Mem. S.A.It. Vol. 88, 801

Memorie della

A combined MUSE / X-Shooter study of the TH28 jet

A. Murphy[1], E. Whelan[1], F. Bacciotti[2], C. Dougados[3], T. Ray[4], D. Coffey[5], J. Alcalá[6], P. Garcia[7], F. Comerón[8], and J. Eislöffel[9]

[1] Maynooth University Department of Experimental Physics, NUIM, Ireland
e-mail: `aisling.murphy.2017@mumail.ie`
[2] INAF–Osservatorio Astrofisico di Arcetri, Firenze, Italy
[3] Univ. Grenoble Alpes, IPAG/CNRS, Grenoble, France
[4] Dublin Institute for Advanced Studies, School of Cosmic Physics, Ireland
[5] University College Dublin, Belfield, Ireland
[6] INAF–Osservatorio Astronomico di Capodimonte, Napoli, Italy
[7] Universidade do Porto - Faculdade de Engenharia, Porto, Portugal
[8] European Southern Observatory, Santiago, Chile
[9] Thuringer Landessternwarte Tautenburg, Tautenburg, Germany

Abstract. Here we present the first results from a MUSE / X-Shooter study of the jet from the classical T Tauri star TH 28. The combination of MUSE and X-Shooter enables us to take advantage of both spectro-imaging and broadband spectroscopy to comprehensively investigate the TH 28 jet. We present a MUSE spectro-image and PV plot of the Hα emission line and use flux ratios from the X-Shooter spectrum to estimate the mass accretion rate at log($\dot{M}_{acc}$) = -9.4. Future work will focus on diagnostic analyses on both sets of data, including estimating the mass outflow rate ($\dot{M}_{out}$) and the extinction of the jet.

1. Introduction

Magnetohydrodynamic (MHD) models propose that jets act to remove angular momentum from young stellar objects, slowing their rotation and enabling further accretion from the surrounding disk. However many unanswered questions remain (Frank et al. 2014). The techniques of integral field and broadband spectroscopy have proved to be especially useful of obtaining observational constraints to jet models. Here we present results of integral field and broadband spectroscopic observations of the TH 28 jet carried out with the Multi-Unit Spectroscopic Explorer (MUSE) and X-Shooter respectively. Both MUSE and X-Shooter are VLT instruments. The focus of this study will be on the CTTS TH 28 (also named Sz102), which is located in the Lupus 3 cloud, approximately 185 pc distant. This is thought to be a G-K type dwarf with an estimated mass of 1-2 solar masses and age < 3.5 Myr (Louvet et. al. 2016). Sz102 possesses a bipolar jet that has been well-resolved in previous optical and infrared studies and has a total known length of 0.32 pc (Comerón & Fernndez 2011).

TH 28 is significantly underluminous, suggesting an edge-on view of the accretion disc which obscures the star itself. This makes it a

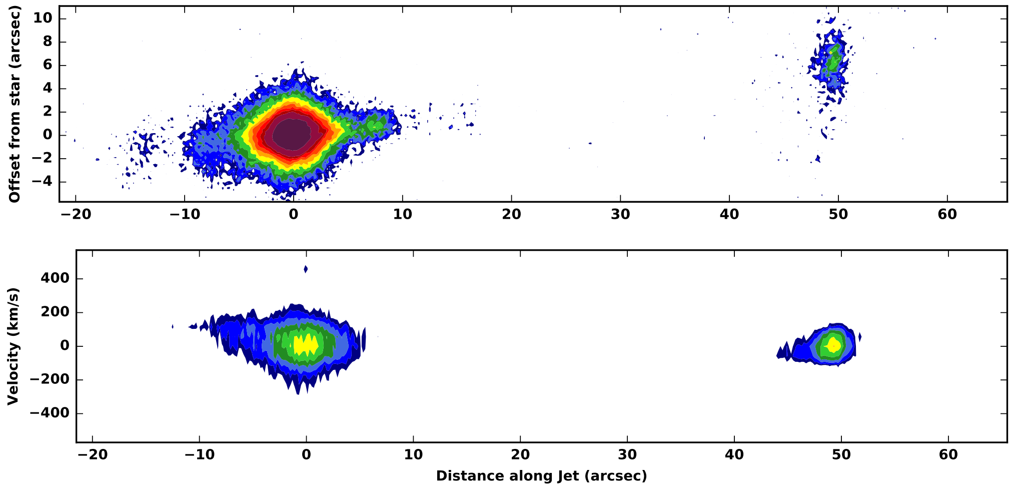

Fig. 1. Velocity channel maps and position-velocity diagram of the TH 28 jet. The top figure shows the Hα emission line binned across the +/- 250 km s^{-1} velocity range.The bottom figure shows the corresponding position-velocity diagram of the Hα emission line. In each case the continuum has been subtracted and velocities are LSR velocities.

useful object for study by enabling a wider extent of both red and blue-shifted jets to be observed close to the star. Previous studies with HST STIS (Coffey et. al., 2004) and ALMA (Louvet et al. 2016) have reported signatures of jet rotation with a counter-rotation between the disk and the optical jet for TH 28.

2. Observations and data reduction

The MUSE observations were made on 23rd June 2014. The average seeing was 0.″9 during the observations and MUSE has a field of view of 1′×1′. The wavelength range of the observations was 4570 Å to 9350 Å with a wavelength dependent spectral resolution of between 170 km s^{-1} (4750 Å) and 75 km s^{-1} (9350 Å). The X-Shooter observations were taken on 17th April 2015 in nodding mode. The average seeing was 1.″0. The slit was aligned with the jet axis at a position angle of 95° and the slit widths of the UVB, VIS and NIR arms were 0.″5, 0.″4 and 0.″4 respectively. This choice of slit widths yielded spectral resolutions of 9100, 17400 and 10500 for each arm respectively. The pixel scale is 0.″16 for the UVB and VIS arms and 0.″21 for the NIR arm. The data was reduced using the MUSE ESO pipeline.

3. Data analysis

The X-Shooter data was analysed using the usual IRAF routines for spectral analysis. For the MUSE data python routines have been constructed which enable us to obtain images in a given line at a chosen velocity, tracing different components of the jet. Position-velocity diagrams can be obtained by extracting a slice of the data along the jet axis. This is a valuable tool for examining the variations in emission and velocity components as the jet moves outward from the star. To account for systemic errors in the wavelength calibration of the detector, we compared a number of skylines visible in the data with wavelength values obtained from a UVES catalogue (Hanuschik, 2003). The maximum wavelength offset was determined to be approximately 45 km s^{-1}, significantly less than the velocity resolution of the detector at any wavelength.

4. Results to date and future work

Results to date include: 1. Figure 1 shows a spectro-image and a PV plot of the Hα line, extracted from the MUSE datacube. The next step in this study will be to apply the diagnostic method of Bacciotti & Eislöffel to the datacube (Maurri et al. 2014). 2. By measuring the fluxes of accretion tracers in both spectra we have estimated the mass accretion rate at $\log(\dot{M}_{acc})$ = -9.4. We have followed the method of Alcalá et al. (2014). The next steps in the analysis of the X-Shooter data are to correct $\log(\dot{M}_{acc})$ for the subluminous nature of the source and to carry out the diagnostic analysis including estimating the mass outflow rate ($\dot{M}_{out}$). The same methods as described in Whelan et al. (2014) will be followed. 3. In PV plots of the jet in He I 1μm, [Fe II] 1.257μm and [Fe II] 1.644μm lines taken from the X-Shooter spectra, some extension is seen in the He I lines while the inner 5 arcsec of the red-shifted jet is bright in [FeII]. The ratios of these [Fe II] lines can be used to estimate the extinction of the jet (Nisini et al. 2005).

Acknowledgements. Murphy and Whelan would like to acknowledge the support of the Irish Research Council under the Ulysses Programme

References

Alcalá, J. M., et al. 2014, A&A, 561, A2
Coffey, D., et al. 2004, ApJ, 604, 758
Comerón, F. & Fernndez, M. 2011, A&A, 528, A99
Frank, A., et al. 2014, PPV, p. 451
Hanuschik, R. W. 2003, A&A, 407, 1157
Louvet, F., et al. 2016, A&A, 596, A88
Maurri, L., et al. 2014, A&A, 565, A110
Nisini, B., et al. 2005, A&A, 441, 159
Whelan, E. T., et al. 2014, A&A, 565, A80