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A near-infrared photometric study of the massive star forming region IRAS 21413+5442

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Abstract. We report initial results from the near-infrared continuum studies on the massive star forming region IRAS 21413+5442. The colour-colour diagram and colour-magnitude diagram were used to determine the evolutionary stage and type of the central object powering the compact HII region. Distance to the object is estimated from H band flux in combination with published radio continuum fluxes.[1]

Keywords : star formation – compact HII region – infrared photometry – IRAS sources: IRAS 21413+5442

1. Introduction

IRAS 21413+5442 is one of the most luminous massive star forming regions situated at a distance of 7.7 kpc (Wouterloot et al., 1989). The source is associated with an ultra-compact region. The far infrared luminosity calculated from IRAS fluxes at 12, 25 and 60 μm is 32x10^4 L$_\odot$ and makes it one of the most luminous infrared YSOs (Carpenter et al., 1995 and Campbell et al., 1989). The CO surveys of Shepherd and Churchwell (1996) have classified this source as a massive star forming region with outflows of high velocity gas. Ishii et al., (1998 and 2002) have identified 3.1μm H_2O ice absorption indicative of the nebular matter around this object. The aim of the present infrared observations is to investigate the region surrounding the massive YSO as well as the massive YSO itself. Combining our infrared data with published radio continuum fluxes(Miralles et al. 1994), we estimate the distance to the object which was the subject of considerable debate (see Shepherd and Churchwell 1996).

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[1]A full paper describing results and discussions that include GMRT radio continuum observations is under preparation with S.K. Ghosh, D.K. Ojha and S. Vig of TIFR, Mumbai.

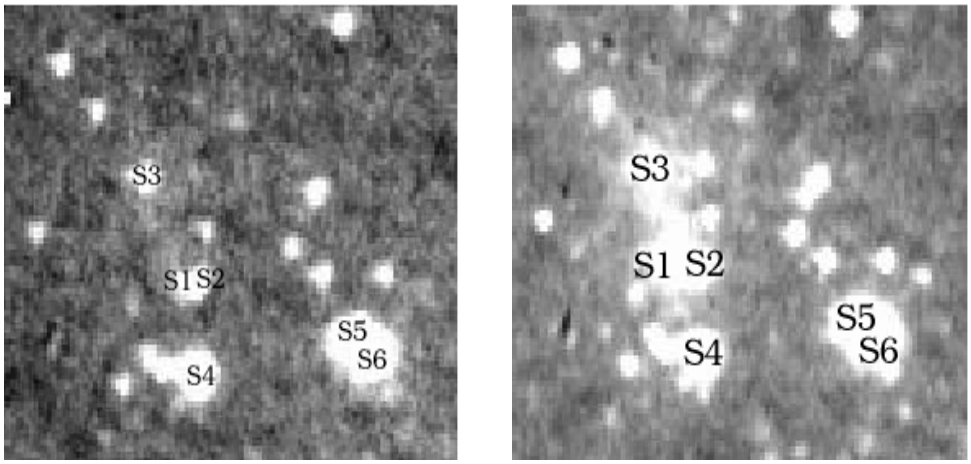

Figure 1. J band (left) and H band images (right) of IRAS 21413+5442. The field of view is $2' \times 2'$. North is up, east is to the left.

2. Observation and data reduction

The near-infrared (NIR) photometric observations were made in the J(1.253μm/0.296μm), H(1.659μm /0.288μm), K$'$(2.120μm/0.360μm) bands during 23 & 24 October 2003 using the 1.2 m PRL Infrared Telescope, Mt. Abu attached with a 256×256 HgCdTe array (NICMOS-3) camera/spectrograph. The plate scale is $0.5''$/pixel corresponding to a field of view $2' \times 2'$.The images were subjected to standard procedures like dark and sky subtraction and flat-fielding. The images were then co-added to obtain a final image in each band averaged over a total integration time of 1300s in the J,H and K$'$ bands respectively. The data reduction was done using the DAOPHOT (Stetson 1987) package in IRAF. The flux calibration was done using ARNICA standards AS 37-1&2 observed on the same dates as the programme object. The limiting magnitudes obtained for the above said integration time in the J, H and K$'$ bands are 17.62, 16.29, 14.90 respectively.

3. Results and discussion

Figure 1 shows the J and H band images of the star forming region IRAS 21413+5442. Figure 2 shows the colour-colour diagram(C-CD) and colour-magnitude diagram(C-MD) of sources from the 2 Micron All Sky Survey (2MASS) public archive over a search radius of $1'$ around the central source. In C-CD the solid curve is the locus of points corresponding to unreddened main sequence stars and giants (Bessell and Brett 1988). The two dotted parallel lines are the reddening vectors drawn up to the visual extinction of A_v=20. Young Stellar objects are usually identified with intrinsic colour excess and hence occur on the right side of the reddening vector (Lada and Adams 1992; Lada et

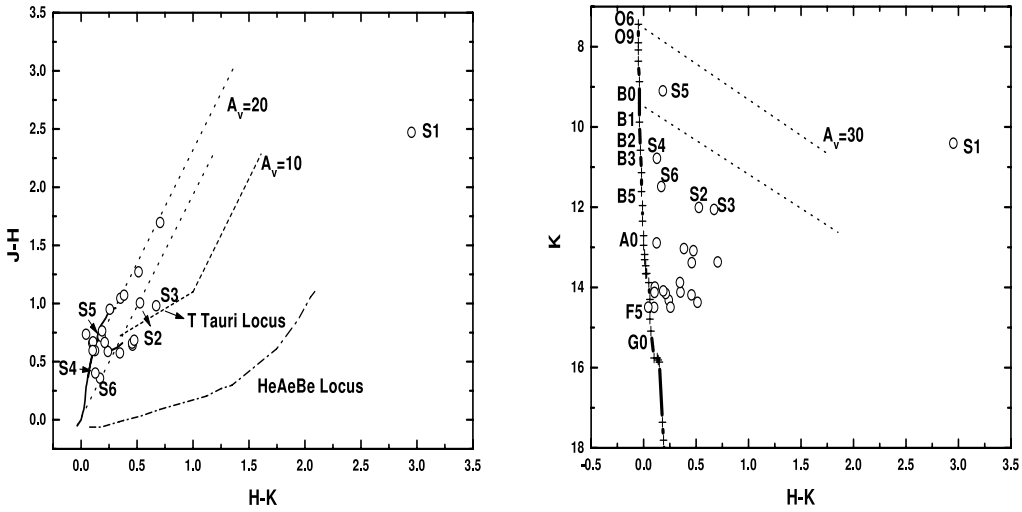

Figure 2. Colour-colour and colour-magnitude diagram of the sources from 2MASS.

al., 1993). The loci of the CTTS and HeAeBe stars and the reddening vectors for CTTS locus are also shown. In the C-CD the sources situated at 30″ around the central source are designated by S1...S6. The central source in IRAS 21413+5442 (S1) was beyond the completeness limit in the J band, but detected in the H and K′ bands by 2MASS. At long integrations we were able to detect the central source in the J band (mag = 15.83) and the point represented as S1 corresponds to the colour obtained from Mt. Abu observations. The rest of the photometric results from the Mt. Abu observation were close to 2MASS with a few showing a deviation of $\leq$ 0.5 magnitudes in certain cases. From the position of S1 in the C-CD it is evident that it is a Class I YSO with infrared excess.

The solid line in the C-MD represents unreddened main sequence stars (Koorneef 1983; Bessell and Brett 1988) and dashed line is the reddening vector of A_v=30 mag. In the C-MD the sources situated at 30″ around the source are represented from S1 to S6. It is evident from the C-MD that the central source suffers greater extinction. So this position in the C-MD suggests the central region to be ∼O6 YSO, which agrees with the earlier results (Ishii et al., 2001). S3 is the ionizing star for the compact HII region north of UCHII region around S1. S3 could be of type B3-B5. S2 is very close to S1 and is likely to be B3-B5 type. The other stars in the cluster namely S4, S5 and S6 appear to be mainsequence stars of spectral type B0-B3. The absolute K magnitude calculated using the extinction law, distance modulus and following Palla and Stahler (1999) evolutionary tracks further suggests that these stars to be massive with spectral type of early B or late O.

The VLA radio observations at 2 and 6 cm by Miralles et al., (1994), resolved the two HII regions and tabulated the physical parameters obtained from the radio fluxes for the

two regions. An approximate method was proposed by Comeron and Torra (2001) for finding the distance to HII regions. This method uses radio continuum flux in combination with de-reddened H band flux to find the distance under some usually valid assumptions (see Comeron and Torra, 2001 for details). We have used a standard method to find the extinction in K band and then using Rieke and Lebofsky's (1985) extinction law, found the de-reddening in the H band flux. In this way, we obtained a distance of 4.9 - 6.4 kpc which is in reasonable agreement with the value of 7.7 kpc derived by Shepherd and Churchwell(1996).

4. Conclusion

NIR photometric observations were made over a large region surrounding the massive YSO IRAS 21413+5442. These observations were used to study the nature of the YSO and the other surrounding stars. The massive YSO appears to be a late O type star powering the ultra-compact HII region. The distance to the object was estimated to be 4.9-6.4 kpc by combining our infrared and published VLA radio continuum fluxes.

Acknowledgements

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