Understanding the Origin of the [OI] Low-Velocity Component from Young Stars

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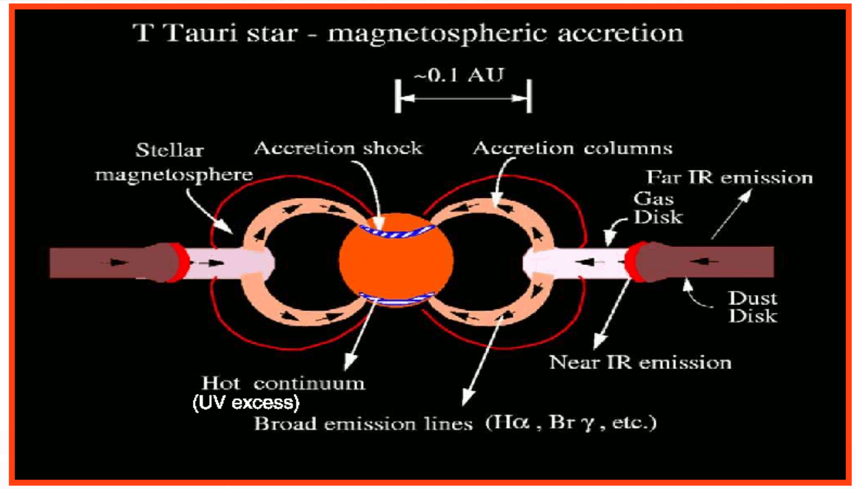
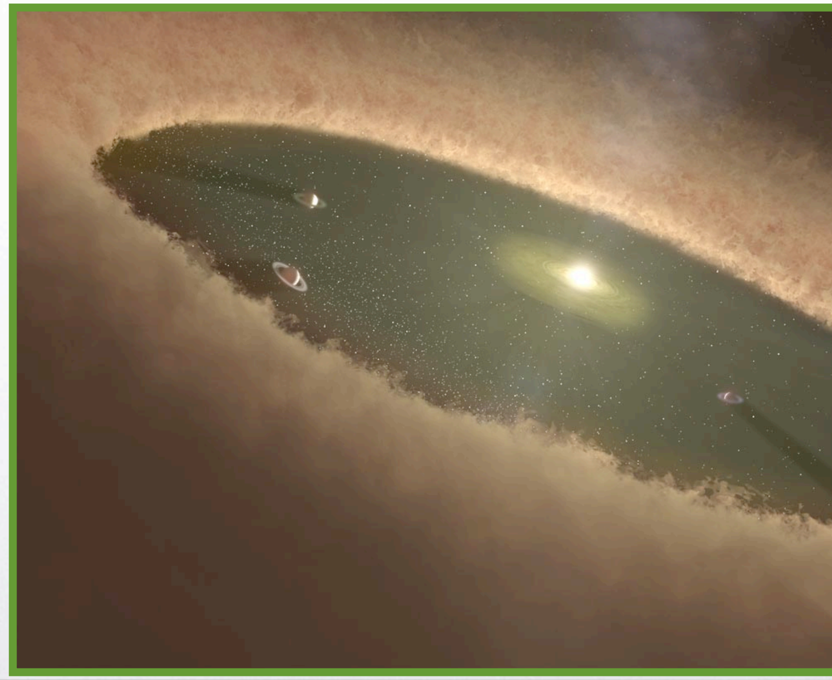
The context

There are main disk dispersal mechanisms:
i) viscous evolution
ii) photoevaporation driven by the central star
iii) planet formation



Many diagnostics have been identified to trace accretion and jets, and a few to trace photoevaporation.
We present a study connecting these different diagnostics that trace disk dispersal mechanisms.



The context

Potential diagnostics of the photoevaporation process:

- [NeII] at λ12.81 μm (Pascucci & Sterzik 2009, Sacco et al. 2012 and next talk)
- CO ro-vibrational band at λ4.7 μm (Herczeg et al. 2011, Pontoppidan et al. 2011, Bast et al. 2011)
- [OI] LVC of the transition 6300Å, 5577Å and 6363Å (Ercolano & Owen 2010)

The winds can be driven by X-rays (Ercolano & Owen 2010), FUV (Gorti & Hollenbach 2009) -- high photoevaporation rate (~10^{-8} M_{sol}/yr)
or by EUV (Alexander+ 2006) -- lower mass flow rates (~10^{-10} M_{sol}/yr)

Distinguishing between these possibilities is important to understand the effect of photoevaporation on planet formation and evolution.

The sample I

8 T Tauri stars with high-resolution optical spectra and at least one wind diagnostic (hereafter called "wind sources")

The sample II

32 accreting T Tauri stars medium/high resolution optical spectra (Hartigan, Edwards & Gandhour 1995, hereafter called "HEG sample")

Stellar Parameters & Accretion Properties

Masses and Radii have been derived in a homogeneous way for both samples using the Siess et al. (2000) evolutionary tracks.

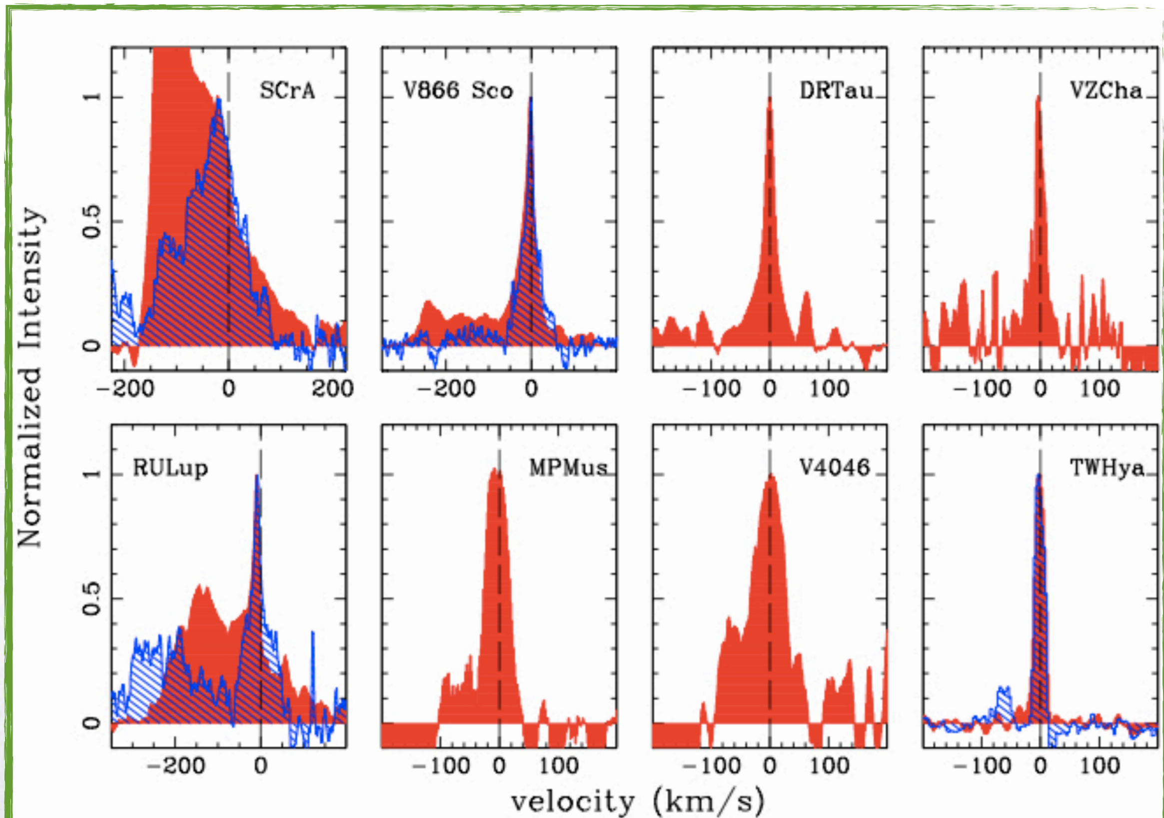
From the Hα line luminosities we have computed the Accretion Luminosities (L_{acc}) using the relationship:

$$\log (L_{acc}/L_{sun}) = 2.99 + 1.49 \times \log(L_{H\alpha}/L_{sun})$$ (Rigliaco et al. 2012)

then the Mass accretion rates (M_{acc}):

$$M_{acc} = 1.25 (L_{acc}*R)/(G*M_{star})$$ (Hartigan et al. 1995)

The [OI] lines for the “wind sources”



Comparison between the [OI] lines. [OI]6300Å (red) and [OI]5577Å (blue).

The high-resolution spectra enables a comparison of the three [OI] transitions: [OI] 6300Å, [OI] 6363Å, [OI] 5577Å

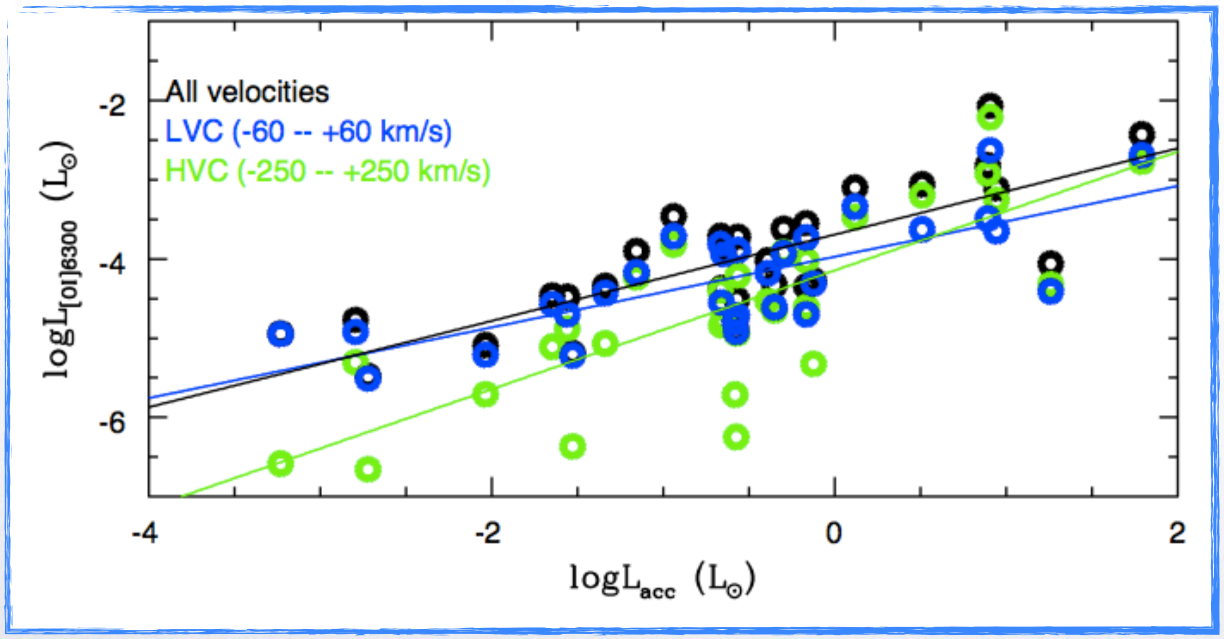
The LVC is very similar (in FWHM and peak velocity), ‘often’ with a small blueshift (<10 km/s), suggesting the three transitions arise all from the same slow wind.

We have computed the Equivalent Widths (EWs) of the three lines using the same method as Hartigan et al. (1995), thus considering the LVC as the portion of the profile between -60 km/s and +60 km/s.

Correlation between the [OI] flux and the stellar FUV

Ingleby et al. (2011) and Yang et al. (2012) have found that the FUV luminosity scales with L_{acc} according to the relationship:

$$\log (L_{FUV}/L_{sun}) = -1.670 + 0.836 \log (L_{acc}/L_{sun})$$



There is a clear trend among the HEG sample of increasing [OI] 6300Å LVC line luminosity for increasing FUV luminosity

⇩

photoevaporative flow

Higher FUV gives higher [OI] LVC, suggesting that FUV may be responsible for the observed [OI] luminosity.

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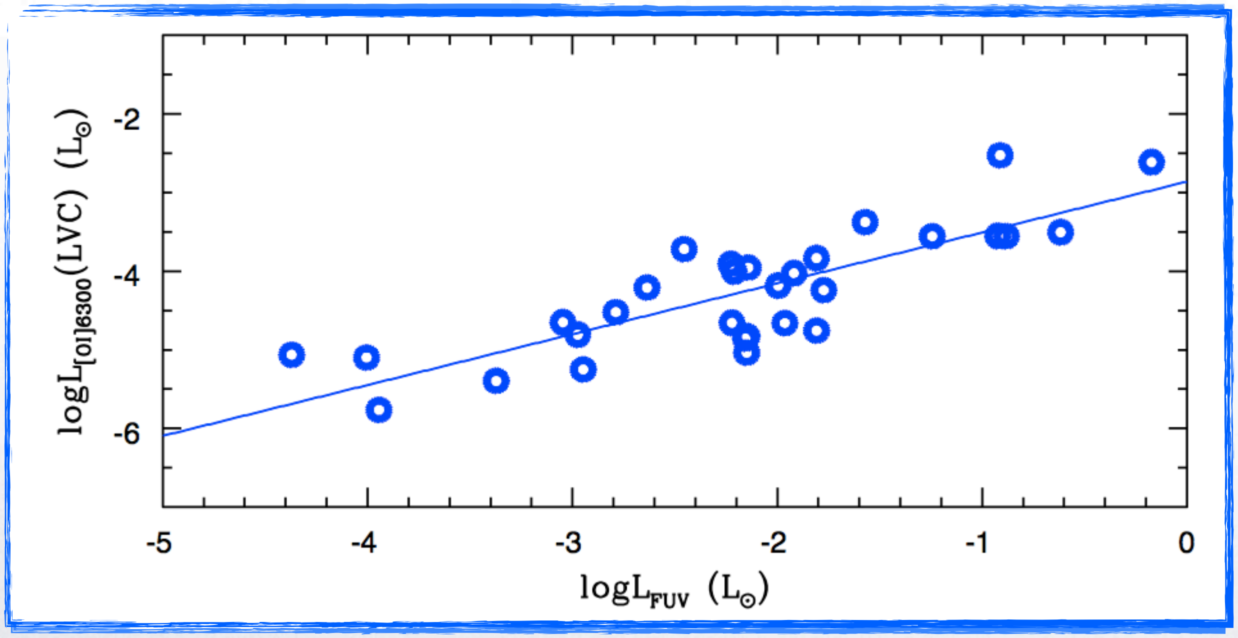

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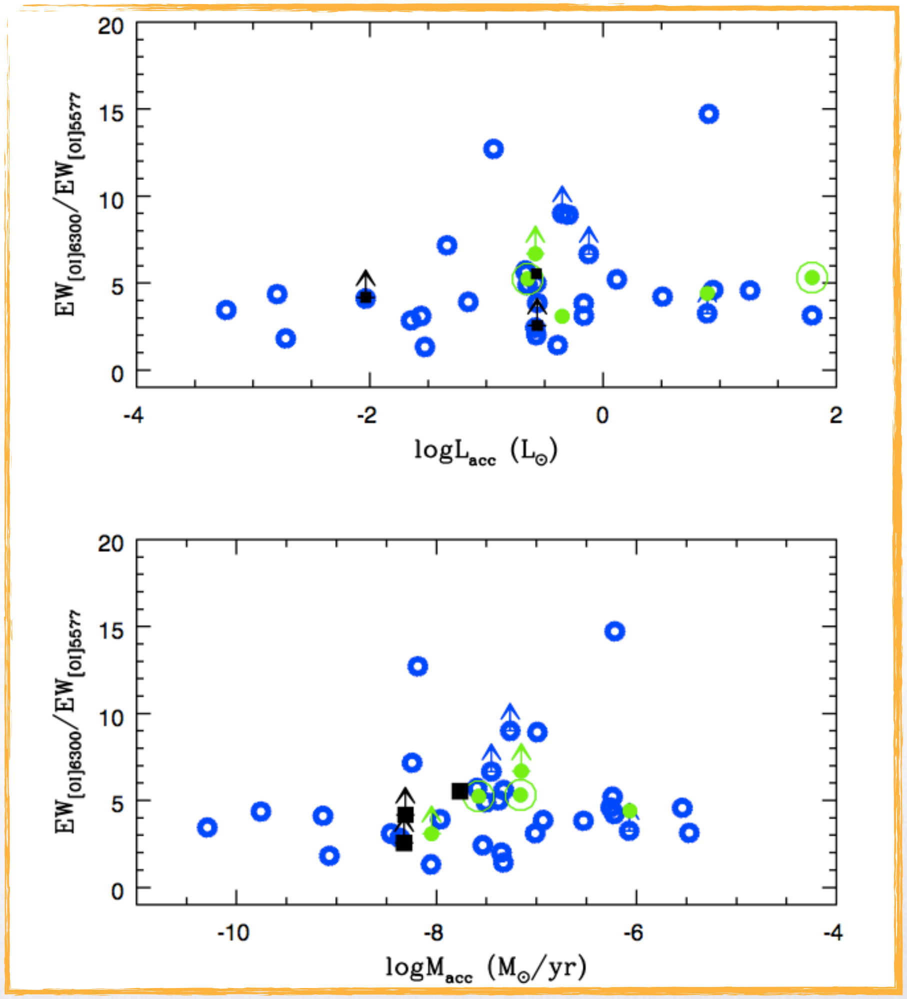
EW ratio versus Accretion Properties

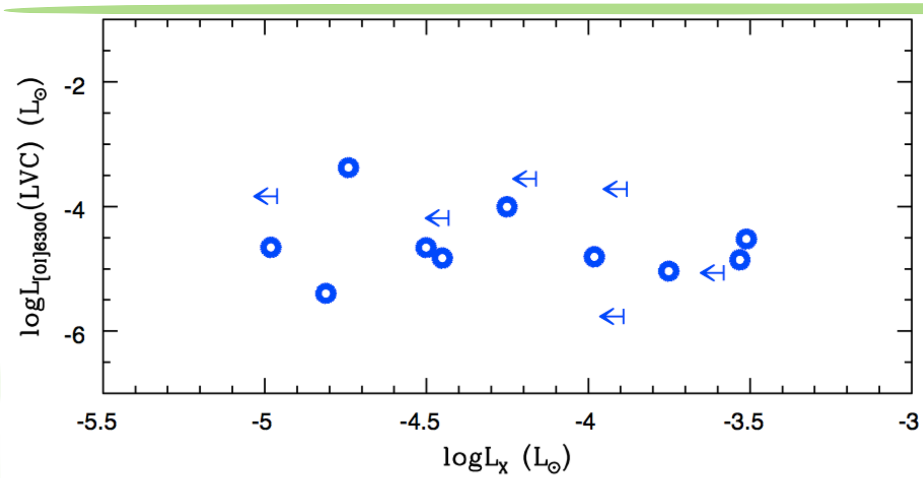
Correlation of [OI] line properties with stellar accretion properties can be used to infer the physical origin of the emission.
The ratio of the EW changes little in a very large range of accretion luminosities and mass accretion rates

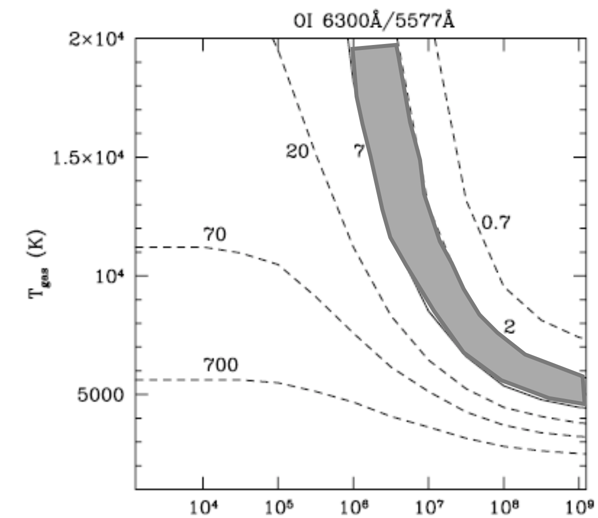
⇒ this ratio is very little affected by the rate at which the star is accreting.



Non-thermal [OI] production

$L_{[OI]\ LVC}$ does not show any trend with L_X -- unlikely to be thermal emission due to the X-rays heating





Gorti et al. 2011

The EW ratio ranges approximatively between 1-7 these ratios point out to a *non-thermal process* (Gorti et al. 2011)

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OH dissociation

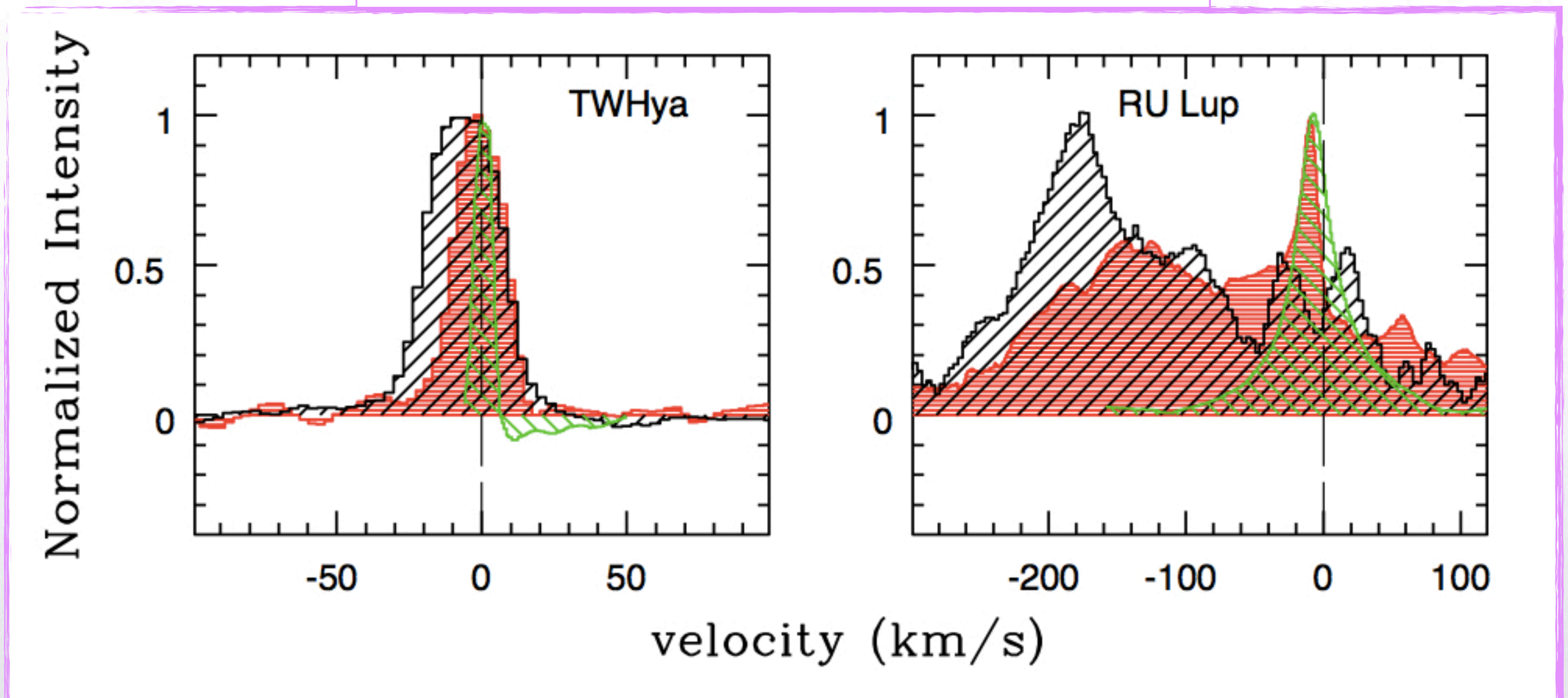
[OI] 5577Å produced from S → D state
[OI] 6300Å produced from D → P state

OH dissociation produces [OI] (S state) which decays into [OI] (D state) emitting [OI] 5577Å
The [OI] (D state) reacts with H_2 forming again OH
The results is that the [OI] 6300Å is "poisoned" and lowest EW ratios are reached

Comparing the line profiles

We have compared the [OI] line profiles with those of other lines which are supposed to be produced in a photoevaporative wind: CO 4.7 µm and [NeII] 12.81 µm

[OI] 6300 vs [NeII] vs CO



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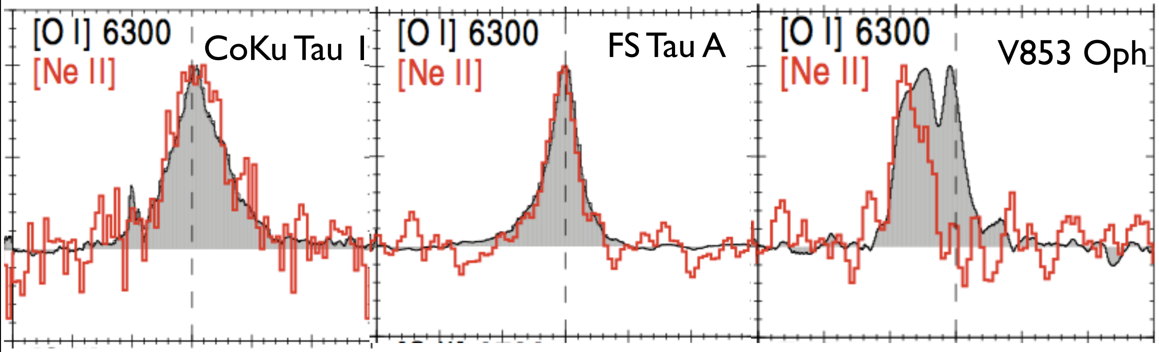
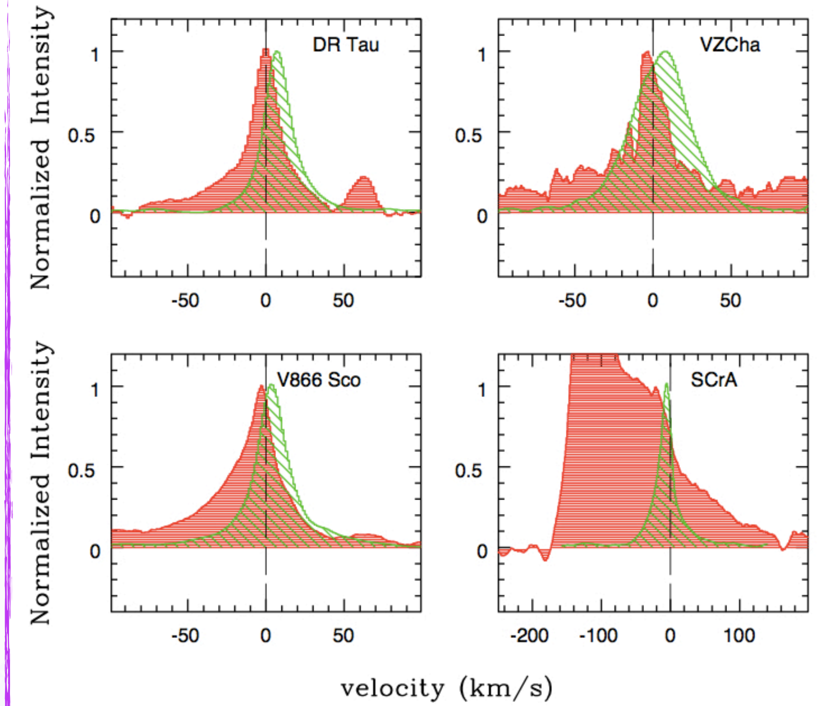


Baldovin-Saavedra et al. 2012

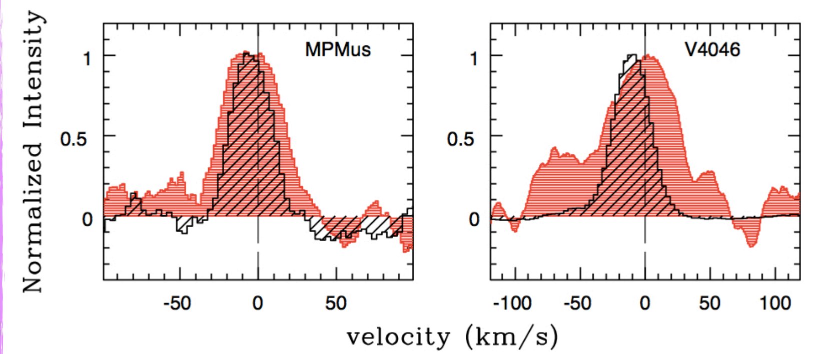
[OI] 6300 vs CO



For the wind sources:

- 4/8 objects show negligible or no blueshift
- 3/8 show a small blueshift (<10 km/s)
- 1/8 shows complex profile that cannot be easily separated into LVC and HVC

[OI] 6300 vs [NeII]



Preliminary results and comments

The [OI] LVC emission likely arises from FUV photodissociation of OH.

Further investigations are needed to understand if the gas is bound to the system or is a real flow.

We are now engaged in modeling the line profiles assuming the contribution of a thermal broadening and of a Keplerian broadening of the lines.

Preliminary results suggest that in addition to the keplerian component of the disk we might need a wind component.The thermal broadening is negligible.