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Bright-rimmed clouds and Young Stellar Objects in IC 1396

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Abstract. Spectroscopic observations of Young Stellar Objects (YSOs) in IC 1396 are presented. It is found that there is a systematic variation, as a function of position, in W_λ (Hα) of the YSOs in/around SFO 38 e.g YSOs close to bright-rim have stronger Hα emission and show significant variations compared to the W_λ (Hα) obtained from literature. The nearly coplanar geometry of HD 206267 and the globules is also discussed using 1.4 GHz images from NRAO VLA Sky Survey.

Keywords : ISM: globules, stars: formation, pre-main-sequence, HII regions: IC 1396

1. Space distribution of Bright-Rimmed Clouds (BRCs)

IC 1396, a bubble shaped Galactic H II region in Cep OB2 association, is ionized by the O6.5V star HD 206267. 11 globules with embedded IRAS sources and several other globules (with/without bright-rims) have been found near the border of IC 1396. From Morgan et. al. (2004), the relation between the rate of Lyman continuum photons ($\Phi, cm^{-1}s^{-1}$) and the intensity of free-free emission (S, mJy) associated with the ionized rim can be written as, $\Phi = 1.24 \times 10^{10}\ S_\nu\ T_{\rm e}^{0.35}\ \nu^{0.1}\ \theta^{-2}$, where $T_{\rm e}$ is the effective electron temperature of the ionized gas in K, ν is the frequency of the free-free emission in GHz and θ is the angular diameter over which the emission is integrated in arcseconds. We used the 1.4 GHz images from NRAO VLA Sky Survey (NVSS) (Condon et al. 1998). We estimate the distances for SFO 36 , SFO 38 and SFO 40 from the central O type star as 5.7 pc (4 pc), 12.6 pc (10.4 pc) and 14.6 pc (13.4 pc)

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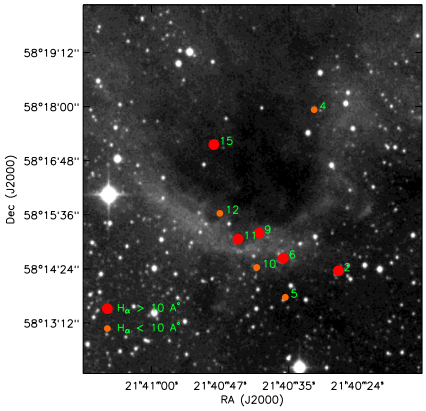

Figure 1. Hα emission YSOs in SFO 38.

respectively. Projected distances, given in brackets, are calculated assuming a distance of $\sim$ 900 pc of IC 1396. The similarities between the projected and estimated distances of the globules indicate a nearly coplanar geometry of HD 206267 and the globules and also justify the distance of IC 1396.

Table 1. W$_\lambda$ (Hα) and NIR excess of the YSOs.

Object Number	W$_\lambda$ (Hα)(Å) Ogura et al.	W$_\lambda$ (Hα)(Å) This work	(J-H) 2MASS	(H-K) 2MASS
2	−59.3	−70	1.00	0.42
4	–	−5	1.14	0.50
5	−4.0	−3	0.93	0.34
6	−63.3	−52	1.01	0.66
9	−26.1	−46	1.36	0.92
10	−14.8	−8	1.03	0.45
11	−75.7	−29	1.27	0.69
12	−19.0	−3	0.94	0.28
15	−22.2	−17	1.28	0.73

2. Young Stellar Objects associated with the BRCs in IC 1396

We have combined the lists of Ogura et. al. (2002) and Getman et. al. (2007) to select potential YSO candidates for spectroscopic observations. Medium resolution ($\sim$ 7 Å) spectra of the selected candidates were taken during 2008 in the wavelength range (5200-9200 Å) with the Himalayan Faint Object Spectrograph Camera (HFOSC) mounted on the 2-m Himalayan *Chandra* Telescope

(HCT), Hanle, India. We find that there is a systematic variation, as a function of position, in W_λ (Hα) of the YSOs e.g YSOs close to bright-rim have stronger Hα emission and show significant variations compared to the W_λ (Hα) of Ogura et. al. (2002) (Fig. 1) which indicate that YSOs which are close to the rim are the youngest and accreting material from its surrounding . We list the W_λ (Hα) of the selected objects along with near-IR excesses obtained from 2MASS in Table 1. Supportive evidences of triggered star formation scenario have been reported in comparatively massive BRCs of IC 1396, SFO 36 and SFO 38 and also cometary shaped BRC SFO 37. We do not find any near-IR colors star near SFO 35 and SFO 34 though they are at projected distance of 17 and 14 pc respectively from HD 206267. Based on the analysis of 2MASS (Skrutskie et. al. 2006) data, we have identified 2 near-IR excess stars on the heads of two globules which are at a average projected distance of 15 pc but they are not categorized as BRCs. This kind of discrepancy could be due to the effect of asymmetric radiation (as HD 206267 is not exactly at the center of the bubble) or due to the density, mass or size of the individual globule. Detailed studies of these globules and the associated YSOs will be helpful to understand these issues.

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