PHOTOEVAPORATION OF AN EVOLVED DISK AROUND A LOW-MASS TTS

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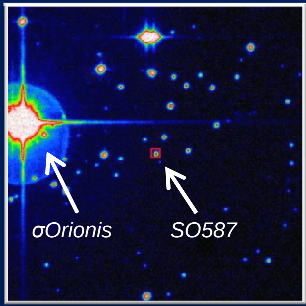


σOri $O9.5V$	SO587 $M3.5$
$T \sim 33000K$ $L \sim 8 \times 10^4 L_\odot$	$T \sim 3300K$ $L \sim 0.3 L_\odot$ $M \sim 0.2 M_\odot$

SO587 and σOri. The projected distance Δ ≈ 0.35pc. (D=400pc).

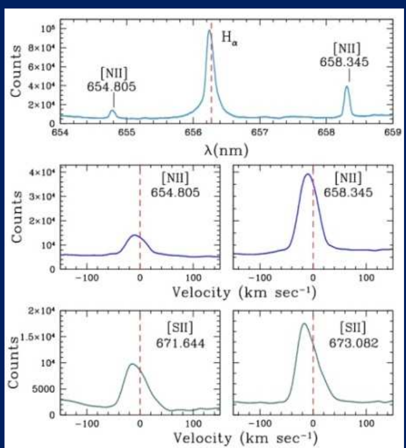
The low-mass T Tauri star SO587 (Hernandez et al., 2007) in the σOri cluster is surrounded by an evolved disk, with no evidence for a large inner hole. The accretion rate onto the central star is very low. Nonetheless, strong forbidden lines of [SII], [NII] and [OI] are present in the optical spectrum, which, interpreted as coming from a jet/wind, as in typical T Tauri stars, require a mass-loss rate of ≈ 10^{-8} M_{sun} , i.e. a ratio M_{loss}/M_{acc} ≈ 10. Such a high ratio excludes all accretion driven mass loss mechanisms. We suggest that the forbidden lines are coming instead from the photoevaporation of the outer disk by the central star itself. This slow and neutral outflow, which is in general very hard to detect, stands out in SO587 because of the effect of the nearby bright star σOri, which ionizes and heats the outer part of the outflow.

1. Mass accretion rate and mass loss rate

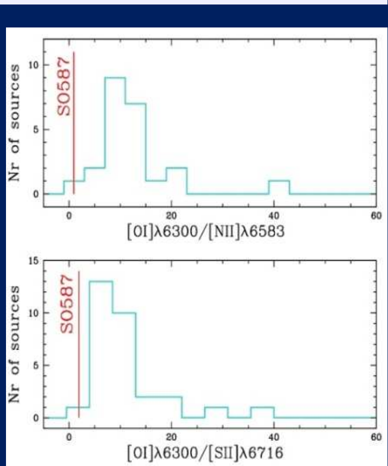
SO587 shows no evidence of significant accretion onto the central star. We estimate M_{acc} ≈ $7x10^{-10}$ M_{sun}/yr from the U-band magnitude, consistent with the the narrow (10% width≈190 km/sec) and weak (EW ≈15Å) Hα emission line and the lack of detectable veiling in the optical spectrum. On the other hand, the mass loss rate from the luminosity of the forbidden lines is about $1.5x10^{-8}$ M_{sun}/yr (Hartigan et al.,1995). The ratio M_{loss}/M_{acc}≈10 rules out all accretion driven mass-loss mechanisms.

2. Optical spectrum

The optical spectra was obtained by Sacco et al., (2008) using FLAMES/Giraffe on the VLT (R ≈17,000) in the range 647-679 nm. The forbidden lines have a slightly blue-shifted peak (10-14 km/sec) and an asymmetric profile with pronounced red wings. They are much more similar to lines from the Orion proplyds (Henney & O'Dell, 1999) than to TTs (Hartigan et al., 1995). The strong [NII] lines and the weak [OI] emission are also unusual for TTs winds.



Hα, [NII] and [SII] emission for SO587. The forbidden lines show a small shift of the peak to the blue (10-14 km/sec) and more extended red wings. In general the TTs forbidden lines have a larger blue-shift of the peaks and more emission in the blue than in the red wings. The SO587 lines are very similar to the profiles of the Proplyds lines in the Orion Nebula, where the lines are generated by photoevaporation of the disk from θ¹C Ori.



Distribution of the EW ratios [OI]/[NII] and [OI]/[SII] of the Hartigan et al. TTs. The full sample contains 67 spectra with [OI] detections; of those 30 have [SII] and 22 have [NII] detections. The location of SO587 is shown by the red lines; the [OI] EW is from the low-resolution data of Zapatero-Osorio et al. (2002). In SO587, the lines have similar luminosity, while in TTs the [OI] lines are the strongest, and the [NII] lines are much weaker or absent.

3. Proposed Model

-Mass-loss from disks can be due not only to the combined effect of accretion, rotation and magnetic field, but also to photoevaporation by the high energy radiation (FUV and EUV) from the central star.

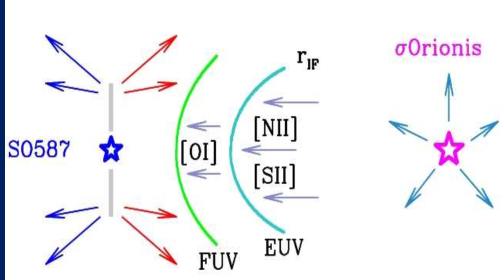
-This radiation heats the gas at the disk surface and results in an outflow of material from the outer region of the disk. Mass loss rates of ≈ $10^{-9}M_{sun}$/yr are typical of low-mass TTs (Gorti & Hollenbach, 2008).This outflow, however, is cold and neutral, with a speed of a few km/s; no emission in the optical forbidden lines is expected.

-In SO587 we detect this outflow only because SO587 is close to the O9.5 star σOri, which ionizes and heats the outer region of the wind.

-σOri can ionize the disk outflow down to very close its base, and well within FLAMES beam (200 AU in radius). The ionization front r_{IF} is given by:

$$r_{IF} \approx 90AU(M_{loss}/(10^{-9}M_{sun}/yr))^{2/3}(\Delta/0.35pc)^{2/3}$$

-For a M_{loss} ≈ $10^{-9}M_{sun}$/yr we find an electron density $n_e(r_{IF})$ ≈ $4x10^3$ cm^{-3}, in rough agreement with the value obtained from the ratio of the two [SII] lines ($1.5x10^3$ cm^{-3}). The predicted luminosity of the [SII] and [NII] lines within our beam is ≈ 10^{-5} L_{sun}, as observed.



Sketch of the proposed model

SO587 is as close as the ONC but it does not suffer from a strong background emission ⟹ it may be the most suitable proplyd discovered so far for in depth studies!

References

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