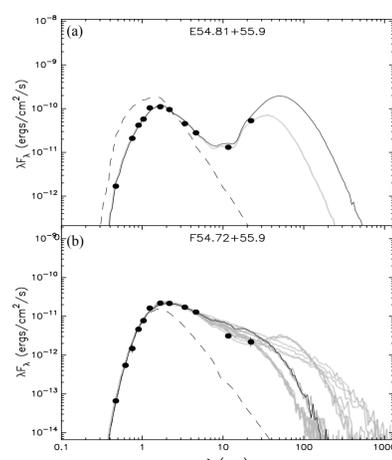


Figure 4. (a) Star E and (b) Star F SED fittings. The filled circles show the input fluxes. The black line shows the best fit, and the gray lines show subsequent good fits. The dashed line shows the stellar photosphere corresponding to the central source of the best fitting model.

Table 1. Archival data of CTTS candidates and SED fitting results.

ID	RA, DEC J2000 [deg]	PS1 (g,r,i,z,y)	2MASS (J,H,K)	WISE (1,2,3,4)	PPMXL [mas/yr]	Age [Myr]	Mass [solar]	Av [mag]	note
A	54.720+55.922	24.575,21.989,20.357,19.094,18.367	16.2, 15.3, 14.6	---	-7.6, 53.9 (± 8.3)	---	---	---	ZMASS
B	54.755+55.902	25.989,20.589,18.951,17.929,17.226	15.3, 14.5, 14.0	13.9, 13.8, 10.3, 7.4	-5.7, 11.1 (± 5.3)	4.10	0.68	4.74	ZMASS
C	54.804+55.969	21.954, 22.100,17.940,16.841,16.119	14.2, 13.1, 12.5	12.0, 11.7, 9.4, 6.0	-6.2, 3.9 (± 5.4)	0.35	0.30	1.82	WISE
D	54.803+55.974	20.029,17.704,16.814,15.992,15.472	13.9, 13.1, 12.6	12.1, 11.7, 9.3, 5.2	4.0, -0.3 (± 4.0)	0.19	0.34	1.50	WISE
E	54.811+55.982	17.716,15.718,14.429,13.655,13.171	11.4, 10.5, 9.9	9.4, 9.0, 6.9, 3.3	-2.2, -2.1 (± 5.0)	0.37	2.94	2.16	ZMASS, WISE
F	54.752+55.961	21.129,18.656,17.053,16.036,15.851	13.4, 12.3, 11.5	10.5, 9.8, 8.5, 6.7	-1.5, -6.3 (± 5.3)	8.50	1.80	7.57	ZMASS, WISE
G	54.766+56.019	26.010,20.730,19.316,18.528,18.814	16.1, 15.3, 14.8	---	-10.3, -13.3 (± 5.5)	---	---	---	ZMASS

Kinematic Members

- Straizys & Laugalys (2007) divided Cam OB1 association into three subgroups: 1A, 1B and 1C, all are at the similar distance of ~ 1 kpc.

Table 2. Three groups of the Cam OB1.

	(l, b)	Mean P.M. [mas/yr]	No. *	Dist
A	140.0 \pm 1.5	(-1.0 \pm 2.0, -1.9 \pm 1.5)	>30	~ 1 kpc
B	148.0 \pm 0.5	(-0.8 \pm 0.5, -2.3 \pm 1.0)	~ 10	
C	143.7 \pm 7.7	(-0.7 \pm 0.5, -0.7 \pm 0.6)	1	

- The mean proper motions of Cam OB1A and 1B are consistent, suggesting physical association (see Table 2).

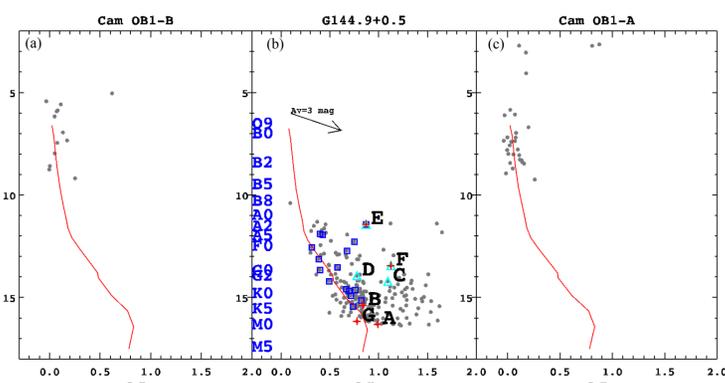


Figure 5. (a) and (c) are Cam OB1-A and -B ZAMS (red lines) fitting at 1 kpc. (b) Blue boxes are selected with proper motions similar to the CamOB1 association. CTTS candidates are red crosses (2MASS) and cyan triangles (WISE). Gray dots in (a) and (c) are Cam OB1 members, while in (b) are stars in G144.9+0.4 region.

- We selected 18 stars in G144.9+0.4 with proper motions similar to that of the Cam OB1 association. These stars could be fitted by a zero-age-main-sequence located at about 1 kpc with interstellar extinction A_v about 2 mag in the color-magnitude diagram, (see Figure 5). Therefore, G144.9+0.4 is associated with the Cam OB1 association.

Discussion and Future Work

- Star E is one of the kinematic members of G144.9+0.4 and is a CTTS confirmed by its spectrum (Figure 6), therefore, **the cluster itself must be also young**, still associated with abundant molecular materials (Figure 7).
- The physical diameter of G144.0+0.4 is about 2.2 pc at a distance of 1 kpc. With about 20 members, the escape velocity of this cluster is about 5 km/s. If star A, B and G are at the same distance 1 kpc, their space velocities would have been > 50 km/s. They are escaping the cluster or are likely foreground stars.
- Follow-up observations have been carried out to confirm CTTS candidates and the spectral type of kinematic members. We will use the Pan-STARRS data to find and to characterize uncharted star clusters.

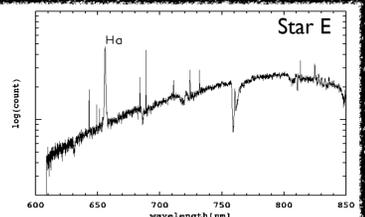


Figure 6. Optical HCT/HFOSC spectrum of star E with the strong H α emission line is labeled. The clear visible absorption line is due to tellurium.

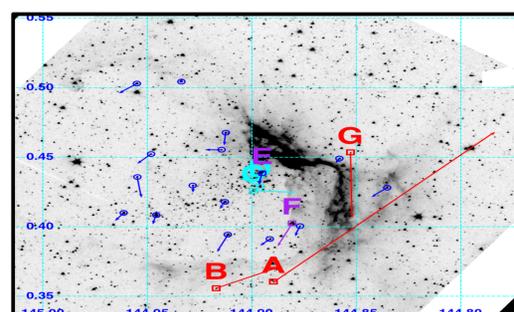


Figure 7. Proper motions of kinematic and photometric members (in blue circles) and of young star candidates (in red, purple and cyan boxes). Each arrow shows the angular speed and direction. Background is the Spitzer 3.6 micron image.

Acknowledgment

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