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Analysis of accretion in young stellar objects of NGC 6530

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Abstract. The Lagoon Nebula cataloged as M8 (NGC 6523) is a giant emission nebula located in the constellation of Sagittarius. Associated with the Lagoon nebula we have NGC 6530, a young open cluster (~ 2 Myrs) that allows us to study how the star formation process occurs in a high mass environment. A selected sample of approximately 110 members of NGC 6530 ranging from spectral types K5 to B0 was observed by the VLT (ESO) with the FLAMES spectrograph. Our work consists in analyzing the profile of the Hα emission line from each of these observed objects. We removed the emission contribution of the nebula from the observed spectra, normalized and analyzed the emission of Hα by calculating the equivalent width and the width at 10% of maximum intensity. We present preliminary results obtained with a sample of 8 spectra, used to test the procedure of removing the nebular contribution that allows the classification of the system as accreting or non-accreting.

Resumo. A Nebulosa da Lagoa catalogada como M8 (NGC 6523) é uma nebulosa gigante de emissão localizada na constelação de Sagitário. Associada à nebulosa da Lagoa temos NGC 6530, um jovem aglomerado aberto (~ 2 Ma) que nos permite estudar como ocorre o processo de formação estelar em um ambiente de alta massa. Uma amostra selecionada de aproximadante 110 membros de NGC 6530 variando dos tipos espectrais K5 a B0 foi observada pelo VLT (ESO) com o espectrógrafo FLAMES. Nosso trabalho consiste em analisar o perfil da linha de emissão de Hα de cada um desses objetos observados. Removemos a contribuição de emissão da nebulosa dos espectros observados, normalizamos e analisamos a emissão de Hα, calculando a largura equivalente e a largura a 10% da intensidade máxima. Apresentamos resultados preliminares obtidos com uma amostra de 8 espectros, usados para testar o procedimento de remoção da contribuição nebular que permite a classificação do sistema como em acreção ou não.

Keywords. Accretion, accretion disks – Stars: pre-main sequence – Stars: variables: T Tauri

1. Introduction

T Tauri stars are optically visible, low-mass stars ($< 2M_{\odot}$) with an age of a few million years, still contracting toward the main sequence. Some T Tauri stars, known as Weak line T Tauri Stars (WTTS) do not exhibit evidence of disk accretion, while the Classical T Tauri Stars (CTTS) still do (Bouvier et al. 2007).

CTTS present spectral types from F to M and are surrounded by a circumstellar disk from which they accrete and with which they interact (Ménard & Bertout 1999). CTTSs have magnetic fields strong enough (1 a 2 kG) to interrupt the accretion disk at a few stellar radii from the star and, at the truncation radius, the gas dynamics becomes dominated by stellar magnetic field and the accreting gas follows the magnetic field lines, forming accretion funnels, where strong emission lines, like Hα, are partially formed, while open field lines drive outflows from the system (Fig. 1) (Hartmann et al. 2016).

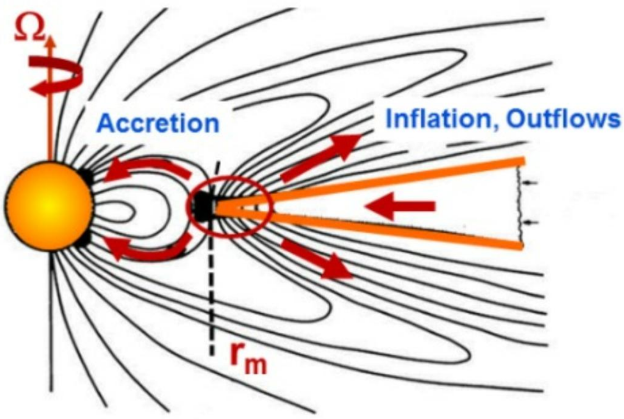

Figure 1. Sketch of Classical T Tauri stars magnetospheric accretion model. Figure from Camenzind (1990) and adapted by Romanova & Owocki (2015).

2. NGC 6530

The Lagoon Nebula, also known as M8 (NGC 6523) is a giant emission nebula located in the constellation of Sagittarius (Fig. 2) (Lada 1976). Associated with it is NGC 6530, a star formation region 1250 pc from the Sun containing stars with a median age of 2.3 Myrs (Prisinzano et al. 2005). This open cluster is composed of OB stars and stars of later spectral type (Walker 1957). A cluster like NGC 6530 allows us to study how the star formation process occurs in a high mass environment.

3. Goal

Our initial goal is to determine if the stars in NGC 6530 are accreting by analyzing the Hα (6562.82 Å) emission line profile, calculating its equivalent width ($EW_{H\alpha}$) and the width at 10% of maximum intensity ($W10\%_{H\alpha}$).

4. Data

A selected sample of approximately 110 members of NGC 6530, ranging from spectral types K5 to B0, was observed by the VLT (ESO) with the FLAMES spectrograph for 1 hour runs distributed over 20 days from June 10 to July 1 2016. This resulted in several rotational periods of spectroscopic monitoring

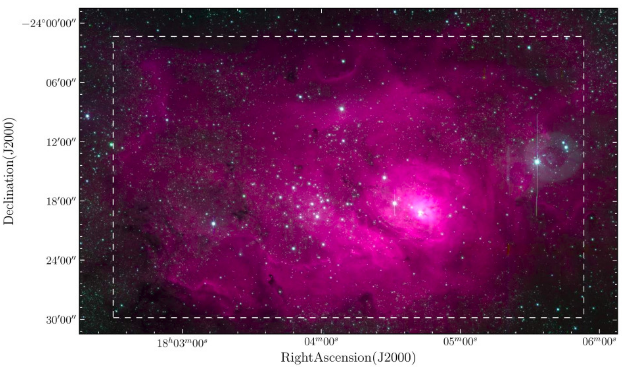

Figure 2. VPHAS+ *ri*Hα three-colour image of the Lagoon Nebula. North is up and east is left (Kalari et al. 2015).

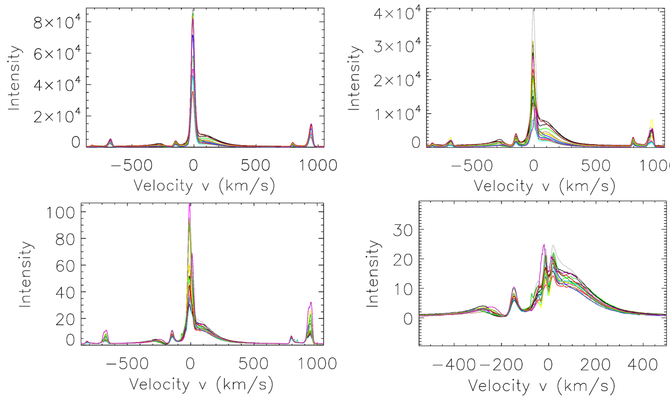

Figure 3. Spectra from 17 nights of the CTTS J18034519-2423254. Top left: Original spectra with the nebular contribution. Top right: Stellar spectra after subtracting the sky fiber nebular contribution. Bottom left: Normalized spectra. Bottom right: Normalized spectra after the gaussian subtraction of the residual nebular emission.

of the stars, which typically present periods of less than 10 days (Henderson & Stassun 2012).

5. First Results

We removed the Hα nebular contribution from the observed stellar spectra by subtracting the sky spectrum of a selected sky fiber for each object. We then continuum normalized the resulting spectra. We noticed that often a nebular contribution was still present in the stellar spectra and removed it by fitting the observed spectra with gaussian components and subtracting the one corresponding to the remaining nebular contribution (Fig.3).

We were then able to calculate the Hα equivalent width and the Hα width at 10% of maximum intensity from the stellar emission line profiles. The values measured are presented in Tab. 1 and they allowed to classify the system as WTTS or CTTS.

Using the criteria from White & Basri (2003), a star is classified as CTTS if W10%$_{H\alpha}$ is larger than 270 km/s or EW$_{H\alpha}$ is larger than a threshold that depends on the stellar spectral type as:

- EW$_{H\alpha}$ $\geq$ 3Å, for spectral type K0-K5
- EW$_{H\alpha}$ $\geq$ 10Å, for spectral type K7-M2.5
- EW$_{H\alpha}$ $\geq$ 20Å, for spectral type M3-M5.5
- EW$_{H\alpha}$ $\geq$ 40Å, for spectral type M6-M7.5

Table 1. CTTS classification. The spectroscopic parameters EW$_{H\alpha}$ and W10%$_{H\alpha}$ have units of Å. The spectral types (SPT) were taken from Prusti et al. (2016) and Brown et al. (2018).

2MASS	$T_{eff}(K)$	SPT	EW$_{H\alpha}$	W10%$_{H\alpha}$	CTTS
J18034519-2423254	5095.63	K1	80.80	596.66	YES
J18034700-2422044	5143.45	K1	146.23	393.39	YES
J18035164-2428265	4765.87	K3	9.35	499.12	YES
J18035853-2424585	4287.25	K5	10.93	424.02	YES
J18041053-2426559	4426.00	K5	17.46	416.50	YES
J18041141-2427162	4531.27	K4	87.92	486.49	YES
J18041573-2419017	4374.67	K5	10.01	486.90	YES
J18041664-2421360	4297.50	K5	7.24	290.34	YES

6. Conclusions

- Removing the nebular contribution from the stellar spectra can be quite challenging.
- All the stars we analysed so far were classified as CTTSs acording to W10%$_{H\alpha}$ and EW$_{H\alpha}$.

7. Perspectives

We plan to analyze all the remaining stars of NGC 6530 observed with the VLT/FLAMES (ESO) spectrograph, using the same methods presented in this contribution. We will then be able to select the CTTSs and characterize the accretion process across the mass spectrum in NGC 6530.

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