

Research Note

The central part of the young open cluster NGC 6383^{*}

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Abstract. The spectral and extinction properties of 14 pre-main sequence candidates in the central part of the very young open cluster NGC 6383 were investigated. None of these stars shows evidence for anomalous circumstellar extinction. However, six out of 14 programme stars do show an infrared excess, indicative of the presence of circumstellar dust, heated up by the central star. One of these stars (number 4), also shows H α in emission and shows some indications for the presence of circumstellar gas in its spectrum, and might therefore be a newly identified Herbig Ae star.

Key words: stars: circumstellar matter – stars: pre-main sequence – ISM: dust, extinction – ISM: H II regions – Galaxy: open clusters and associations: individual: NGC 6383

1. Introduction

NGC 6383 ($\alpha_{1950} = 17^{\text{h}}31^{\text{m}}4$, $\delta_{1950} = -32^{\circ}32'$) is a relatively small (10 arcmin radius, Hagen 1970) very young open cluster, centered around the bright spectroscopic binary HD 159176 (O7 V + O7 V, $P = 3.366767$ days; Stickland et al. 1993). The weak H α emission nebula Stromlo 67 (Gum 1955), also known as S11 (Sharpless 1953) or RCW 132 (Rodgers et al. 1960), is centered approximately on HD 159176, by which it is excited. Together with NGC 6530 and NGC 6531, NGC 6383 belongs to the Sgr OB1 association.

A photoelectric study by Eggen (1961) showed that the stars in NGC 6383 later than A0 lie above the zero-age main sequence (ZAMS) and might therefore still be contracting. A photographic study of stars in a larger area around the cluster by Thé (1965) confirmed Eggen’s results, but failed to find weak H α emission line stars of the type found in other very young open clusters, such as NGC 2264, NGC 6530 and NGC 6611.

Fitzgerald et al. (1978) studied stars in the central core (1.25 arcmin radius) of NGC 6383 using photoelectric photometry and derived an average colour excess $E(B - V) = 0^{\text{m}}33 \pm 0^{\text{m}}02$,

a cluster distance d of 1.5 ± 0.2 kpc and a cluster age of 1.7 ± 0.4 million years. Luiken-Miller (1982) derived a similar numbers for the $E(B - V): 0^{\text{m}}31 \pm 0^{\text{m}}02$. However, her cluster distance of 2.4 ± 0.3 kpc deviates considerably from the value by Fitzgerald et al. (1978). Furthermore, Luiken-Miller found a considerable spread in the ages of the stars in NGC 6383, with an average age of 2.2 million years.

The spectral energy distributions of stars in the central core of NGC 6383 were studied by Thé et al. (1985) using photoelectric photometry in the Walraven *WULBV*, Cousins *VRI* and Near-IR *JHKLM* photometric systems. They found a considerable infrared excess around three stars located above the ZAMS, probably due to thermal emission of circumstellar dust grains, confirming the pre-main sequence nature of these objects. Thé et al. also derived a colour excess $E(B - V) = 0^{\text{m}}30 \pm 0^{\text{m}}01$ and a distance of 1.4 ± 0.15 kpc for NGC 6383, in excellent agreement with the values found by Fitzgerald et al. (1978).

However, spectral types of some of the stars studied by Thé et al. (1985) are still uncertain, and previous authors did not take the possibility of anomalous extinction into account while deriving properties of the stars in NGC 6383. Therefore, a new study of the pre-main sequence candidates in this cluster is in place. For this, 14 stars in NGC 6383, mostly located in the core, were selected from the paper by Thé et al. (1985). The stars along with the available data in the literature are listed in Table 1. We shall use the star’s number as given in Fitzgerald et al. (1978) except for the last two stars in Table 1 which are assigned number T17 and T54 following the numbering system by Thé (1965).

2. Observations

Low resolution ($1.80 \text{ \AA pix}^{-1}$) CCD spectra of our programme stars, in the wavelength range of 4200 to 7800 \AA , were obtained on the 16th of June 1992 at the European Southern Observatory, La Silla, Chile, using the Boller & Chivens spectrograph mounted on the ESO 1.52 m telescope. Using the MIDAS software package, the spectra were reduced with the usual steps of bias subtraction, flatfielding, background subtraction and spec-

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^{*} Based on observations collected at the European Southern Observatory, La Silla, Chile.

Table 1. Programme stars in NGC 6383.

Star number			Other	α (1950)	δ (1950)	V	Spectral
F78	T65	E61	designation			[^m]	type
1	1	1	HD 159176	17 31 26	-32 32 57	5.64	O7 V + O7 V
2	2	2	HD 317847	17 31 19	-32 31 50	10.33	B2 V
3	3	3	HD 317857	17 31 18	-32 34 12	10.30	A1:IV:p
4	27	-		17 31 21	-32 34 20	12.61	A5 IIIp
5	26	-		17 31 15	-32 32 39	12.86	A2 Vep
6	-	-		17 31 23	-32 32 01	13.77	A
18	18	18		17 31 20	-32 33 26	13.37	F8
20	20	20		17 31 22	-32 31 51	11.42	B9 IV
21	21	21		17 31 27	-32 31 39	11.97	F2 IV:p
22	22	22		17 31 33	-32 33 21	12.30	A3 V:e
23	23	23		17 31 31	-32 32 22	13.79	G3
24	24	24		17 31 32	-32 33 14	11.35	B9 Ve
-	17	13a		17 31 16	-32 31 27	12.54	A3 Vp
-	54	-		17 31 40	-32 33 20	12.32	F0 Ve

Table 2. New *JHKLM* photometry of star No. 6.

Date	<i>J</i>	<i>H</i>	<i>K</i>	<i>L</i>	<i>M</i>
23/7/86	11.87	9.43	7.97	6.87	6.09
25/7/86	11.98	9.46	7.97	6.85	6.53
Error	0.02	0.01	0.01	0.08	0.42

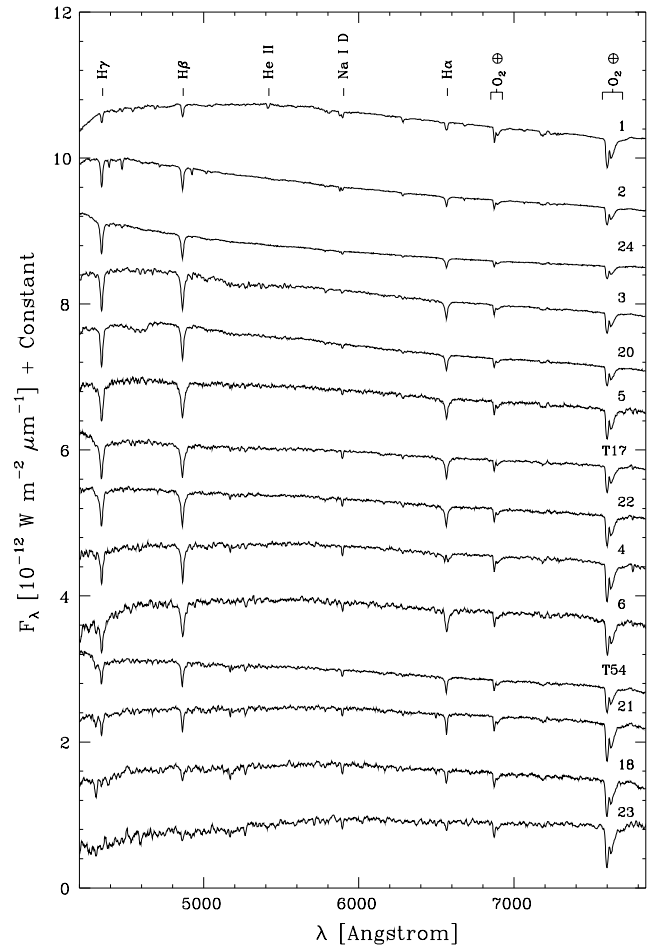
tral extraction, and wavelength and flux calibration. The resulting spectra are shown in Fig. 1.

New *JHKLM* near-IR photometric data of star number 6 in the numbering system by Fitzgerald et al. (1978) were obtained by P.S. Thé in July 1986 with the ESO 1 m telescope at La Silla with the InSb detector attached. These observations were made through a 15'' diaphragm. Sky subtraction was achieved by chopping, with a frequency of 8 Hz, in the east-west direction with a throw of 30'' amplitude. The measurements and their accuracies are listed in Table 2.

3. Spectral classification

New spectral classifications for our programme stars were made by comparing our new spectra with the standard MK spectra by Jacoby et al. (1984). The resulting spectral classifications are listed in Table 3. Particularly interesting is the spectrum of star number 4, which shows $H\alpha$ in emission and also has the $O\ I\ 7774$ line strongly in absorption. According to the relations obtained by Danks & Dennefeld (1994), the relative strength of this last line indicates that it must be a giant. Furthermore, the $Na\ I\ D$ lines in this star appear to be somewhat stronger than those in the other spectra shown in Fig. 1, suggesting the presence of circumstellar gas in this object.

Additional spectral classifications were made from the photometric data by Fitzgerald et al. (1978) and by Eggen (1961) by dereddening all programme stars in the $(U - B)$ versus $(B - V)$ diagram, assuming a normal extinction law, i.e. $E(U - B)/E(B - V) = 0.72$. They are listed in Table 3. The

**Fig. 1.** Low-resolution spectra of programme stars in NGC 6383 taken with the ESO 1.5 m.

adopted final classification, determined by comparing literature classifications with ours is also listed in Table 3. Note that with the exception of star number 4 we do not retrieve the emission-

Table 3. Astrophysical parameters of programme stars.

Star	Spectral type			$E(B - V)$	R_V	$\log T_{eff}$	$\log L_*/L_\odot$	IR Excess
	Photometric	Spectroscopic	Adopted					
1	O9	O7	O7 V	0.36	3.1	4.580	5.777	N
2	B2	B2	B2 V	0.34	3.1	4.342	3.324	N
3	B9/A8	B8	B8 IV	0.40	3.1	4.086	2.858	N
4	A0/A8	A5 IIIe	A5 IIIe	0.45	3.1	3.908	1.695	Y
5	B9/A8	A1 IV	A1 IV	0.43	3.1	3.971	1.659	Y
6	B9/A8	A6	A6 V	0.35	–	3.905	1.166	Y
18	B7/F5/G5	G0	G0 V	0.24	3.1	3.780	1.194	Y
20	B8	B7	B8 V	0.28	3.1	4.076	2.243	Y
21	B8/F2/G5	F2	F2 V	0.37	3.1	3.838	1.884	N
22	A0/A7	A3 IV	A3 IV	0.45	3.1	3.938	1.850	N
23	B7/F5/G5	G5	G5 V	0.30	3.1	3.761	1.121	N
24	B6	B7	B7 V	0.31	3.1	4.114	2.383	Y:
T17	A0	A2 IV	A2 IV	0.45	3.1	3.953	1.752	N
T54	B7/F5	F1	F1 V	0.27	3.1	3.848	1.614	N

line classification obtained for several programme stars by previous authors. We believe this to be due to the superior background subtraction procedures allowed by our long-slit CCD observations.

4. Spectral energy distributions

Spectral energy distributions (SEDs) of all programme stars were constructed using photometric data from Thé et al. (1985), Fitzgerald et al. (1978), Eggen (1978), the ANS catalogue (Wesselius et al. 1982), the TD1 catalogue (Thompson et al. 1978) and our new photometry from Table 2. No reliable IRAS data were available for any of our programme stars. The resulting SEDs, shown in Fig. 2, were analyzed by comparing them to Kurucz (1991) models corresponding to their spectral classification, using the method described by van den Ancker et al. (1997). The values for the ratio of total to selective extinction R_V , which are the result of the application of this procedure are also given in Table 3. No deviation from a normal interstellar extinction law (i.e. $R_V = 3.1$) could be found in any of these stars.

As can be seen from Fig. 2, three of our programme stars (numbers 4, 5 and 6) show large amounts of excess radiation above photospheric levels, similar to those seen in many Herbig Ae/Be stars, in the near-infrared. Two additional stars (numbers 18, 20 and possibly 24) show a modest amount of infrared excess. This probably indicates the presence of circumstellar dust, heated up by the central star, in these systems. Since star number 4 is the only one of our programme stars which also shows $H\alpha$ in emission (see Fig. 1), this makes it a new candidate for membership of the Herbig Ae/Be stellar group in our sample.

5. Evolutionary status

Again following the method of van den Ancker et al. (1997), luminosities of our programme stars were computed from their SEDs, adopting the distance of 1.4 ± 0.15 kpc towards NGC

6383 obtained by Thé et al. (1985). The computed luminosities are also listed in Table 3. Using these and the temperatures corresponding to the spectral types, a Hertzsprung-Russell diagram was constructed (Fig. 3). In this diagram we also plotted the pre-main sequence evolutionary tracks by Palla & Stahler (1993), as well as their so-called “birthline”, where a star becomes visible for the first time during its evolution towards the main-sequence, for accretion rates of 10^{-5} and $10^{-4} M_\odot \text{ yr}^{-1}$.

From Fig. 3 we notice that all stars in NGC 6383 fall below both stellar birthlines, and therefore confirm the Palla & Stahler models. Furthermore, the stars we classified spectroscopically with luminosity classes III or IV in Table 3 all seem to be located to the right of the main-sequence, and therefore are probably true pre-main sequence stars. However, no strong correlation between position in the HR diagram and the presence of a near-infrared excess seems to be present within our sample.

6. Conclusions

The spectral and extinction properties of 14 pre-main sequence star candidates in the central part of the very young open cluster NGC 6383 were investigated. From fitting of Kurucz (1991) models to their Spectral Energy Distributions, it was concluded that none of these stars shows any evidence for anomalous circumstellar extinction. However, six out of out 14 programme stars do show an infrared excess, indicative of the presence of circumstellar dust, heated up by the central star. No correlation between the infrared excess and the position in the cluster’s HR diagram could be found.

One programme star (number 4), has a large infrared excess, reminiscent of the one displayed by many Herbig Ae/Be stars. Furthermore, it shows $H\alpha$ in emission and shows some indications for the presence of circumstellar gas in its spectrum. Therefore it was concluded that this star can be considered as a new Herbig Ae star candidate. A literature search was done for photometric data for this star, but the available data do not show

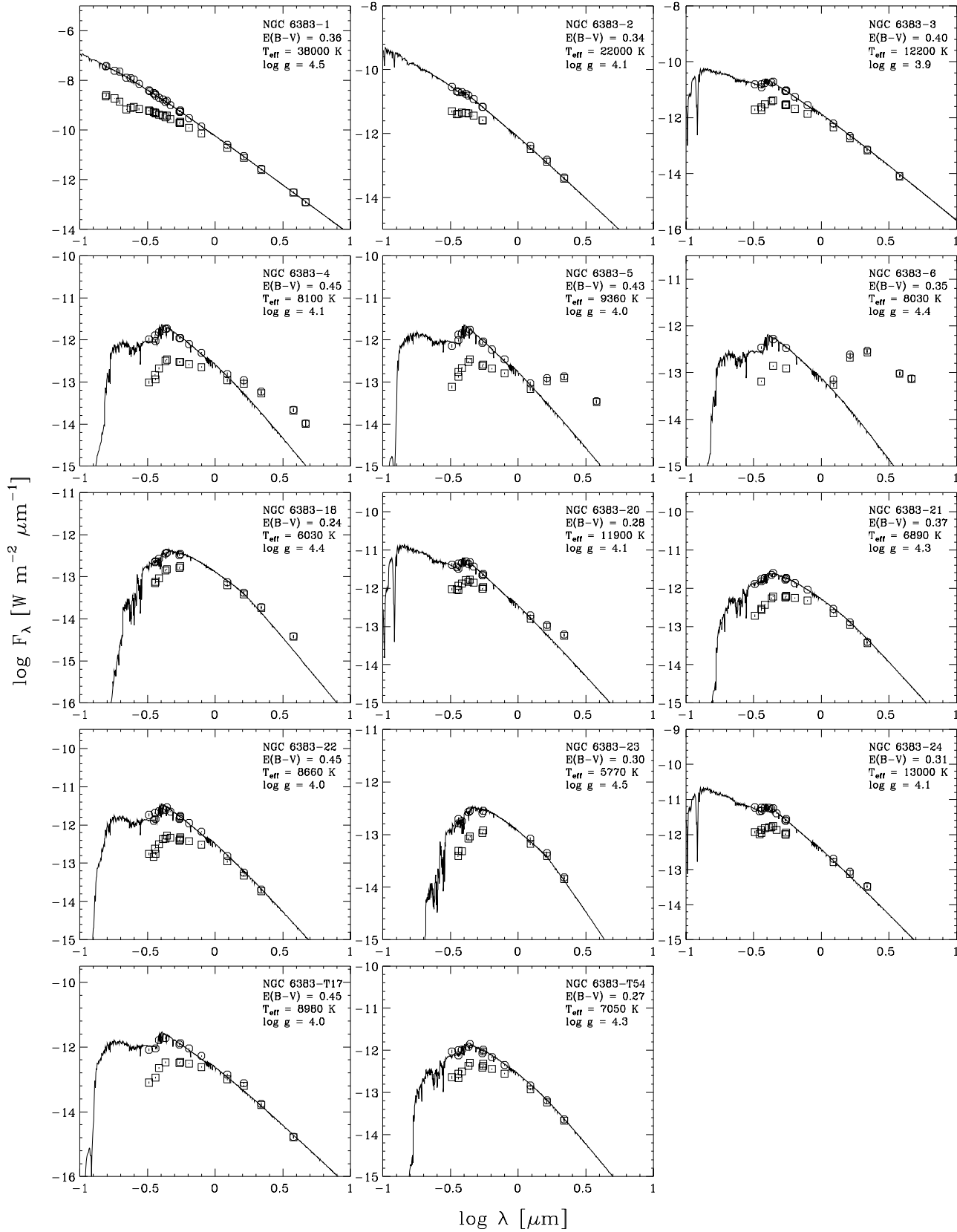


Fig. 2. Observed (squares) and extinction-free (circles) SEDs for all programme stars. The solid lines are the Kurucz (1991) models fitted through the extinction-free SEDs.

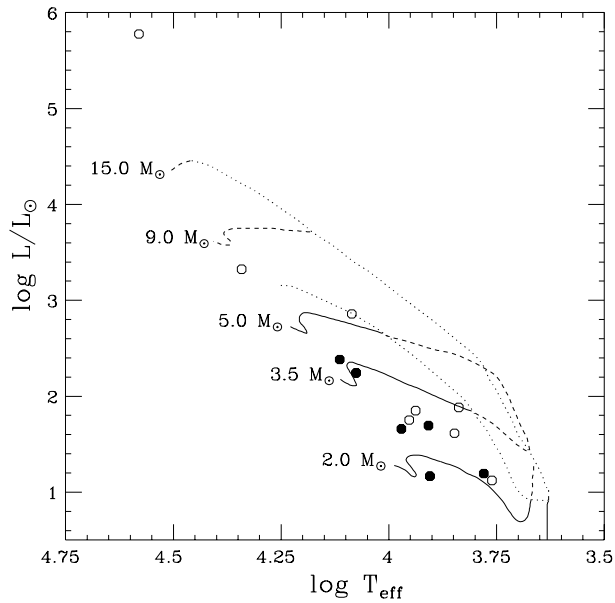


Fig. 3. Hertzsprung-Russell diagram of our programme stars in NGC 6383. The filled circles indicate the positions of the stars with infrared excess. Also shown are the theoretical pre-main sequence evolutionary tracks (solid lines and dashed lines) and the birthlines for 10^{-4} (upper dotted line) and $10^{-5} M_{\odot} \text{ yr}^{-1}$ (lower dotted line) by Palla & Stahler (1993).

any indications for photometric variability, such as displayed by many Herbig Ae stars.

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