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# Connection between the accretion and outflow processes in T Tauri stars

F. Lopez-Martinez[1] and J. F. Gameiro[1,2]

[1] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP, Rua das Estrelas, PT4150-762 Porto, Portugal, e-mail: `Fatima.Lopez@astro.up.pt`
[2] Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre 687, PT4169-007 Porto, Portugal

**Abstract.** Understanding the connection between the accretion and outflow processes in T Tauri stars (TTS) is one of the major challenges in the study of pre-main sequence evolution. Most likely the outflows are related with magnetohydrodynamic processes in the stellar magnetosphere interacting with the accretion disk. In this work we determine the physical properties, such as temperature and density, through the forbidden [N II], [O I] and [S II] lines using a code developed in a previous work, and adapted to these lines. We analyzed several spectra for SZ 102 and DG Tau on the stars and also on their jets, characterizing them by two components, whenever is necessary. We have derived the temperature and density of the region where these lines are formed, finding that the temperatures and densities of the SZ 102 jet are lower than those for DG Tau. The temperatures found in this work are compatible with those found in the previous work in the accretion flow.

## 1. Introduction

T Tauri stars are low-mass pre-main sequence stars surrounded by a disk truncated close to the corotation radius by the interaction with the strong magnetic fields. Accretion has a significant impact on the evolution of low-mass stars by providing both mass and angular momentum. The mass-loss through jets/winds is one of the possible mechanisms through which the stars may loosed their angular momentum. Most likely the outflows are related with magnetohydrodynamic (MHD) processes in the stellar magnetosphere interacting with the accretion disk. Deriving the properties of young stellar systems, of their associated disks and outflows is an important step to understand the connection between star, disk and outflow. The forbidden optical lines [N II], [S II] and [O I] are very sensitive tracers of outflows (Herbig 1962; Simon et al.2016). It is possible to measure the physical properties of the region where they are formed because they are optically thin. These lines in TTS are characterized in many cases by two components: a high velocity component (HVC) and a low velocity component (LVC) (Hartigan et al.,1995). The HVC is formed in microjets, but the origin of the outflows traced by it is not yet fully understood. The origin of the LVC is even less well understood.

We developed in a previous work (Lopez-Martinez & Gomez de Castro 2014) a code which finds the best-fitting spectrum to the original data using a grid of simulated profiles computed for a broad range of electron densities and temperatures. To calculate the sim-

**Table 1.** Results for both components corresponding to the best fit found for DG Tau and SZ 102. $\sigma$ corresponds to the standard deviation of the fitted gaussian and $\delta$ is the shift of the line respect to the rest wavelength.

| | LVC | | | | HVC | | | |
|---|---|---|---|---|---|---|---|---|
| Star | $\log(T_e)$ (K) | $\log(n_e)$ ($cm^{-3}$) | $\delta$ (km/s) | $\sigma$ (km/s) | $\log(T_e)$ (K) | $\log(n_e)$ ($cm^{-3}$) | $\delta$ (km/s) | $\sigma$ (km/s) |
| SZ102 (star) | 4.05 | 3.5 | 4.9 | 35.8 | 4.2 | 4.5 | 30.5 | 51.98 |
| SZ102 (Recd.) | 4.2 | 4.0 | 17.58 | 59.18 | 4.25 | 5.0 | 81.6 | 26.6 |
| SZ102 (Appr.) | 4.2 | 4.0 | 10 | 82.87 | 4.4 | 6.5 | -74.85 | 109.23 |
| DG/HST (star) | 5.475 | 7.0 | -54.63 | 59.34 | 5.15 | 7.25 | -164.34 | 191.7 |
| DG/UES (star) | 5.55 | 6.5 | -38.16 | 47.8 | 4.2 | 5.0 | -151.18 | 84.1 |
| DGTau (Appr.) | 5.6 | 6.5 | -40 | 36.7 | 4.2 | 5.25 | -161.9 | 56.4 |

ulated profiles we use the theoretical flux ratios from several UV spectral lines, for every temperature and density. We have adapted this code to the optical [N II], [S II] and [O I] lines, fitting two different components to each line, whenever it is necessary. In this work we determine the physical properties, among others, of the region where both components are formed for two stars: SZ 102 (seen almost edge-on) and DG Tau (jet inclination of 52°). We have applied the code to some observations carried out on the star (from ESO archive and WHT) and on the jet (from HST data archive with the slit perpendicular to the jet direction at 0.”3 from the star).

## 2. Results and conclusions

In this work we have determined the physical properties, among others, of the region where the forbidden optical [N II], [S II] and [O I] lines are formed. In the case of SZ 102, these lines are characterized by a HVC and LVC. In the case of DG Tau, a HVC and LVC are contributing to the [S II] and [O I] lines, but [N II] lines are characterized only by the HVC. Table 1 shows the results corresponding to the best fits for all the studied observations. For the LVC, the temperatures and densities found for DG Tau are much higher than those found for SZ 102. The lines are more centered and wider in the case of SZ 102, which is expected due to the inclination of the system. In DG Tau we have found high temperatures and densities, very different to those found for most of the SZ 102 observations. This points out that the LVC and HVC found in this work are formed in different places of the jet, varying their physical properties from one system to the other. The temperatures found in this work for SZ 102 are compatible with those found in Lopez-Martinez & Gomez de Castro (2014) in the accretion flow for most of the stars. However, the densities are lower than in the previous work. In the case of DG Tau the temperatures derived on the jet and star are higher than those found in the accretion flow. In the particular case of SZ 102 and DG Tau, the accretion flow and the base of the jet do not have similar physical properties. The stellar parameters derived in this work will constrain even further on-going MHD simulations carrying out in the group.

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## References

Hartigan, P., et al. 1995, ApJ, 452, 736
Herbig, G. H. 1962, AdA&A, 1, 47
López-Martínez, F. & Gómez de Castro, A. I. 2014, MNRAS, 442, 2951
Simon, M. N., et al. 2016, ApJ, 831, 169