STUDIES OF THE PRE-MAIN SEQUENCE STARS IN THE H II REGION Sh2-87

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ABSTRACT

With an aim to accumulate the observational evidence of triggered star formation by the influence of massive stars, we are studying few molecular environment and young stellar objects surrounded by dense H II regions using multi-wavelength data in the optical to the mid-infrared (MIR) range. Identifying and characterizing the member stars in a given region, harbouring massive stars are key idea to understand the physical processes associated with new generation star formation. In this context, we present here a multi-wavelength analysis of an optical H II nebula Sh2-87 (S87), located at a distance of 2.242 kpc in Vulpecula OB association. S87 is a moderately populated region evolving with low-to-high mass ranges pre-main sequence sources, distributed in an embedded, high extinction region(Av ~0.118 mag-12.18 mag). Using optical and infrared data, we have estimated few critical parameters of the region. From optical to MIR colour-colour, colour-magnitude diagrams, spectral energy distribution, spectral features, and extinction map analysis, we reveal the evolutionary structure of S87.

- In order to understand the star formation activity in galactic H II regions, studies of the properties of various star-forming regions (SFR's) at different environments are very essential.
- We aim to explore the fundamental parameters like young stellar population, their classification, distance, reddening, age of the region S87.
- Using optical spectrophotometric analysis of a few bright sources, the spectral types are estimated to get further details about distance, membership, reddening of individual sources.
- From the deep NIR and MIR data, the different types of young stellar objects (YSO's) can be classified more precisely. From the spatial distribution of these YSO's, the structural evolution of the regions can be stated.
- We aim to explore the evolution of the Galactic H II regions and determine the physical conditions of their environs using multi-wavelength data.

STAR-FORMING REGION Sh2-87

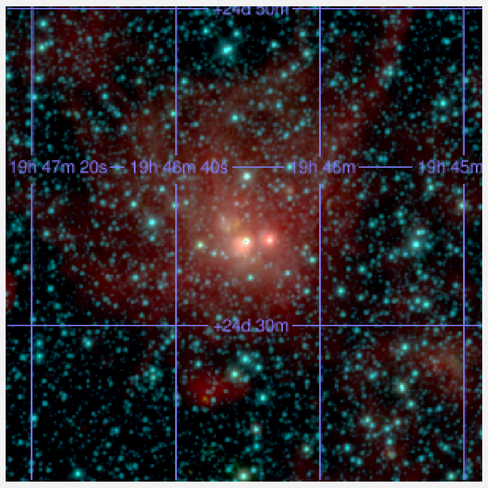

Fig 1. The figure shows the RGB image of Sh2-87, generated from WISE 3.4 µm , WISE 4.6 µm , WISE 12 µm three bands image blue, green and red.

Coordinate: RA (J2000) : $19^h\,46^m\,20.7^s$,
Dec (J2000) : $+24^o\,35^m\,15^s$

- **Distance** : ~ 2242 pc

Galactic H II regions concern the formation and early evolution of stars of various masses over a time scale of a few million years. S87 is an active site of star formation located at VulOB association at a distance of 2.242 kpc. The source of the excitation of this region is a B2E star, HD 338936 (Felli et al. 1981). A bright FIR source IRAS 19442+2427 (Xue et al. 2008) is associated with this region. Apparently, the SFR may not be isolated, another two H II regions S86 and S88 are the neighbours of this region. The presence of Bipolar outflows and H_2O maser line emissions indicates a strong star formation activity in this region.

DATA SETS USED

Observational Data :

Optical slit spectroscopy : Optical spectra are acquired from HFOSC on 2m HCT with suitable Grism specifications and different exposure times.

Archival Data :

Archival catalog data are taken from different NIR to MIR ground-based to space facility telescopes such as , WISE, IPHAS, SPITZER etc.

OPTICAL SPECTROSCOPIC RESULTS

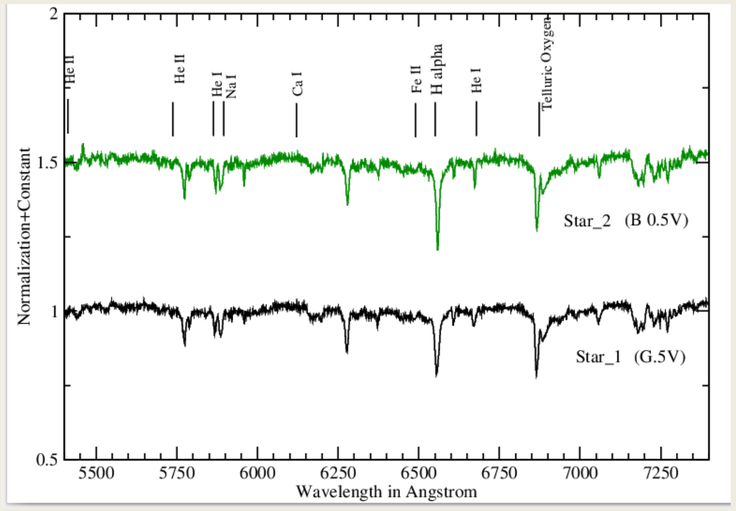

Fig 2.

Fig 2. The flux calibrated normalized spectra for optically bright sources of the region **Sh2-87** is shown here. The spectroscopic data were obtained from **HFOSC** of **2m HCT**, India using **Grism 8 (5800-8350 Å)**. Details of spectroscopic observations are given in Table 1.

Table 1

ID	$\alpha_{(2000)}$ (h:m:s)	$\delta_{(2000)}$ (d:m:s)	Spectral classification	Distancwe (pc)
Star_2	19:46:22.67	+24:37:48.03	B0.5 V	1309
Star_1	19:46:19.91	+24:37:52.11	G5V	184

CLASSIFICATION AND CHARACTERIZATION OF YSO's USING MIR COLOR-COLOR AND COLOR-MAGNITUDE DIAGRMS

YSO's show excess emission in infrared (IR) wavelengths above bare photosphere due to thermal emission from their circumstellar material. Hence, IR survey of a SFR can be used as a powerful tool to distinguish the stars with IR excesses from stars without such excesses. YSO's are categorized into Class 0, I, II and III evolutionary stages.

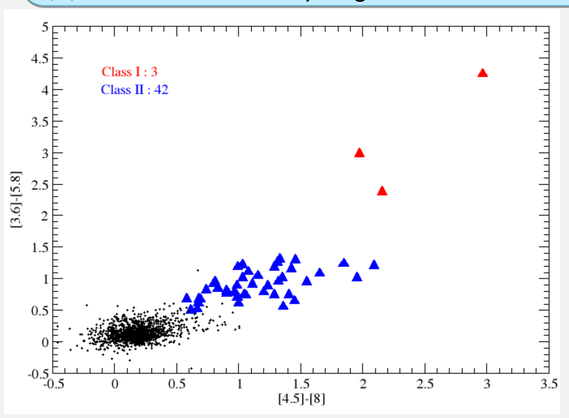

Fig 3.

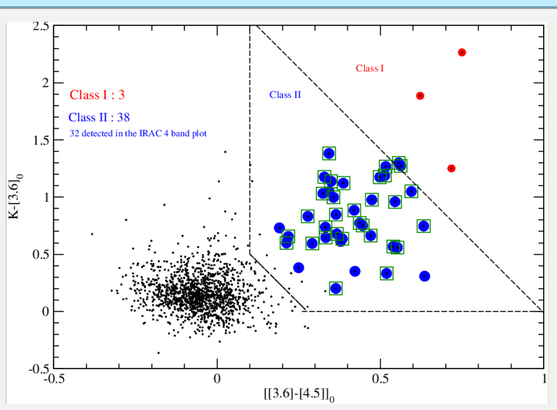

Fig 6.

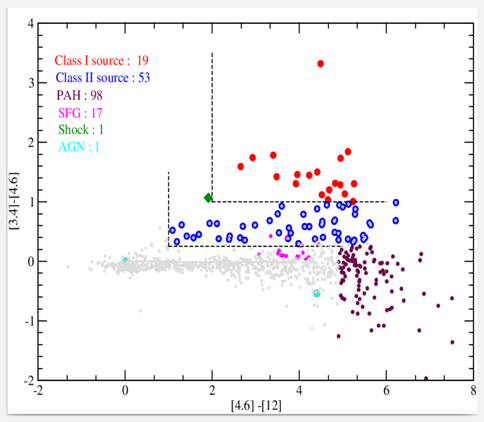

Fig 5.

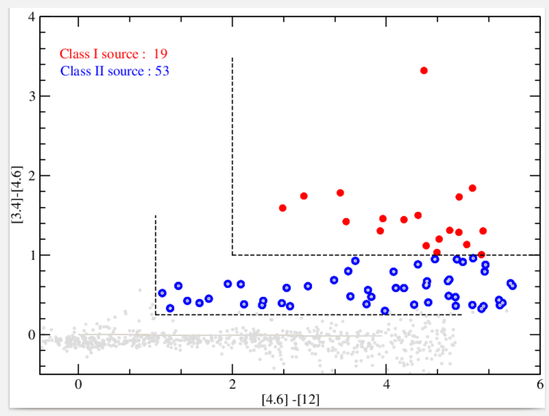

Fig 6.

Fig 3. IRAC 4 band color-color diagram with 42 Class II (blue circles) and 3 Class I (red circles).
Fig 4 . 2MASS-IRAC color-color diagram with 38 Class II (blue circles) and 3 Class I (red circles). Among them 32 are already detected in the IRAC 4 band. Green Box indicated already detected class II starsin IRAC 4 band plot.
Fig 5&6. ALLWISE band 1, 2 and 3 color-color diagram, showing the distribution of diskless (grey dots),with PAH,Shock, AGN, SFG and 53 Class II (blue circles) and 19 Class I (red circles), source classification scheme is adapted from Koenig et al. 2012. Dashed lines indicate the boundaries by which we classify Class I and Class II sources.

IPHAS PHOTOMETRIC RESULTS

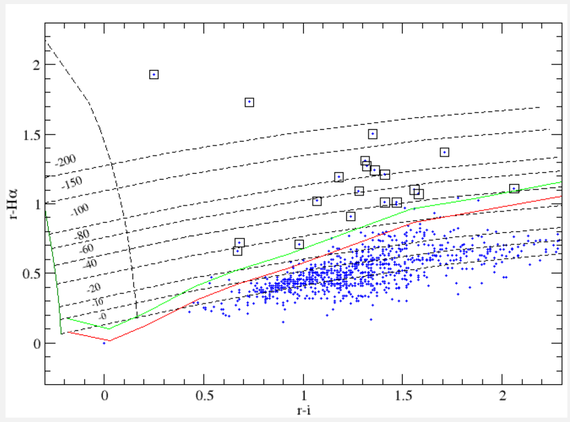

Fig 7.

Fig 7. shows the IPHAS CC diagram (r-i) vs. (r - H α) in the star-forming region Sh2-87. Following the method of Barentsen et al. 2014, the greenline is chosen as CTTS threshold for H α emission stars and we've selected 20 sources as Hα emitting stars, which are located above the 3σ confidence level from CTTSs threshold.

Reuslts & Discussion

In this work we report multiwavelength analysis on young cluster S87, a compact nebulosity.

- By matching the YSOs as identified from the different color-color diagram, **23 class I** one and **76 class II** soucres have been classified.
- From the spectral analysis of two bright sources, they have been primarily classified.
- From the IPHAS cc diagram, **20 H alpha** sources have been identified.
- Thus the multi-wavelength study will give a compact result.

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