Near-IR and *HERSCHEL* observations of the complex star forming region RCW 121 (IRAS17149-3916)★

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ABSTRACT: RCW121 is a visible HII region at a distance of 2.0 kpc, associated with the IR source IRAS17149-3916. The presence of a 6.7 GHz methanol maser, a water maser and an HII region detected at 18 GHz suggests that RCW 121 is a high-mass star forming region. In order to determine the physical conditions of the complex, we combine new near-IR narrow and broad-band images, near-IR spectroscopy, *Herschel* PACS and SPIRE images and *Spitzer*/IRAC images from 3.6 to 8.0μm.

OBSERVATIONS:

NEAR-IR Images J,H,Ks broad-band and H_2, and Brγ narrow-band images were collected at the Magellan (BAADE) 6.5m/Baade telescope of Las Campanas Observatory, using the PANIC camera at a scale of 0.125"/pix. The sensitivity limits at J, H, and Ks is 22.5, 21.5 and 19.5 (3σ) respectively with a PSF= 0.7-0.8"(FWHM).

Near-IR spectroscopy: Low-resolution long-slit spectroscopy of several parts of the region were obtained with the Folded-port Infrared Echellette spectrograph (FIRE) mounted on the 6.5m Magellan/Baade telescope. This configuration provides spectra from 0.82 to 2.51 μm with resolutions R_J=500, R_H=450 and R_K=300.

Herschel Images: RCW 121 was observed with PACS (70 and 160μm), and SPIRE (250,350, and 500 μm) in parallel mode, using the Herschel Infrared Galactic Plane Survey (HI-GAL, Molinari et al.2010). The images have pixel size 3.2", 4.5", 6", 8" and 11.5" at 70, 160, 250, 350 and 500 μm, respectively.

Spitzer/IRAC archive images: Flux calibrated images taken at 3.6 ,4.5 , 5.8, and 8.0 μm were retrived from the GLIMPSE archive.

DISCUSSION:

From the color-coded image of Fig.1, made from 70 μm (blue), 160 μm (green) and 350 μm (red) *Herschel* images, three dense cores can be observed around the IRAS position. These are labelled I, II, and III. The cores are located at the same positions (within the uncertaunts) of the dense clumps found at millimeter wavelengths by Beltran et al. (2006). Combining the far-IR fluxes with the 1.2mm fluxes we derived the spectral energy distributions (SEDs) of the dense cores illustrated in Fig.2. In order to determine their temperatures and masses, the SEDs have been fitted with a single-temperature backbody, such that

$$F_\nu = \frac{M k_0}{d^2}\left(\frac{\nu}{\nu_0}\right)^\beta B_\nu(T),$$

The derived parameters are reported in Table 1.

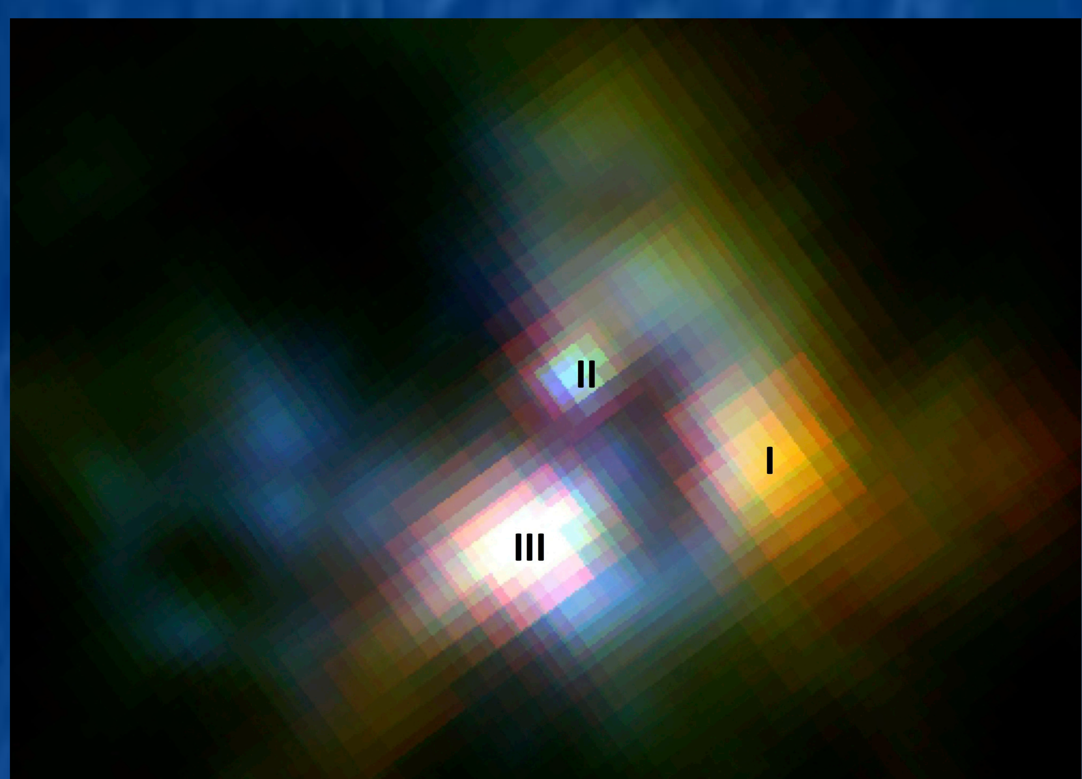
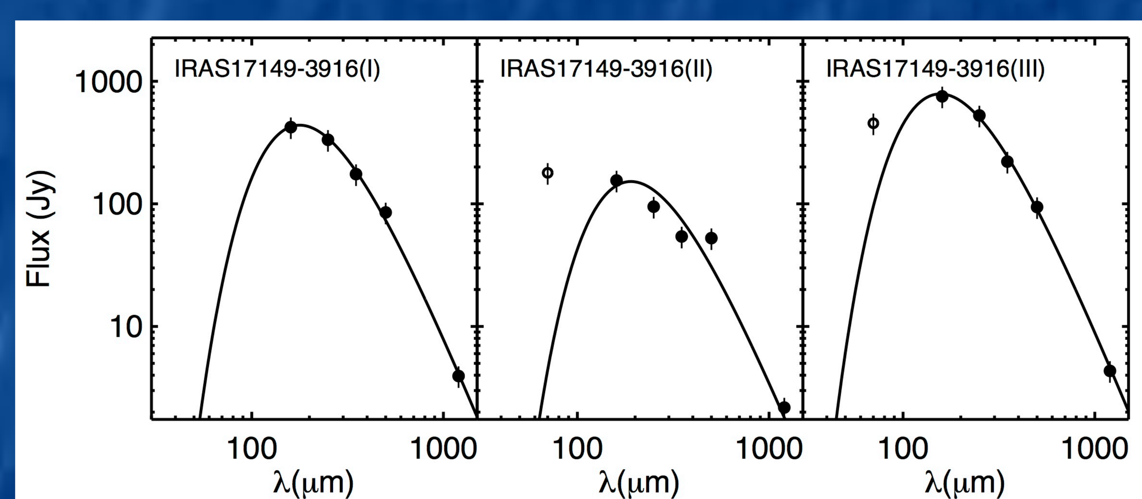


Fig.1 *Herschel* color coded image of RCW 121



Fig,2 Far-IR and millimeter SEDs of the three cores

Table 1:Masses and temperatures of the dense cores in IRAS17149-3916

Source	M ($M_\odot$)	T_d (K)
IRAS17149 (I)	121.8	19.0
IRAS17149 (II)	93.0	15.0
IRAS17149 (III)	230.1	16.7

The JHKs composite image of Fig .3 (*left panel*) is characterized by the presence of a large number of very red sources, evincing the presence of a young stellar cluster in the region.

Bright extended emission in the Brγ line is observed (green in the *(right panel)* of Fig.3 and coincides with the extended HII region. In addition, a conspicuous knot of H_2 emission is located at α(2000)= 17ʰ18ᵐ23.52ˢ, δ(2000)=-39°18′41.4″ (red in the same color-coded image). Near-IR photometry has been obtained within a radius of 15" centered on the dense core (I) located at the border of our near-IR images, and 30" centered on the dense cores (II) and (III). Fig. 4 shows the J-H versus H-Ks diagrams of each of these areas. We have found at least 13 objects in core (II) and 8 in core (III) showing significant near-IR excess.

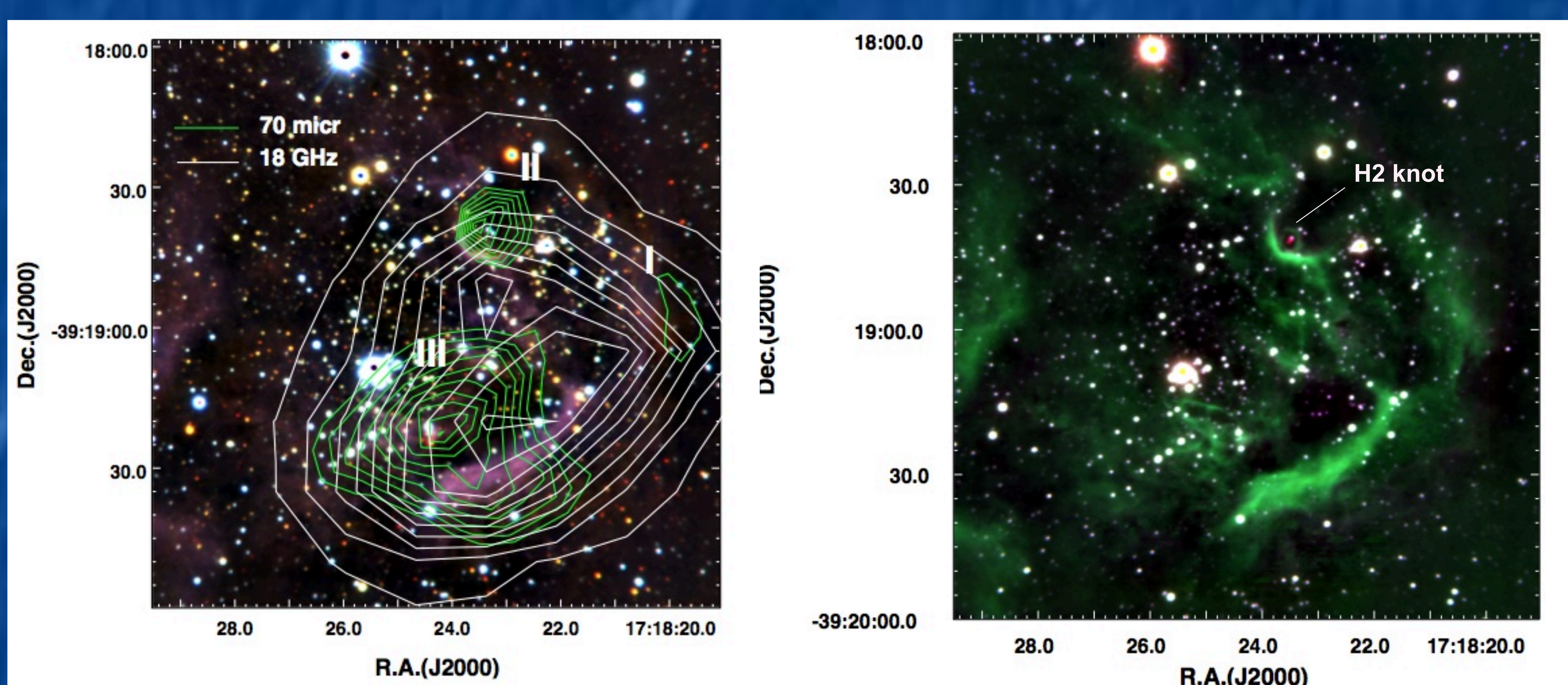


Fig.3 (*Left panel*) JHKs color-coded image of RCW 121. The overposed contours represent the radio emission at 18 GHz and the 70 μm emission. *(Right panel)* Color-coded imag made with the Ks (blue), Brγ(green) and H2 (red) individual frames.

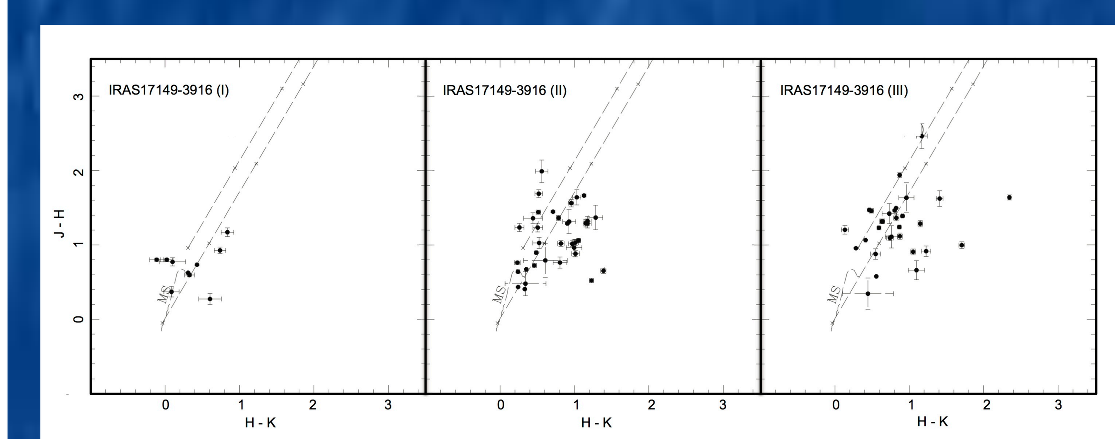


Fig.4 J-H versus H-Ks diagrams around the dense cores.

Core (I), however, shows no sources with near-IR excess. This is also confirrmed by the Spitzer/IRAC color-coded image shown in Fig. 5 .Two bright *Spitzer* sources are located at the center of cores (II) and (III) and have been identified with two sources, #5 in core (II) and #3 in core (III), with near-IR excess. Combining near-IR, *Spitzer*/IRAC, *Herschel* and 1.2mm data we have obtained the SEDs of the two sources shown in Fig. 6. The SEDs have been fitted with the infalling envelope+disk+ central star radiation transfer model developed by Robitaille et al. (2007). The parameters of the model that best-fit the SEDs are shown in Table 2.

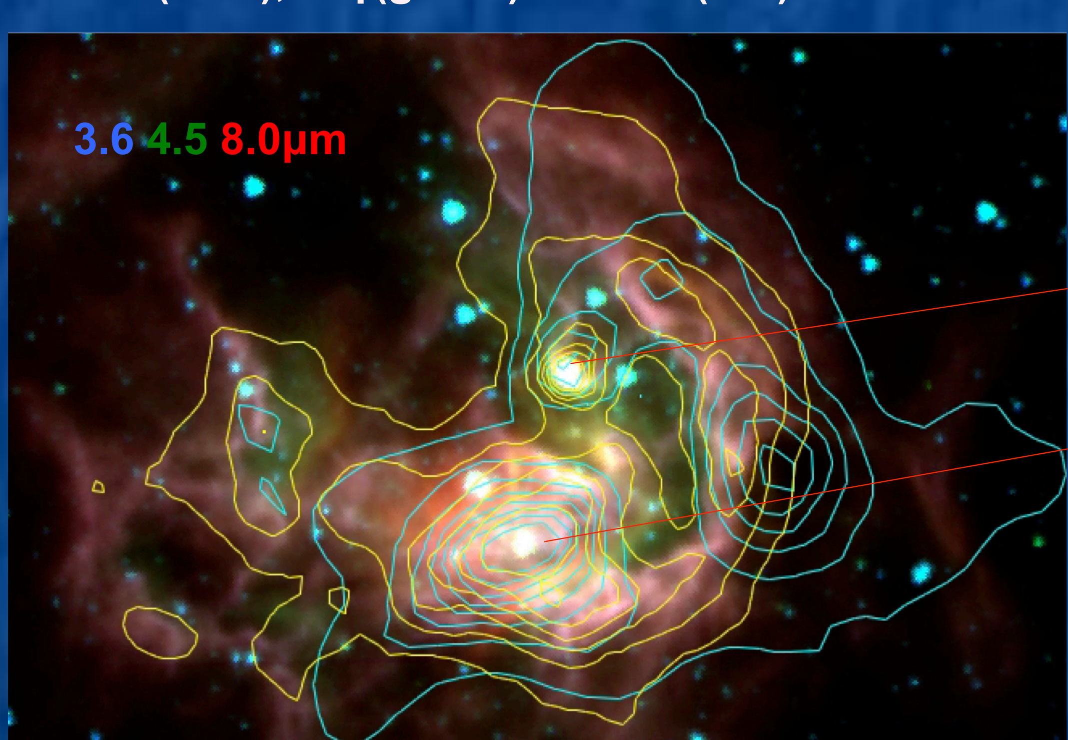


Fig.5 IRAC color-coded image. The contours correspond 70 μm (yellow) and 250 μm (cyan).

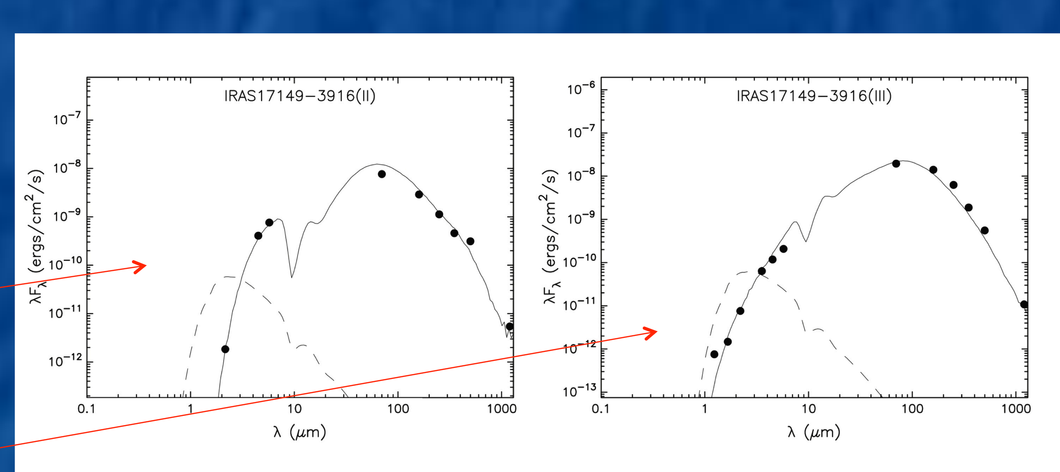


Fig.6 SED of sources #5 in core (II) and of #3 in core III. The solid line is the best-fit using the Robitaille et al's (2007) model.

Table 2: Physical parameters of sources #5 and #3

Parameters	#5 (II)	#3 (III)
Stella Mass ($M_\odot$)	8.26	9.87
Stellar Temperature (K)	11000	9190
Envelope Accretion Rate ($M_\odot$/yr)	1.02 10^{-3}	2.67 $^{-3}$
Envelope Outer Radius (AU)	1.0 10^5	1.0 10^5
Envelope Cavity Angle (deg)	31.1	9.2
Disk Mass ($M_\odot$)	6.89 10^{-3}	1.68$10^{-3}$
Disk Outer Radius (AU)	52.2	73.5
Disk Accretion Rate ($M_\odot$/yr)	4.65 10^{-8}	1.25 10^{-8}
A_V	51.4	23.6
D (kpc)	2.0	2.0
$L_{bol}(L_\odot)$	2.60 10^3	3.03 10^3

The SEDs indicate that the sources are massive YSOs with luminosities of early –B ZAMS stars.

We obtained 1.0-2.5 μm spectra in three different positions of the slit (labelled A,B,and C in Fig, 7). The spectra of the sources exhibiting emission line are shown in Fig. 8.

The spectrum C3 of source #3 in core (III) displays a very red continuum from the YSO with hydrogen and helium emission lines arising from the associated HII region. The 2-2.5 μm spectrum of A3 is dominated by the series of roto-vibrational H_2 characteristic of shoched gas and is associated with the H_2 knot illustrated in Fig.3 (right panel). This knot Is excited by source #5 in core (II). The other spectra are dominated by Bracket and Paschen ionic hydrogen emission lines as well as the HeI(2.058 μm) lines.

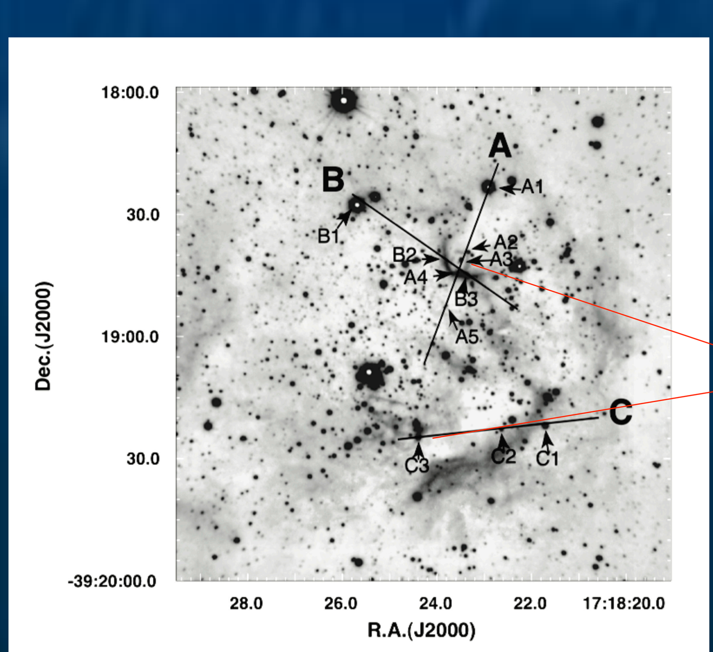


Fig.7 Ks band image of RCW121 showing the three slit positions (label A ,B, and C)

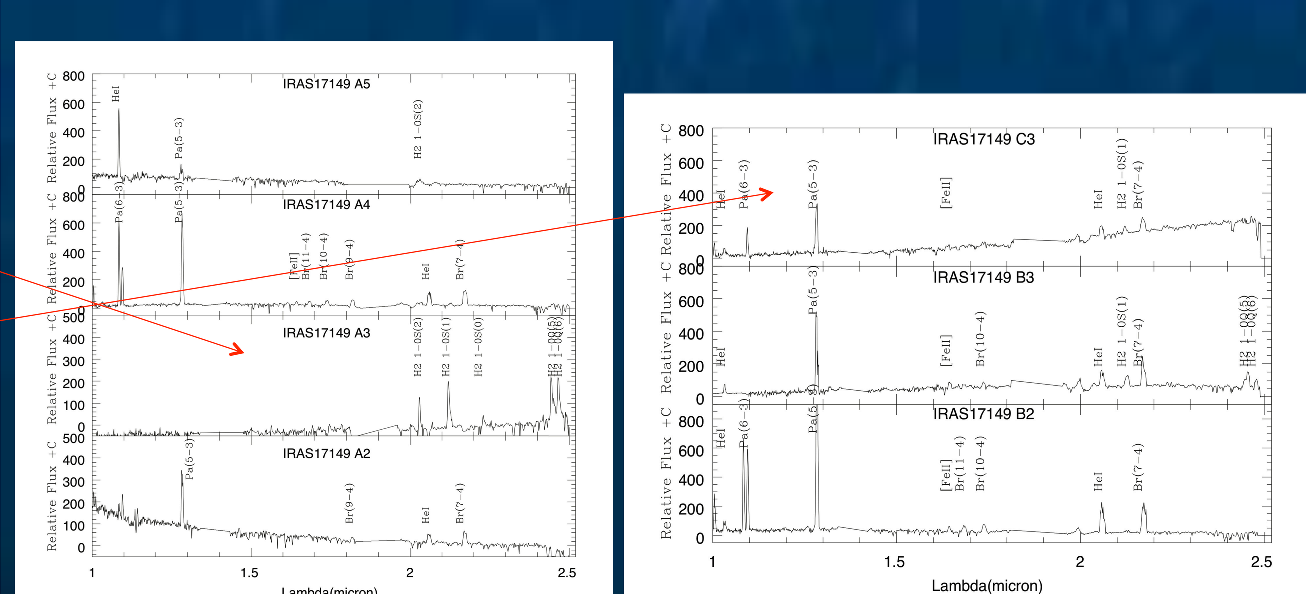


Fig.8 1.0-2.5μm spectra of the sources with emission lines

CONCLUSIONS: Three dense and massive cores have been detected in the far-IR by Herschel that are located in the outskirts of a visible expanding HII region. Core (I), undetected at λ<100μm, is at earliest stage that can be detected, while core (II) and core (III) are in more advanced evolutionary stages, having massive envelopes and disks surrounding the central recently formed stars. An H_2 – bright jet emanates very close to the YSO in core (II), with an associated water maser.

This work uses data obtained at Las Campanas Observatory and the FIRE spectrograph, and with *Herschel* and *Spitzer Space Observatories.*

REFERENCES: Beltran et al.2006 A&A 447 221; Robitaille et al. 2007 ApJS 169 328