Optical study of the Southern high mass star forming region RCW 34

R.J. Czanik, D.J. Van der Walt, S.I. Loubser

Centre for Space Research, North-West University, Potchefstroom campus, Potchefstroom 2520, South Africa

E-mail: `20175132@nwu.ac.za`

Abstract. RCW 34 is a Southern HII region in the constellation of Vela. Recent studies on the region by Bik et al. (2010) and De Villiers (2009) indicated that there is a strong presence of PMS stars in the region. A photometric and spectroscopic done in 2002 showed that there are PMS stars in a wide $7' \times 7'$ field surrounding the HII region of which two exhibit an Hα emission line. A follow up spectroscopic study done in 2011 found 4 more stars that exhibit an Hα emission line.

1. Introduction

Stars are the most basic luminous objects in the Universe and are the building blocks of large structures like galaxies. All of the stages of stellar evolution are well understood, one exception being their formation which occurs deep in molecular clouds. A theoretical foundation for star formation involves an understanding on the dynamics of molecular cloud collapse when its mass exceeds the critical Jean's mass, and how a starless part of the molecular cloud contracts due to radiative cooling under the influence of gravity.

The collapse of molecular clouds with sufficient angular momentum will result in the formation of discs. Hartman[1] (1998) states that from these discs, those with high enough angular momentum will form accretion discs. The matter in the centres of these accretion discs results in the formation of protostars. The first accretion disc model was proposed by Lynden-Bell[2] (1974) which can describe most of the properties of T Tauri stars. These are lower mass pre-main sequence stars characterized by variable luminosity and an infrared excess due to dust emission from an accretion disc. Lynden-Bell[2] (1974) can explain a strong blue spectrum that spikes in the ultra violet by means of dust moving from an elderly disc towards the star's atmosphere. Excess matter left over after star formation has occurred may result in planet formation.

A star forming region that is only visible in the Southern hemisphere and which is not often mentioned in the literature is RCW 34 (α=08:56:28.1;δ=-43:05;28) which was first catalogued by Alex Rodgers, Colin Campbell, and John Whiteoak in their nebula catalogue published in 1960. A stacked image of RCW 34 is shown in figure 1 Although this region has been studied by a number of researchers, it was only recently that a small number of new studies revisited this region. One of them is the near-infrared (NIR) study of De Villiers[4] (2009). Using data obtained with the 1.4 m IRSF telescope at Sutherland a total of 1283 objects were found in the J, H and K bands in a field of $7' \times 7'$ centred on the star which excites the HII cloud. Using their NIR colours in a J-H against H-K two-colour diagram, De Villiers (2009) found that a group of nearly 800 objects cluster near and above the empirical classical T Tauri locus of Meyer et al.[3] (1997) as shown in figure 1. The formula for the empirical classical T Tauri locus is:

$$(J - H)_{CTTS} = 0.58 \pm 0.11 \times (H - K)_{CTTS} + 0.52 \pm 0.06 \tag{1}$$

This group might be reddened classical T Tauri's[1]. A smaller group of objects seem to cluster above the main-sequence branch, which might be reddened weak line T Tauri[2] type stars.

2. Observation and data reduction

The photometric and spectroscopic data were obtained in February of 2002 by D.J. van der Walt. The photometric data was collected with Dandicam on the 40″ telescope. The spectroscopic data was collected with grating number 6 and the longslit spectrograph on the 74″ telescope at the SAAO in Sutherland. The follow up spectroscopic data was collected with grating number 7 and the longslit spectrograph on the 74″ telescope during February of 2011.

The photometric images were stacked in IRAF with a sum algorithm, resulting in a total exposure time of U: 960, B: 3110, V: 2850, R: 2250 and I: 2250 seconds. The spectroscopic images were stacked after aperture extraction using a sum algorithm in IRAF.

The spectroscopic observations done is 2002 was of 12 sources in the blue with peak wavelength of $\lambda = 4500\mathring{A}$. 22 sources were observed in the red region which has a peak wavelength of $\lambda = 5900\mathring{A}$.

From the photometric study very few sources were discovered in the U, B and V so that 184 sources matched in the R and I. In the NIR study by De Villiers (2009) a smaller field was observed so that from the 184 only 172 matched so that a magnitude in the R, I, J, H and K were available. It was decided that only sources with an apparent R magnitude of 17.5 would be practically observable with the 74″ telescope, the list was narrowed to 76 candidates. From the 76 sources a total of 38 were observed. Those with $M_R < 16$ had an exposure time of 1200 seconds while if $M_R > 16$ an exposure time of 2400 seconds was used. The sequence of observation of the candidates were according to their H-K colours, starting with the most reddest sources.

The photometric and spectroscopic data were reduced with the IRAF software package. A collection of 25 standard e-region stars were used for the photometric calibration. The spectroscopic dataset observed in 2002 was normalised by means of polynomial fitting. The standard star that was used for flux calibration in the spectroscopic dataset obtained in 2011 is LTT-3864.

3. Results and discussion

3.1. Photometry

The sources were dereddend using $A_V = 4.2$ as measured for the HII region by Hedary-Malayeri et al.[5] (1987). The distance modulus was calculated for the distance of 2.5 kpc as measured by Bik et al.[6] (2010). A control population of 23 PMS stars as observer by Cusano et al.[7] (2011), were dereddened for a distance of 4 kpc and each star for its individual value of A_V. All of the observed sources were dereddened using the interstellar extinction law as given by Rieke and Lebofsky[8] (1985).

The colour-magnitude diagram shown in figure 3.1 shows the population observed by Cusano et al. (2011) and which they discovered to be younger than 10 Myrs. A metallicity of $Z = 0.02$ was used in the construction of the main sequence branch for an age of 10 Myrs. The population for RCW 34 seems to be in the same age range as the comparison population because both

---

[1] Classical T Tauri's are T Tauri class stars where the accretion disc has a very strong emission in the near .

[2] Weak line T Tauri stars are pre-main-sequence stars of which the accretion disc has stopped contributing matter to the protostar and has receded from the centre of the formation region.

populations cluster above the main sequence branch. The molecular cloud associated with RCW 34 lies towards the top of figure 1 so that the extinction may be higher for stars in this region of than those close to the HII region. Pagani et al.[9] (1993) shows that the molecular cloud spans the entire top half of figure 1, with the densest part of the cloud almost next to the dissociation region of the cloud. No stars in the population of RCW 34 shown in figure 3.1 have an absolute magnitude fainter than $M_R = 5$. This can be due to incorrect calculation of extinction for individual stars. It can also be due to the chosen limit of an apparent magnitude of $M_R = 17.5$ for the candidates.

3.2. Spectroscopy

Out of the set observed in 2002 two were identified to have an Hα emission line shown in figure 3.2. A set of 38 stars were observed during 2011 from which 4 showed an Hα emission line shown in figure 3.2. An Hα emission line is due to an accretion disk around a proto-star and is characteristic to a T Tauri class star. The position of each star is given in figure 3.1. Stars A and F lies far from the molecular cloud and the HII region and stars B and C lies in an open crescent area where the excited gas has been blown away. Star D and E lies close to the densest part of the molecular cloud as shown by Pagani et al.[9] (1993). Star D and E has an apparent magnitude of 12.51 and 12.11 which suggests that the stars may lie outside of the molecular cloud.

4. Conclusion

The colour magnitude diagram in figure 3.1 shows that the population of 76 objects in RCW 34 are PMS stars due to their position relative to the isochrones. An accurate estimation of most of the stars' age cannot be made without more precise knowledge of extinction in the region. The position of the six stars that showed Hα emission lines gives an indication that the emission comes from an accretion disc and not from heated gas to each star.

References

[1] Hartman L 1998 *Accretion processes in star formation* 1st ed (*Cambridge Astrophysical series* vol 32) (Cambridge University press) ISBN 0 521 43507 2

[2] Lynden-Bell D; Pringle J 1974 *Monthly notices of the Royal Astronomical Society* **168** 603–637

[3] Meyer M R, Calvet N and Hillenbrand L A 1997 *Astronomical Journal* **114** 288–300

[4] de Villiers H 2009 *A near-infrared study of the Southern high mass star forming region RCW 34* Master's thesis North-West University, Potchefstroom campus

[5] Heydari-Malayeri M 1988 *Astronomy and Astrophysics* **202** 240–252

[6] Bik A *et al.* 2010 *The Astrophysical Journal* **713** 883–899

[7] Cusano F *et al.* 2011 *Monthly notices of the Royal Astronomical Society* **410** 227–240 (*Preprint* `1009.0435`)

[8] Rieke G H and Lebofsky M J 1985 *The Astrophysical Journal* **288** 618–621

[9] Pagani L, Heydari-Malayeri M and Castets A 1993 *Astronomy and Astrophysics* **275** 573–+

Figure 1. [Left] A deep-field colour-composite of the B, V, and R filter images. The total exposure time of the image is 8210 seconds. [Right] Near infrared two-colour diagram for the 1283 sources that were discovered by De Villiers (2009). The green lines are the empirical T Tauri locus and it's upper and lower limits and given by Meyer et al.[3] (1997)

Figure 2. [Left] Colour magnitude for the 76 candidate stars with isochrones and the 23 PMS stars observed by Cusano et al.[7] (2011). [Right] The 6 stars that showed an Hα emission line.

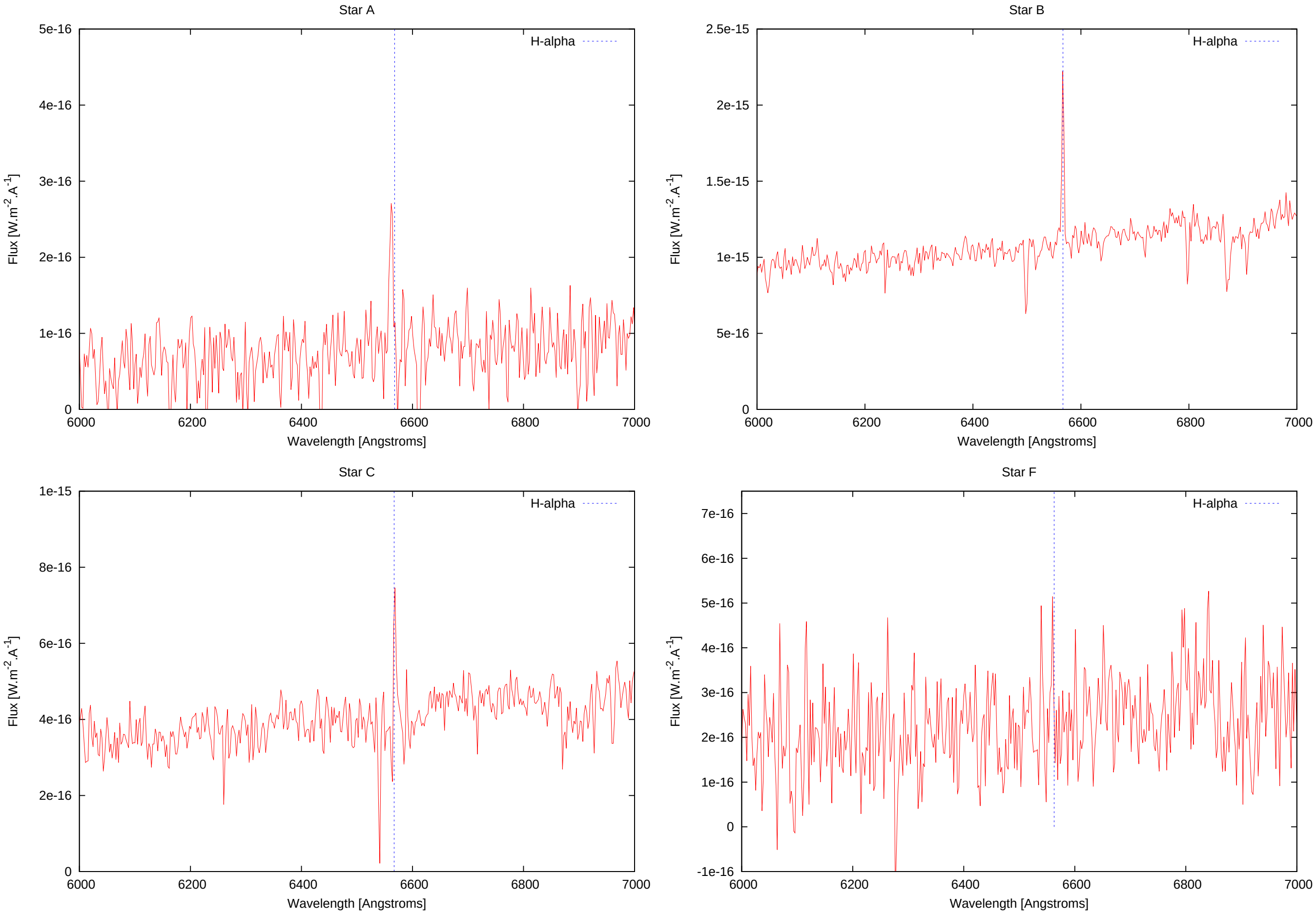

Figure 3. The four stars that were discovered in 2011 indicating an $H\alpha$ emission line.

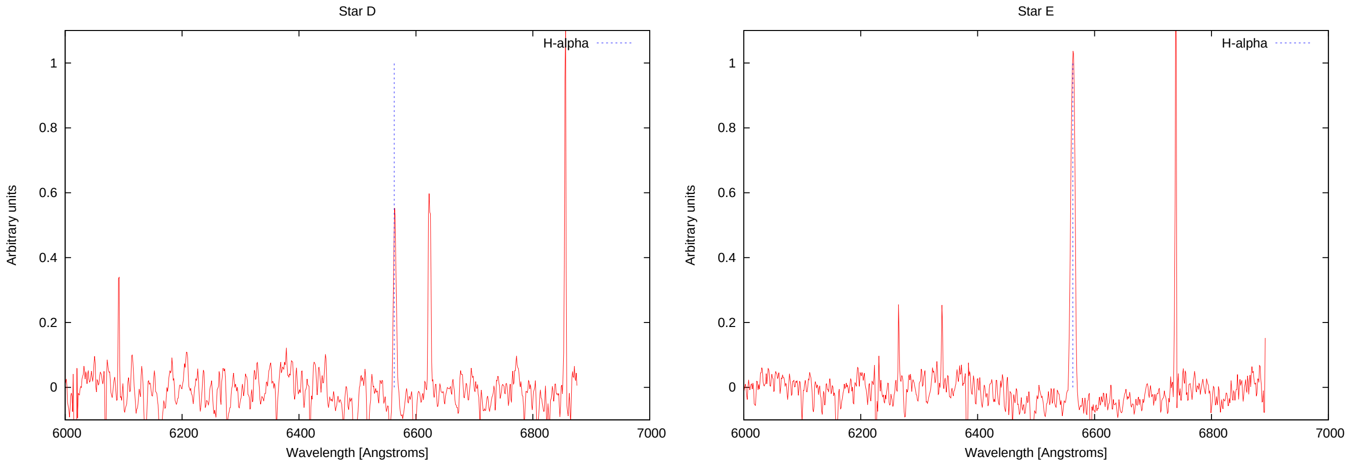

Figure 4. The two stars observed in 2002 that shows an $H\alpha$ emission line.