RevMexAA (Serie de Conferencias), **33**, 145–147 (2008)

EXCITING NEW VISTAS ON THE FORMATION OF HIGH MASS STARS

D. E. A. Nürnberger[1]

RESUMEN

Los objetos estelares jóvenes de alta masa suelen estar profundamente sumergidos en el entorno donde nacen, el cual puede ser penetrado únicamente a longitudes de onda superiores a las del infrarrojo medio. Sin embargo, beneficiándonos del "levantamiento de cortina" producido por los vientos estelares y los fotones ionizantes procedentes de estrellas vecinas de la secuencia principal con tipo espectral O, y haciendo uso de observaciones sensibles y de alta resolución angular en el infrarrojo cercano y medio, hemos sido capaces de caracterizar el entorno circunestelar de estrellas jóvenes masivas en estados evolutivos relativamente tempranos. Nuestro estudio revela que, durante su formación y sus fases más tempranas, dichos objetos están rodeados inequívocamente por discos (de acreción).

ABSTRACT

High mass young stellar objects (YSOs) are usually deeply embedded in their natal environment which can be penetrated only at wavelengths beyond the mid infrared. However, taking advantage of "curtain-lifting" stellar winds and ionizing photons from neighbouring SpT O main sequence stars and making use of sensitive, high angular resolution observations in the near and mid infrared, we were able to characterize the circumstellar environment of high mass YSOs at relatively early evolutionary stages. Our study reveals that, during their formation and early evolution, high mass YSOs are unambiguously surrounded by (accretion) disks.

Key Words: stars: early-type — stars: formation — stars: pre-main sequence

1. INTRODUCTION

In the course of detailed studies of the prominent Galactic H II regions NGC 3603 and M 17 we are characterizing and classifying the young stellar population associated with these two regions (e.g., Nürnberger & Petr-Gotzens 2002; Nürnberger & Stanke 2003; Nielbock et al. 2001; Hoffmeister et al. 2006). Our sensitive and high angular resolution near and mid infrared data obtained at the ESO VLT on Cerro Paranal allow us to identify promising candidates for high mass young stellar objects (YSOs). Given their location in shock and ionization front interfaces between H II region and adjacent molecular cloud (see Figure 1), these sources are revealed at relatively early evolutionary stages and show strong evidence for the existence of circumstellar (accretion) disks.

2. THE CASE OF NGC 3603

Near infrared imaging data of NGC 3603 indicate that the high mass YSOs IRS 9A, IRS 9B and IRS 9C are surrounded by luminous/massive envelopes of gas and dust (Nürnberger 2003, in prep.). As shown in Figure 2, the circumstellar emission extends up to radii of about 10,500 AU (IRS 9A). For comparison, we display the PSF reference source IRS 9D which is free of circumstellar emission. Our NACO L′ data unambiguously reveal asymmetric structures within the envelopes of IRS 9A-C. It seems that circumstellar disks, which are seen almost edge-on or under moderate inclination angles, are taking shape within the circumstellar envelopes. Simultaneously and/or alternatively, the identified asymmetries within the envelopes might indicate that protostellar outflows are at work to clear cavities along the polar axes, perpenticular to the projected disk planes.

3. THE CASE OF M 17

In M 17 we have studied the circumstellar environment of three high mass YSOs which span the entire evolutionary sequence from high mass protostellar candidate to high mass zero-age main sequence star (see Figure 3). Although being the most evolved object, the zero-age main sequence star M 17 IRS 15 is found to be surrounded by a remnant disk (Chini et al. 2006). Furthermore, the central star of the slightly younger, hyper-compact H II region M 17 UC 1 is also associated with near infrared excess emission; it is resolved into two emission areas separated by a dark lane which is reminiscent of an obscuring silhouette caused by a compact circumstellar disk (Nielbock et al. 2007). Finally, associated with the prominent M 17 silhouette disk (Chini et al. 2004), a H_2 jet was recently discovered by means of

[1]European Southern Observatory, Casilla 19001, Santiago 19, Chile (dnuernbe@eso.org).

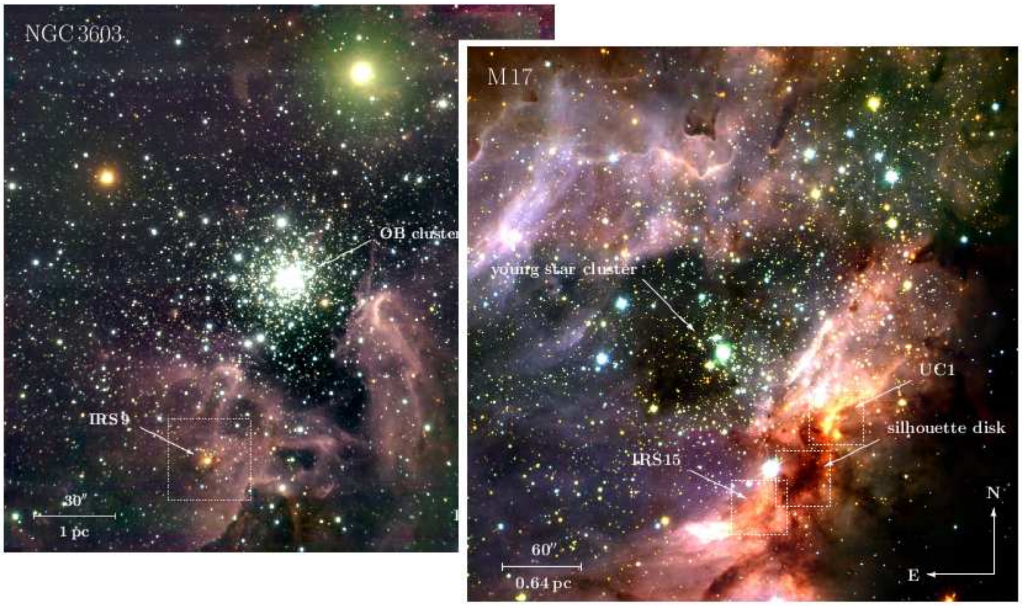

Fig. 1. ISAAC JHK$_s$ data of NGC 3603 (left) and M 17 (right). Dashed boxes outline the position of the NGC 3603 IRS 9 sources (shown in Figure 2) and of the discussed M 17 sources (IRS 15, UC 1 and silhouette disk; see Figure 3).

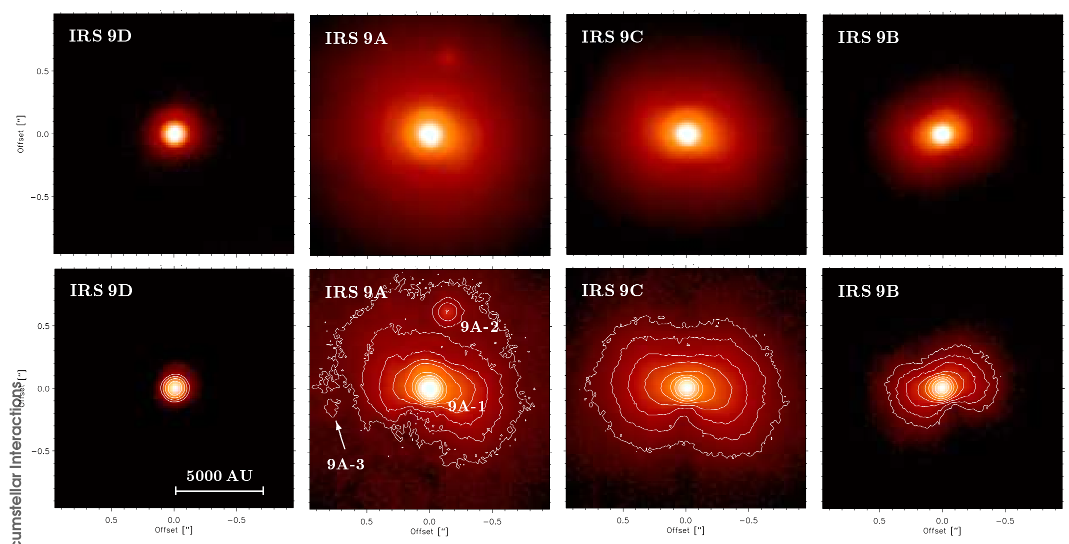

Fig. 2. NACO L′ data of the protostellar candidates NGC 3603 IRS 9A, IRS 9B and IRS 9C, in contrast to the PSF reference source NGC 3603 IRS 9D.

near infrared integral field spectroscopy (Nürnberger et al. 2007); because ejection of material through a jet/outflow is always linked to accretion of gas and dust either onto the circumstellar disk or onto the central (protostellar) source(s), the presence of a H_2 jet provides indirect but unquestionable evidence for ongoing accretion processes.

REFERENCES

Chini, R., et al. 2004, Nature, 429, 155
_________. 2006, ApJ, 645, L61
Hoffmeister, V. H., et al. 2006, A&A, 457, L29
Nielbock, M., Chini, R., Jütte, M., & Manthey, E. 2001, A&A, 377, 273
Nielbock, M., et al. 2007, ApJ, 656, L81

© 2008: Instituto de Astronomía, UNAM - Massive Stars: Fundamental Parameters and Circumstellar Interactions
Ed. Paula Benaglia, Guillermo Bosch, & Cristina Cappa

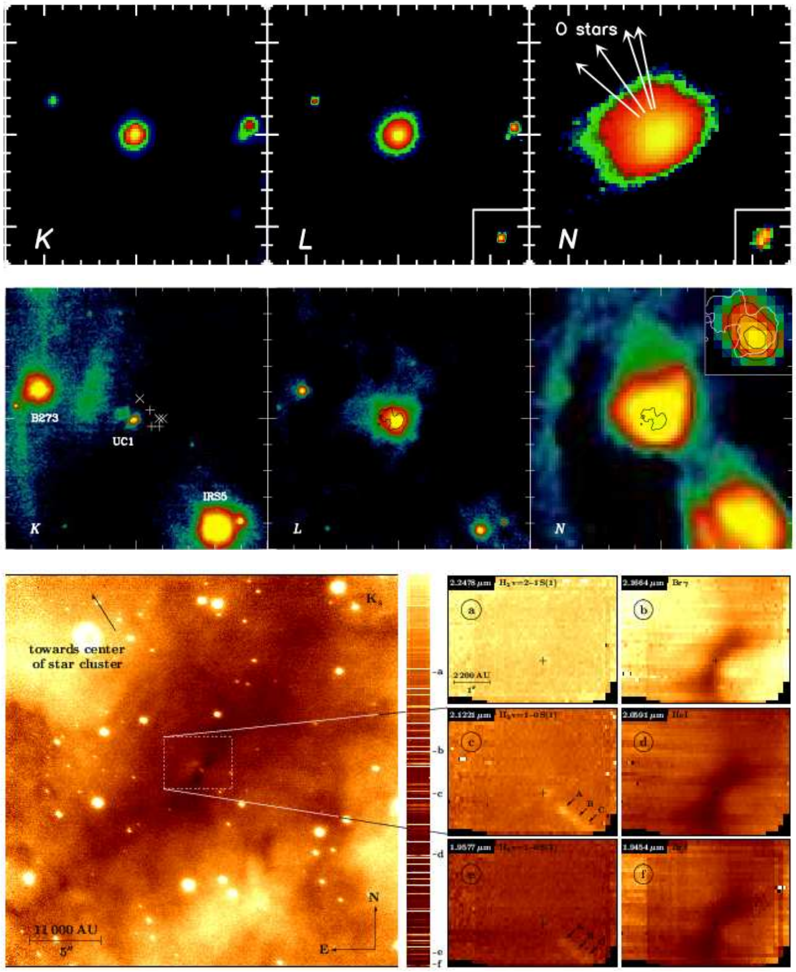

Fig. 3. Top row: ISAAC K_s and L' data together with VISIR N data of the ZAMS source M 17 IRS 15. Middle row: NACO K_s and L' data as well as VISIR N data of the HC H II candidate M 17 UC 1. Bottom row: NACO K_s image (left) and SINFONI integral field spectroscopy (right) of the M 17 silhouette disk and associated H_2 jet.

Nürnberger, D. E. A. 2003, A&A, 404, 255
Nürnberger, D. E. A., & Petr-Gotzens, M. G. 2002, A&A, 382, 537
Nürnberger, D. E. A., & Stanke, Th. 2003, A&A, 400, 223
Nürnberger, D. E. A., et al. 2007, A&A, 465, 931

DISCUSSION

H. Zinnecker - What is the most recent estimate for the mass of the circumstellar disk and the mass of the central star in the M 17 silhouette structure?

D. Nürnberger - Steinacker et al. (2006) performed 3D modelling of the source. For the innermost part of the circumstellar disk the mass is likely less than $5\ M_\odot$ and for the central source(s) the most likely mass estimate is 10–50 $M_\odot$. The relatively high mass outflow/inflow rate ($> 10^5\ M_\odot\ \mathrm{yr}^{-1}$) derived from the SINFONI IFS data also suggests a rather massive source (more massive than low/intermediate mass protostar) in the center of the silhouette disk.

G. Romero - Is there any estimate of the jet velocity in these massive protostars?

D. Nürnberger - No, unfortunately not. In the cases shown here the disks are seen (more or less) edge-on. Hence, one would expect to see the jets being ejected (more or less) in the plane-of-the-sky. The H_2 knots of the associated jet appear to be perfectly aligned to the plane-of-the-sky, and no evidence for jet kinematics is found in the SINFONI IFS data (spectral resolution ≈70 km s^{-1}).