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New Results from the Project MASGOMAS: Near-IR Study of the Stellar Population of Sh2-152

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Abstract: We present a near-IR and optical spectrophotometric characterization of the stellar population of Sh2-152, as part of our MASGOMAS project. Using new broad band photometry (J, H and K_S) for the cluster and a control field, we have constructed CMD in order to select OB-candidates for H and K spectroscopy. Also, we have obtained the cluster mass function, with the disc population subtracted using the control field mass function. From the 13 spectroscopically observed stars, 6 were classified as B-dwarfs and with individual distance and extinction estimations. With these values we have obtained estimations for the distance (3.01 $\pm$ 0.11) kpc, mass (1.86 $\pm$ 0.83)$\cdot 10^3$ $M_\odot$ and age <8.1 Myr for Sh2-152. We also present a new optical spectrum for the central ionizing star of Sh2-152, showing some peculiarities associated to this central object and shed some light over the interesting star deeply embedded into the bright K_S nebulosity close to the IRAS source IRAS 22566+5828.

1 Introduction

Motivated by the discoveries of new massive stellar clusters, containing remarkable massive stellar populations (likes Arches and Quintuplet, Figer et al. 1999, RSGC1, Figer et al. 2006, RSGC3, Clark et al. 2009 or Alicante 8, Negueruela et al. 2010), the revelation of the massive natures of previously known stellar clusters (e.g. CygOB2, Knödlseder 2000; Westerlund1, Clark & Neguerela 2002) and the estimations of hundreds of galactic massive stellar clusters still unknown (Hanson & Popescu 2008), we have conceived the project MASGOMAS (MAssive Stars in Galactic Obscured MAssive clusterS, Marín-Franch et al. 2009, Puga et al. 2010), to characterize the stellar population of known massive clusters candidates and to discover new ones. Based on previous catalogues of galactic cluster candidates (Bica et al. 2003, Dutra & Bica 2001), we had completed a near-IR (J, H and K_S) photometric campaign for all our candidates and a spectroscopic follow up for 9 of them. One of these candidates is the star-forming compact H II region Sh2-152 (α(J2000)=22^{h}58^{m}45^s, δ(J2000)=+58°46′50″). Located in the Perseus (close to the Galactic plane; l = 108.76, b = −0.95), it contains two

IRAS sources (IRAS 22566+5828 and IRAS 22566+5830, Kleinmann et al. 1986), 6.7 GHz methanol (Szymczak et al. 2000), water and hydroxyl masers (Harju et al. 1998), indicating active massive star formation. This region has been the target of several near-IR observations but its stellar content has not been spectroscopically studied yet. We present a new near-IR spectrophotometric study and characterization of Sh2-152, using for first time information from several stellar sources from the cluster.

2 Observations

Our whole near-IR data set was obtained with LIRIS, an IR camera equipped with a Hawaii 1024×1024 HgCdTe array detector and a field of view of $4.2' \times 4.2'$. LIRIS has direct imaging, polarimetric and spectroscopic (single and multiobject) modes. Images were obtained with seeing around $0.6''$, while spectroscopy was acquired with seeing around $1.0''$. Thanks to the LIRIS near-IR image, we have been capable to resolve the central region of the cluster. The central ionizing star, previously classified as an O8.5 V star (Russeil et al. 2007), was spectroscopically observed at optical wavelength with the FIES cross disperser (R=46000) echelle spectrograph at NOT 2.5m (ORM-La Palma). Characteristic seeing for this observations was $1.5''$ and the final SNR for this optical spectra is less than 20. The images were reduced with FATBOY (Eikenberry et al. 2006) and the photometry was calibrated using 2MASS. The infrared spectra reduction was done with LIRISDR, while the telluric correction was completed with Xtellcor (Vacca et al. 2003) and telluric, an IRAF task. The optical spectrum was reduced with the FIEStool pipeline. A false colour image for Sh2-152 marking the position of the chosen stars for near-IR spectroscopy is presented in Figure 1.

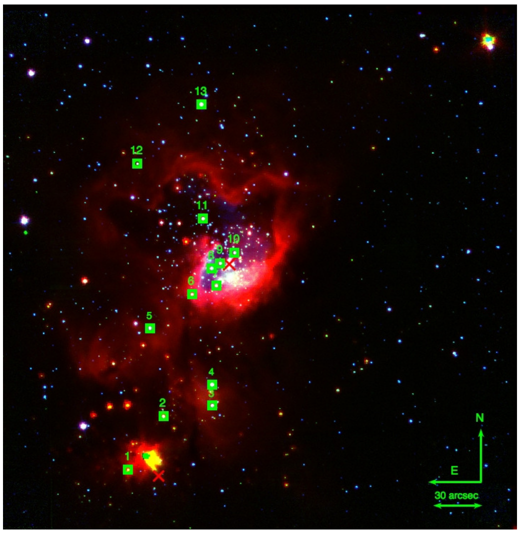

Figure 1: False colour image for Sh2-152, using LIRIS and Spitzer images (blue=J, green=K_S, red=Spitzer 3.6 μm). In this image, we mark the MOS stars with small green squares (numbered) and with red crosses, the IRAS regions IRAS 22566+5830 (central) and IRAS 22566+5828 (down).

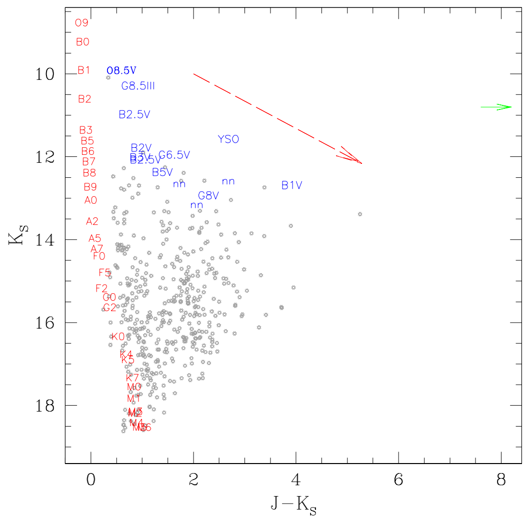

Figure 2: CMD for Sh2-152. The main sequence is located at 3.01 kpc. Spectral types in blue indicate the MOS stars and the origin of the green solid arrow shows the bluest position of the central star embedded into the bright nebulosity, associable with IRAS 22566+5828.

3 Results and Analysis

Using the derived CMD from our photometry, we selected OB-type candidates considering the LIRIS spectroscopic limit ($K_S \sim 12.5$) and its position in the cluster's field. Due to the differential reddening over the field, the cluster main sequence is spread to redder colours, following the reddening vector. To consider this effect, we also include as a selection criterion $J - K_S > 0.5$. The CMD for Sh2-152 is shown in Figure 2.

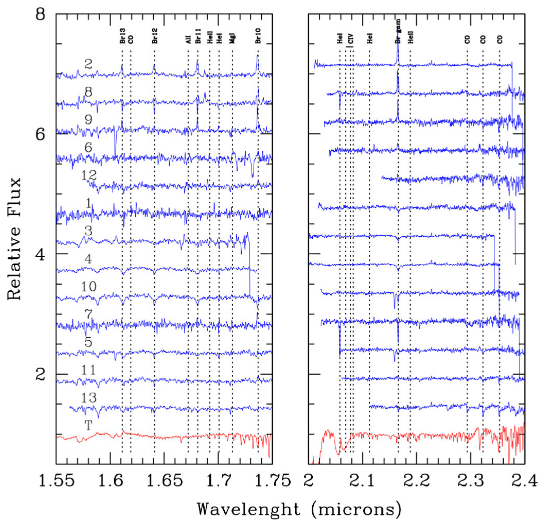

Figure 3: H and K spectra for MOS stars. In red are shown the respective telluric spectra.

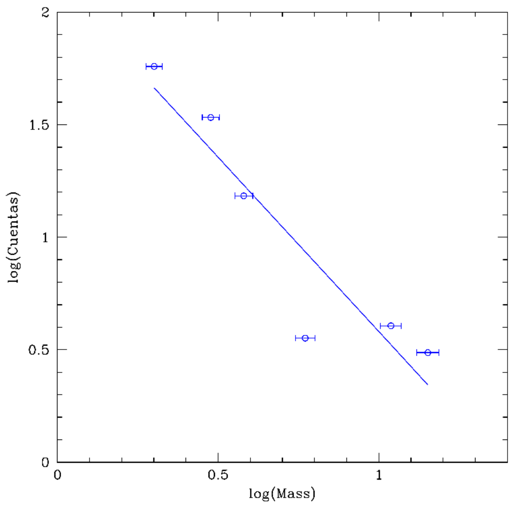

Figure 4: Mass function for Sh2-152. The solid blue line corresponds to the best fit to the data.

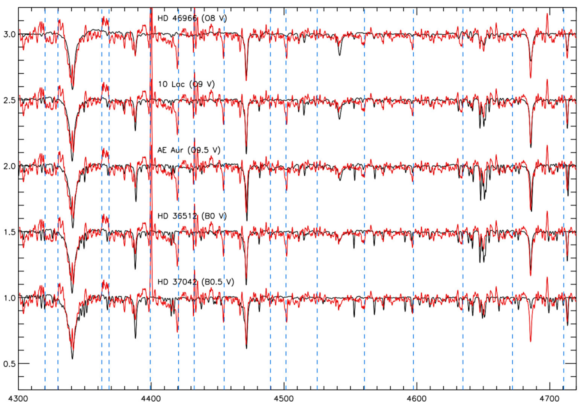

Figure 5: FIES optical spectra for the central star of the cluster (red) is compared with spectral type templates (O8 V to B0.5 V, in black). Remarkable are the depths of the helium lines and the non detection of Si III (4552Å and 4568Å).

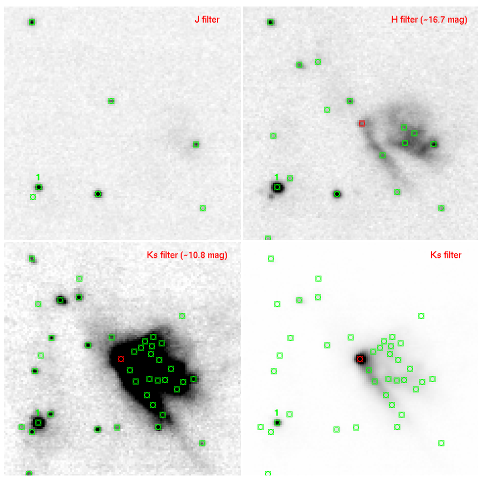

Figure 6: J, H and K_S image for IRAS 22566 +5828. Green squares mark the objects detected in our photometry. The red one, could be the central ionizing star of the nebulosity, marked with a blue arrow in the CMD. Star #1 corresponds to a MOS star.

ID	Spectral Type	A_{K_S}	Distance (kpc)
01	B1 V	2.60	3.35
03	B3 V	0.66	3.18
04	B2 V	0.50	2.92
05	B4 V	0.61	2.68
08	B3-5 V	0.65	2.96
10	B5-6 V	0.86	2.80

ID	Spectral Type
02	YSO
06	- (nebular)
07	- (nebular)
09	- (nebular)
11	G6.5 V
12	G8 V
13	G8-9 III

Table 1: Left: Early-type stars used for the distance determination. Central O8.5 V star was excluded due to saturated (LIRIS) or contaminated (2MASS) photometry. Right: Spectroscopically observed stars without determined spectral type or fore/background late-type stars.

3.1 Spectral Classification, Cluster Distance and Mass

Spectral classification was done using Hanson & Conti (1996), Wallace & Hinkle (1997), Hanson et al. (1998), Meyer et al. (1998), Ranade et al. (2004, 2007) near-IR stellar spectral catalogues. Adopting intrinsic colours (Ducati et al. 2001), absolute magnitudes (Cox 2000) and an extinction law with R=3.09 (Rieke & Lebofsky 1985), we have estimated a cluster distance of (3.01 ± 0.11) kpc, using for first time distance estimations for multiple sources in the field. The individual spectra are shown in Figure 3), and the stellar spectral types, extinctions and distance are summarized in Table 1. The cluster mass was obtained by substracting the stellar population from the Galactic disk, using J, H and K_S images from a control field. The cluster and control field histograms, previously corrected by completeness, were substracted leaving the mass function for the object, shown in Figure 4. The total mass of Sh2-152 derived with this method is $(1.86 \pm 0.83)\cdot 10^3$ $M_\odot$.

3.2 Possible Ionizing Sources

Within the Sh2-152 field there are two interesting sources. First, the central star of the cluster, that has been classified as O8.5 V (Crampton et al. 1978, Russeil et al. 2007) and gives an upper limit for the clusters age of 8.1 Myr (using stellar models from Schaller et al. 1992, and stellar mass from Martins & Plez 2006). From our optical spectra (Figure 5, SNR$\sim$20 per pixel at R=46000) we derive the same spectral type but observing that the He II 4686Å line is deeper than He I 4388Å and He II 4542Å, and very similar to He I 4471Å. We can not determine which line, He II 4686Å or He I 4471Å is stronger, but we note that fulfilling the condition He II 4686Å >He I 4471Å at spectral type $\sim$O9 would indicate that this star is an OVz object. However a spectrum with a better SNR is required to clarify this point. Also is interesting the non detection of Si III 4552Å and 4568Å, setting the spectral type to earlier than O9 V. On the contrary, the Mg II line at 4481Å is detected. The relatively strong He II 4686Å and the lack of Si III at a relatively late O spectral type could also be due to contamination of a companion object (either physical or visual). A better spectrum is needed to solve this uncertainty. The second object is the star colocated with IRAS 22566+5828 (Helou & Walker 1988). This object was not selected as MOS candidate, due to its huge extinction ($J - K_S$ >7), being impossible to measure its J brightness (see Figure 6). With K_S=10.8 and assuming the distance of 3.01 kpc calculated for the cluster, the central star deeply embedded into the nebulosity would have a spectral type earlier than O4 V, being the most massive object of the cluster. Future K or mid-IR spectra for this object would clarify its spectral type and membership to Sh2-152. If this is confirmed, it would contribute to diminish the cluster age and increase the upper part of its mass function.

4 Conclusions

As part of our MASGOMAS project, we have studied the stellar content of the compact H II region Sh2-152. We have obtained a distance estimation of (3.01 $\pm$ 0.11) kpc for the cluster, in agreement with Russeil et al. (2007). It is remarkable that this estimation was obtained for first time using near-IR spectra for multiple sources in the field. Using the cluster luminosity function, corrected by the stellar population from the Galactic disk using a control field, we estimated the cluster's stellar total mass in (1.86 $\pm$ 0.83)$\cdot 10^3$ $M_\odot$. We also set an upper limit for the cluster's age of 8.1 Myr, based on the most massive early-type dwarf, which has not evolved into its giant phase. Future works include the near-IR observation and analysis of the possible ionizing stars of IRAS 22566+5830 and IRAS 22566+5828. The spectral classification of the last one, could improve the cluster age and mass determination.

Acknowledgments

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