Bulg. J. Phys. **33** (2006) 68–72

Age Determination of Possible Binary Open Clusters NGC 2383/NGC 2384 and Pismis 6/Pismis 8

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Received *24 July 2006*

Abstract. Based on 2MASS J and Ks photometry for the open star clusters NGC 2383, NGC 2384, Pismis 6, Pismis 8 and using color magnitude diagrams with isochrones fit, we found an age of $\log(\text{age})$ = 8.3 (200 $\pm$ 6 Myr) for NGC 2383 and $\log(\text{age})$ = 6.9 (8 $\pm$ 6 Myr) for NGC 2384. For Pismis 6 and Pismis 8 we adopted a range of $\log(\text{age})$ = 6 - 7 (1 - 10 Myr). Because of their similar ages, Pismis 6 and Pismis 8 might have been formed in the same Giant Molecular Cloud, and we conclude they are a good candidate for a binary system. In the case of NGC 2383 and NGC 2384, because of the big age difference found, we conclude that most probably they are born in different environments and are not physically connected.

PACS number: 98.20.Di

1 Introduction

Open clusters are very important objects in the study of stellar evolution because all their members are of very similar ages and chemical composition, and in this way the effects of other more subtle variables on the properties of stars are more easily studied than for the isolated stars. The total number of open clusters known in our Galaxy is over 1600, (see "New catalog of optically visible open clusters and candidates" Dias *et al*. [1]) of these the only well established double or binary cluster is NGC 869 and NGC 884 (known also as $h+\chi$ Persei), located at a distance of more than 2 kpc from the Sun. The existence of other possible double clusters has been proposed earlier by Pavloskaya *et al*. [2], but it has not been seriously looked into. Subramaniam *et al*. [3] examine existing catalogues of open clusters and suggested 18 probable binary open star clusters. The aim

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of this study is to determine the ages of two probable couples NGC 2383 - NGC 2384 and Pismis 6 - Pismis 8. Our research is based on J and Ks photometry from Two Micron All Sky Survey (2MASS project use two highly-automated 1.3-m telescopes, and provide all-sky photometry in J (1.25 microns), H (1.65 microns), and Ks (2.17 microns) bands).

2 Earlier Studies

Table 1 presents some data concerning previous investigations of objects under study.

Table 1. Earlier data for open clusters NGC 2383, NGC 2384, Pismis 6 and Pismis 8. Denote: (V&M) Vogt and Moffat; (S&S) Subramaniam and Sagar; (Fitz) Fitzegerald et al; (B&C) Battinelli and Capuzzo–Dolcetta; (F&S) Forbes and Short.

Name	Citation	Distance pc	Age Myr	E(B-V) mag
NGC 2383	V&M	1970		0.27
.....	S&S	3340 $\pm$490	400	0.22 $\pm$0.05
NGC 2384	V&M	3280		0.29
.....	S&S	2925 $\pm$430	20	0.28 $\pm$0.05
Pismis 6	V&M	1650		0.40
.....	Fitz	1700 $\pm$200	30	0.40
.....	B&C		32	0.41
.....	F&S	1850 $\pm$100	8	0.46 $\pm$0.04
Pismis 8	V&M	1420		0.74
.....	Fitz	1700 $\pm$200	30	0.74

In the case of NGC2383 and NGC2384 Vogt and Moffat [4] from their photoelectric UBV measurements concluded that despite both clusters appear close on the sky projection, because of their big distance difference they are not physically connected. Subramaniam and Sagar [5] presented first CCD photometry for NGC 2383 and NGC 2384, within the errors the distances are close enough to still match the selection criterion of Subramaniam *et al.* [3], but the large age difference indicates that the clusters are not formed together out of the same Giant Molecular Cloud (GMC).

First studies of Pismis 6 and Pismis 8 were undertaken by Vogt and Moffat [6] using photoelectric photometry. Besides distance measuremnts of both clusters Fitzegerald *et al*. [7] have found that they are 17 pc of each other in the plane of the sky, and that their spectroscopic distance module is slightly larger than the photometric module (Fitzgerald *et al*. [8]). The reddenings are compatible with the values derived by Vogt and Moffat [6]. Fitzegerald suggested that Pismis 6 and Pismis 8 have a similar age of 30 Myr and thus a common origin. For

Pismis 6 Battinelli and Capuzzo-Dolcetta [9], Forbes and Short [10] derived 32 Myr and 8 Myr respectively.

3 Clusters Data and Age Determinations

Table 2 presents cluster parameters as given in the catalog of Dias *et al.* [1].

Table 2. Basic cluster parameters

Parameter	NGC 2383	NGC 2384	Pismis 6	Pismis 8
R.A.(2000).....	07:24:41.0	07:25:12.0	08:39:04.0	08:41:36.0
Decl.(2000).....	-20:56:42	3-21:01:24	-46:13:36	-46:16:00
Distance (pc).....	1655	2116	1668	1312
Ang. diam (arcmin)	5	5	3	3
E(B-V) (mag)..... ..	0.213	0.255	0.380	0.706
log(age)	7.167	6.904	7.283	7.427

We used the photometry for the clusters from 2MASS using VizieR tool available at http://visier.u-strasbg.fr. We made circular extractions centered on the coordinates for each clusters: Apparent diameters on NGC 2383 and NGC 2384 are of 5.0 arcmin and 3.0 arcmin for Pismis 6 and Pismis 8, for which we use an extraction radius of 5.0 arcmin and 3.0 arcmin respectively. Using the interstellar extinction law $\frac{A_J}{A_V}$ = 0.282 and $\frac{A_K}{A_V}$ = 0.112 from Rieke & Lebofsky [11] and data for the distance and the reddening from [5]

$V - M_V$ = 13.3 $\pm$ 0.3 and E_{B-V} = 0.22 $\pm$ 0.05 for NGC 2383
$V - M_V$ = 13.2 $\pm$ 0.3 and E_{B-V} = 0.28 $\pm$ 0.05 for NGC 2384,

we derived reddening E_{J-K_S} = 0.12 $\pm$ 0.05 and E_{J-K_S} = 0.15 $\pm$ 0.05 respectively. For other two clusters we used data from [8]

$V - M_V$ = 11.2 $\pm$ 0.2 and E_{B-V} = 0.41 $\pm$ 0.06 for Pismis 6
$V - M_V$ = 11.0 $\pm$ 0.25 and E_{B-V} = 0.76 $\pm$ 0.06 for Pismis 8

and derived reddening E_{J-K_S} = 0.25 $\pm$ 0.10 and E_{J-K_S} = 0.40 $\pm$ 0.10 respectively.
Colour-magnitude diagrams (CMDs) M_J versus $(J-K_S)_0$ for clusters are given in Figure 1.

We determined the age of the clusters overplotting the best fitting isochrones on the CMDs. We have adopted an age of

$\log$(age) = 8.3 (200 $\pm$ 6 Myr) for NGC 2383 and
$\log$(age) = 6.9 (8 $\pm$ 6 Myr) for NGC 2384

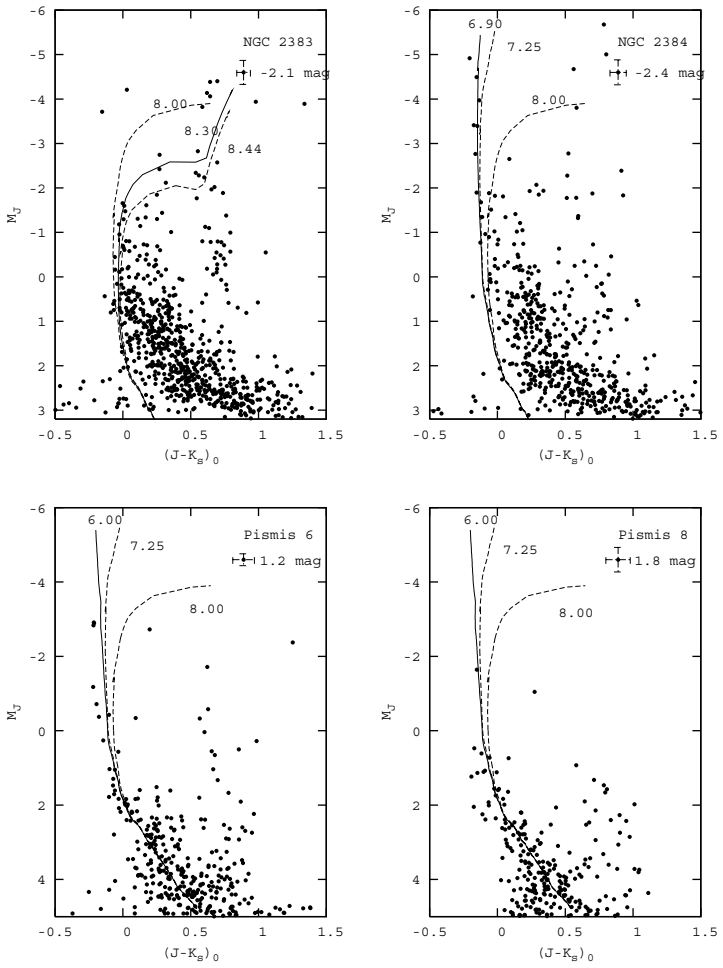

Figure 1. Colour-magnitude diagram for NGC 2383, NGC 2384, Pismis 6 and Pismis 8 with the best isochrone fit. We have adopted an age of $\log(\text{age})$ = 8.3 (200 $\pm$ 6 Myr) for NGC 2383 and $\log(\text{age})$ = 6.9 (8 $\pm$ 6 Myr) for NGC 2384. For Pismis 6 and Pismis 8 we adopted a range of $\log(\text{age})$ = 6 - 7 (1 - 10 Myr).

For Pismis 6 and Pismis 8 we adopted an age range of $\log(\text{age})$ = 6 - 7 (1 - 10 Myr). The isochrones are based on the stellar models of the Geneva group Schaerer *et al.* [12], with Z = 0.008, which corresponds to metallicity [Fe/H] = -0.3 dex. For NGC 2383 and NGC 2384 we determine less age from those given in [5], but for Pismis 6 and Pismis 8 our ages determination are comparable with [8], [9], and [10].

4 Conclusions

Using 2MASS J and Ks photometry for the open star clusters NGC 2383, NGC 2384, Pismis 6 and Pismis 8, and fitting CMDs with isochrones based on the Geneva models, we found $\log(\text{age})$ = 8.3 (200 $\pm$ 6 Myr) for NGC 2383, $\log(\text{age})$ = 6.9 (8 $\pm$ 6 Myr) for NGC 2384, and range of $\log(\text{age})$ = 6 - 7 (1 - 10 Myr) for Pismis 6 and Pismis 8. Pismis 6 and Pismis 8 have similar age and might have been formed in the same GMC, we conclude that they are a good candidate for binary cluster. In contrast NGC 2383 and NGC 2384 have a big age range between, and probably they are not formed in the same GMC.

Acknowledgments

Our work is partially supported by the grant F-1302/2003 of the Bulgarian NSF. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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