Asociación Argentina de Astronomía
BAAA, Vol. 51, 2008
G. Dubner, D. García Lambas, A. Piatti & F. A. Bareilles, eds.

PRESENTACIÓN MURAL

On the Nature of the Stellar Group ESO442-SC04

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Abstract. We propose a definitive test on the real physical nature of ESO 442-SC04, an object which has been listed as a possible open cluster remnant (POCR) by Bica et al. (2001). In order to pursue such analysis, we carried out multi-object spectroscopy of stars in its inner area using GMOS at Gemini-South telescope. By determining their radial velocity and metallicity, in conjunction with 2MASS color-magnitude diagrams and proper motion analysis, we aim at evaluating if the stars form a physical system. Our analysis of the radial velocity data suggests that the stars are not dynamically bound, according to the large radial velocity dispersion ($\gtrsim$ 50 km/s).

Resumen. Proponemos un test definitivo acerca de la verdadera naturaleza física de ESO 442-SC04, un objeto catalogado por Bica et al. (2001) como posible remanente de un cúmulo abierto. A partir del análisis de sus velocidades radiales y metalicidades -obtenidas con el multiespectrógrafo GMOS del telescopio Gemini Sur-, en combinación con movimientos propios y diagramas color-magnitud 2MASS, evaluamos la posibilidad de que dichas estrellas formen un sistema físico. Nuestro aálisis de las velocidades radiales sugiere que las estrellas no se encuentran ligadas dinámicamente, de acuerdo a su relativamente gran dispersión de velocidades ($\gtrsim$ 50 km/s).

1. Introduction

As a consequence of the dynamical evolution of open clusters, it is an expected fact the occurrence of systems characterized by loose clumps with small number of stars in the intermediate state between well defined, concentrated, dense structures and disrupted systems. According to the present knowledge on how this dynamical evolution occurs, the timescales involved indicate that finding clusters in the state of dissolution should be common.
In this context, there is a controversy whether ESO 442-SC04 is, in fact, a dissolving open cluster or the result of a fortuit alignment of stars (Carraro et al. 2005). We propose a definitive test on its real physical nature.

2. Data Analysis

The Gemini Multi-Object Spectrograph (GMOS), on Gemini-South telescope, was used to collect spectra of 36 selected stars on a $5' \times 5'$ region centered on ESO 442-SC04. Radial velocity and metallicity standard stars were also observed using GMOS on longslit mode. Table **??** lists the observed standard stars and summarizes their properties as found in Nordstrom et al. (2004, radial velocities and metallicities) and SIMBAD (spectral types).

Table 1. Standard-stars properties

Object	ST	V_r (km/s)	[Fe/H]	$\overline{\text{E(B}-\text{V)}}$	$\sigma_{E(B-V)}$	E(B-V)$_{SCH}$	E(B-V)$_{BH}$
HD104471	G0V	-7.2 ± 0.1	0.00	0.26	0.10	0.08 ± 0.01	0.10 ± 0.01
HD104982	G2V	10.5 ± 0.1	-0.40	0.14	0.04	0.07 ± 0.01	0.09 ± 0.01
HD105004	F8VI	121.6± 0.3	-0.79	0.10	0.03	0.08 ± 0.01	0.14 ± 0.01
HD107122	F1V	16.2 ± 3.3	-0.42	0.04	0.03	0.07 ± 0.01	0.08 ± 0.01
HD111433	F3IV	4.0 ± 0.6	0.25	0.01	0.01	0.07 ± 0.01	0.07 ± 0.01
CD-289374	—	30.4 ± 0.2	-1.18	0.05	0.02	0.06 ± 0.01	0.09 ± 0.01

The collected spectra cover the spectral range $3875 - 5300$ with resolution $R = 3945$ ($\Delta\lambda = 1.2\,\text{Å}$) and dispersion of 0.4713 /pixel. Grating $B1200\_G5321$ was used with $0.5''$ slit width.

Radial velocities were determined by cross-correlation techniques using the FX-COR task. As a first step the task was applied on the standard stars set using the values given by Table **??** as a first guess to stars radial velocity. A self-consistent set of solutions was then obtained by making corrections to the velocities and redoing the correlation in order to find consistent values for the whole set.

Table **??** shows the results of the employed correlations and the averaged radial velocities obtained.

Table 2. Calculated radial velocities for the standard stars. Boldfaced values represent the velocities adopted for each template in the correlation.

star/template	HD104471	HD104982	HD105004	HD107122	HD111433	CD-289374
HD104471	**-126.3±11.5**	-7.5±5.2	118.0±15.1	16.7±25.9	-24.6±11.4	30.4±5.7
HD104982	-127.5±5.2	**-8.7±5.7**	114.0±13.4	9.4 ±24.7	-28.8±13.0	32.9±11.2
HD105004	-122.7±15.8	-1.1±13.4	**121.6±0.3**	19.6±27.9	-20.6±18.0	37.5±16.6
HD107122	-126.8±25.9	-1.9±24.7	118.2±27.9	**16.2±3.3**	-24.6±18.4	36.0±28.9
HD111433	-126.3±11.5	-4.5±13.0	117.6±18.0	16.2±18.4	**-24.6±11.4**	33.7±17.8
CD-289374	-128.8±11.2	-8.7±5.2	114.5±16.6	10.6±3.3	-27.9±17.8	**30.4±0.2**
$\overline{V_r}$	-126.4±6.1	-5.4±5.4	117.3±7.0	14.8±9.5	-25.2±6.3	33.5±6.6

Next, with the heliocentric velocities previously determined for the standard stars, FXCOR was run on the 17 science spectra using the 6 standard stars spectra as templates. Table **??** shows the used spectra, their corresponding S/N and the average radial velocities obtained.

2.1. Spectral type determination

Spectral types were determined by matching each star's spectrum against ELODIE 3.1 stellar spectral library (Prugniel & Soubiran 2001). As a first step we used ELODIE's lower resolution spectra ($R = 10000$) as templates to the standard stars spectra on task FXCOR in order to determine, through the sharpness of the correlation function peak (Tonry & Davis 1979), the most similar templates to each standard star.

The spectral types were determinated by collecting the ten most similar templates and selecting among them the most recurrent spectral type, giving priority to the ones with higher mean TDR. The determination of luminosity classes followed similar procedures. Table **??** shows the determined spectral types for standard stars and their spectral types as provided by SIMBAD (Table **??**).

Table 3. Comparison of determined Spectral Types for standard stars

	HD104471	HD104982	HD105004	HD107122	HD111433	CD-289374
Determined	K0III	G5IV-V	F8V	F0V	F3IV-V	G5IV
SIMBAD	G0V	G2V	F8IV	F1V	F3IV	—-

It can be seen that, except for HD104471, the spectral types determined by the adopted method are uncertain by up to 3 spectral subclasses. Guided by this result we used the same method to determine the spectral types of our science spectra, as shown in Table **??**.

2.2. Reddening Determination

Reddening was determined by using the Seaton reddening law (Seaton 1979) to deredden the object spectrum with a range of E(B-V) values and then finding the color excess that minimizes the object-template residuals. Figure **??** shows the dereddening process applied to one of our science spectra against the 3 best matching templates.
Table **??** shows the average E(B-V) found for standard-stars, and the standard deviation of the results. Color excess from Schlegel et al. (1998) dust maps ($E(B\text{-}V)_{SCH}$) and Burstein & Heiles (1982, scaled) HI maps ($E(B\text{-}V)_{BH}$) are also shown.
As the standard-stars determined color excesses showed good agreement with predicted values (except for HD104471), we used the same procedure to evaluate the color excess of each science spectra (Table **??**). The predicted color excess values in the direction of science-stars from the dust and scaled HI maps are respectively $E(B\text{-}V)_{SCH} = 0.08 \pm 0.01$ and $E(B\text{-}V)_{BH} = 0.10 \pm 0.01$.

3. Results & Conclusions

By means of cross-correlation with ELODIE's spectral library we were able to determine heliocentric radial velocities, spectral types and reddening for 17 stars in the inner region of stellar object ESO 442-SC04. These results are summarized in Table **??**.
Our results suggests that few, if any, of the studied stars are physicaly bound. The radial velocities obtained show dispersion greater than 50 km/s. Also reddening values calculated allow us to exclude only 3 stars with E(B-V) outside $1\,\sigma$ from the mean. Although further studies are still necessary, the data strongly points out that ESO 442-SC04 is not a physical system.

References

Bica E. et al. 2001, A&A, 366, 827
Burstein D. & Heiles C. 1982, AJ, 87, 1165 (BH)

Table 4. Radial velocities, spectral type and reddening for science spectra

Spectrum	S/N	$\overline{V_r}$	σ_{V_r}	Spectral Type	$\overline{E(B-V)}$	$\sigma_{E(B-V)}$
S2	15	75.8	7.2	G8III-IV	0.02	0.02
S6	40	9.5	5.2	G0I-II	0.15	0.05
S9	20	25.1	4.7	G0I-II	0.11	0.06
S10	10	93.6	10.3	KOIII	0.26	0.02
S12	20	227.2	12.7	G8IV	0.10	0.06
S14	25	110.0	10.9	G5IV	0.17	0.04
S15	30	78.5	7.5	K0IV-V	0.03	0.02
S19	50	68.0	8.2	G5IV	0.22	0.03
S20	25	74.4	6.9	K0III	0.13	0.02
S21	30	31.3	5.6	G5IV-V	0.13	0.05
S23	35	95.5	8.5	K0IV-V	0.14	0.04
S25	6	145.9	17.1	G0I-II	0.58	0.05
S28	30	15.0	5.4	G8III-IV	0.11	0.06
S29	22	10.7	7.1	K0III	0.10	0.04
S30	12	40.0	6.6	G8III	0.01	0.02
S32	10	47.0	6.7	K0III	0.03	0.03
S33	12	142.4	12.9	G8III	0.17	0.04

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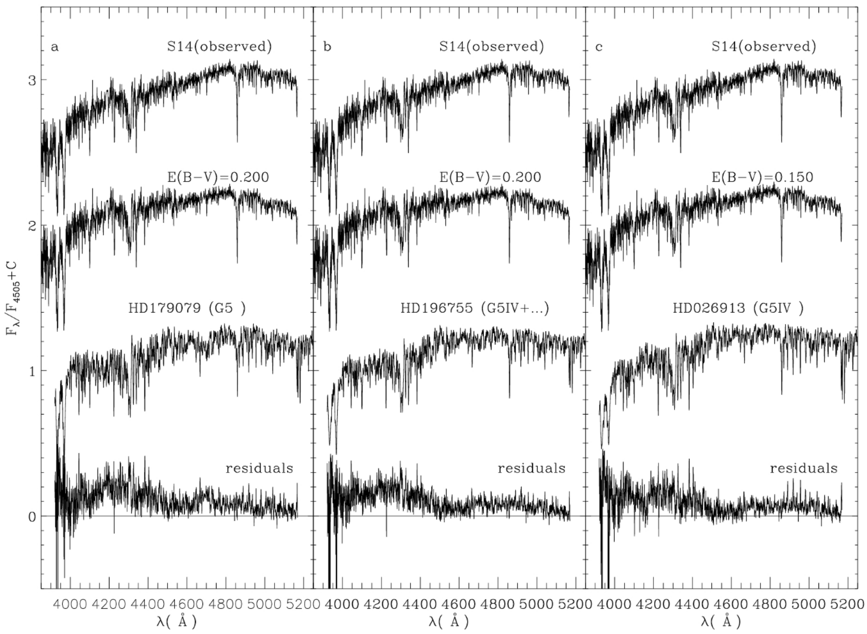

Figure 1. Dereddening process for 3 best templates of spectrum S14.