Mid-Infrared Variability of Actively Accreting T-Tauri Stars

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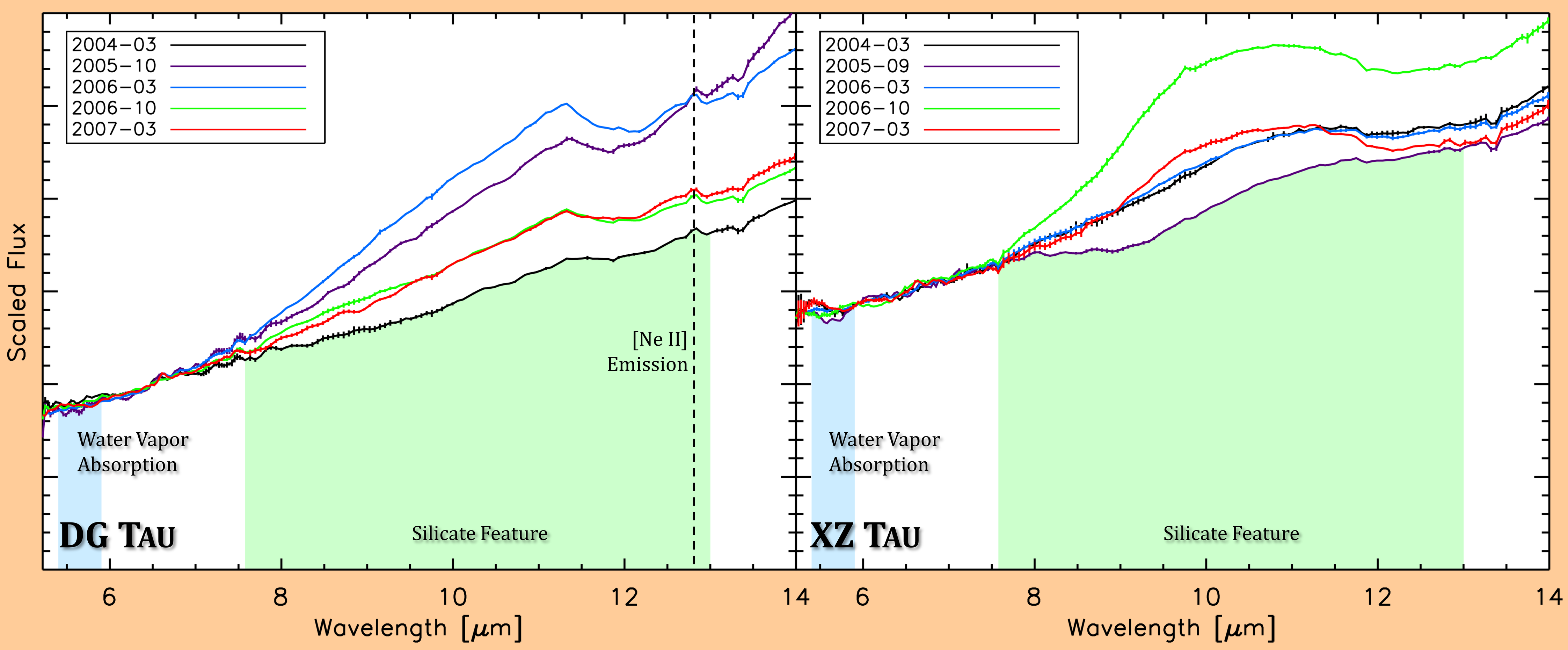
Abstract

We present Spitzer IRS results from a multi-epoch, mid-infrared, spectroscopic survey of actively accreting T Tauri stars in Taurus-Auriga to investigate temporal variations of the gas and dust features residing between 5 and 14 μm. The 11 objects in this survey contain a rich variety of spectral features within the IRS wavelength range including the steam absorption band at ~5.7 μm, the silicate feature at ~10 μm, H I (7-6) emission line at 12.37 μm, [Ne II] emission at 12.81 μm, and a plethora of PAH features. Of the objects in this sample, we detect significant short- and long-term variability in the continuum flux as well as the 10-micron silicate emission feature in DG Tau and XZ Tau, two objects containing vastly different dust profiles, which we discuss here. In addition, these two sources exhibit a water vapor absorption band centered between 5.6 and 5.8 μm that varies on the timescale of months. High-resolution data of DG Tau also shows the [Ne II] emission feature, which appears relatively constant over the 3-year baseline of accumulated observations. We briefly discuss possible scenarios that could account for the variations in these spectral features such as fluctuations in the accretion luminosity, high energy photons incident upon the disk, and possible line-of-sight effects due to mixing in and rotation of the disks.

Spectral Features & Continuum Variations



The prominent spectral characteristics observed for DG and XZ Tau include:

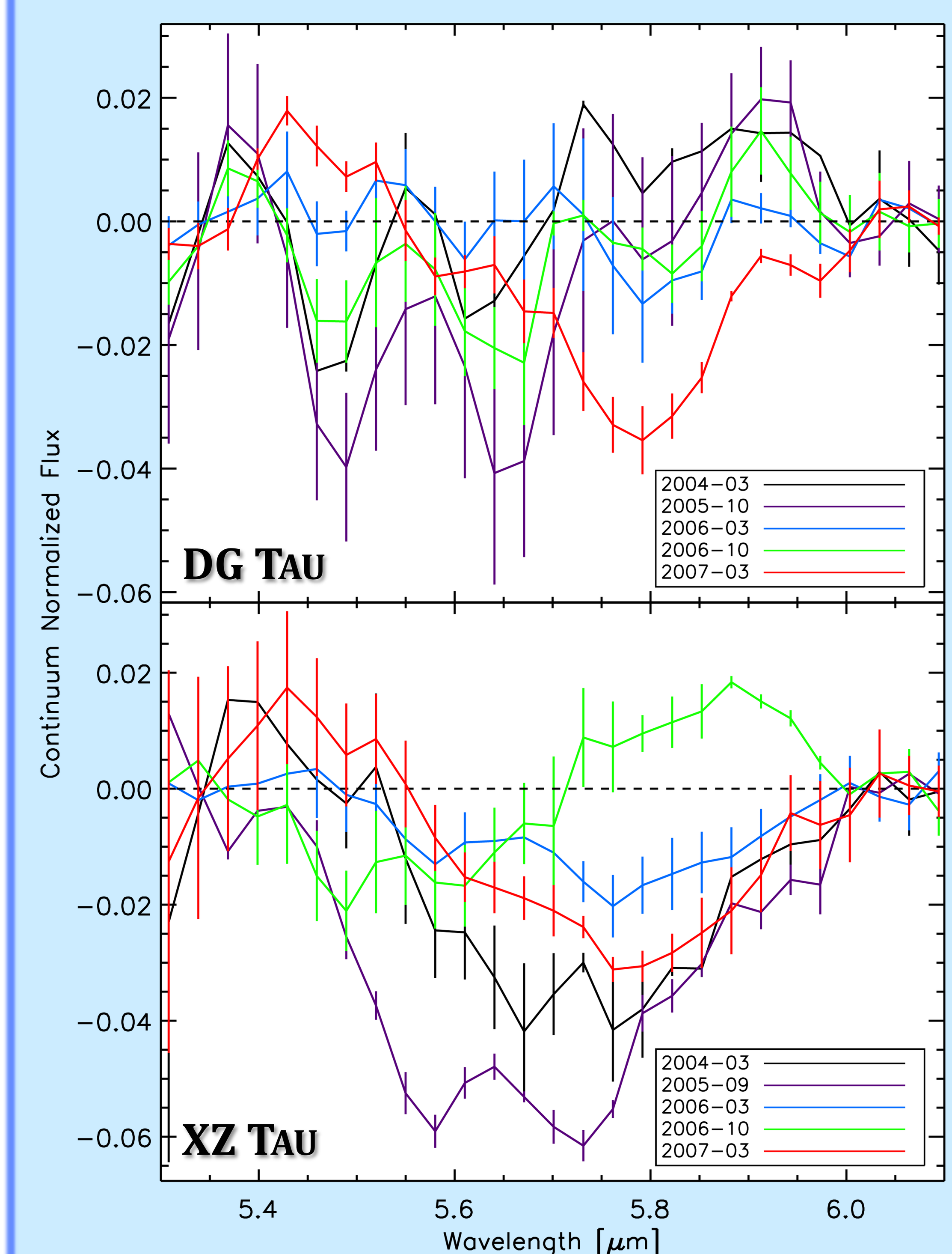
- ***Change in the flux and slope of the continuum***
- ***Water vapor absorption (blue)***
- ***10-micron silicate complex (green)***

T-Tauri stars are generally characterized by silicate *emission* features, however we observe both of these objects' silicate features entering absorption.

We observe significant modulation in the flux and slope of both objects' continua, which appears to correlate with the silicate feature.

In addition, we are unable to characterize DG Tau's [Ne II] line due to the spectra's low resolution as well as possible silica emission at the same wavelength.

Steam Absorption Band

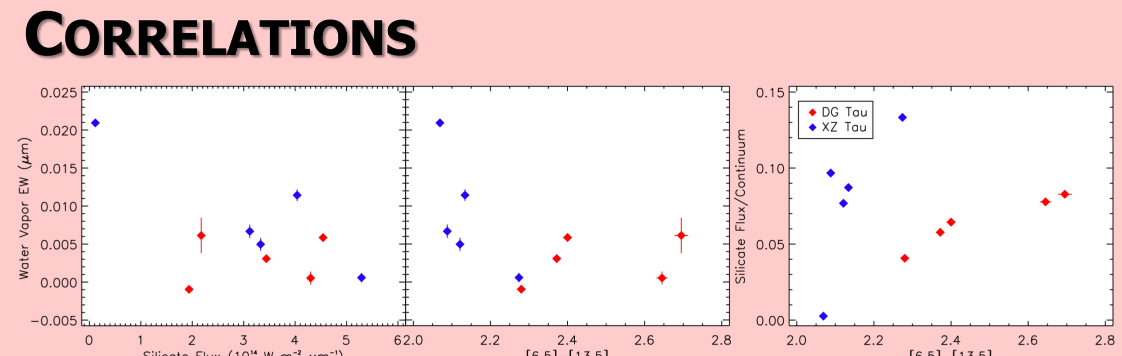


Ubiquitous H_2O vapor absorption feature:

- ***Centered between 5.6 and 5.8 μm***
- ***Varies significantly in both position and flux***

For heavy accretors, such as FU Ori objects, this feature is thought to result from viscous heating within the disk, suggesting the observed variations may be directly related to changes in the mass accretion rate. Other contributors may include variations in high energy photons or changes in structure of the inner disk region.

Correlations



We attempt to find correlations between the variations in the continuum, the water vapor band, and the silicate feature.

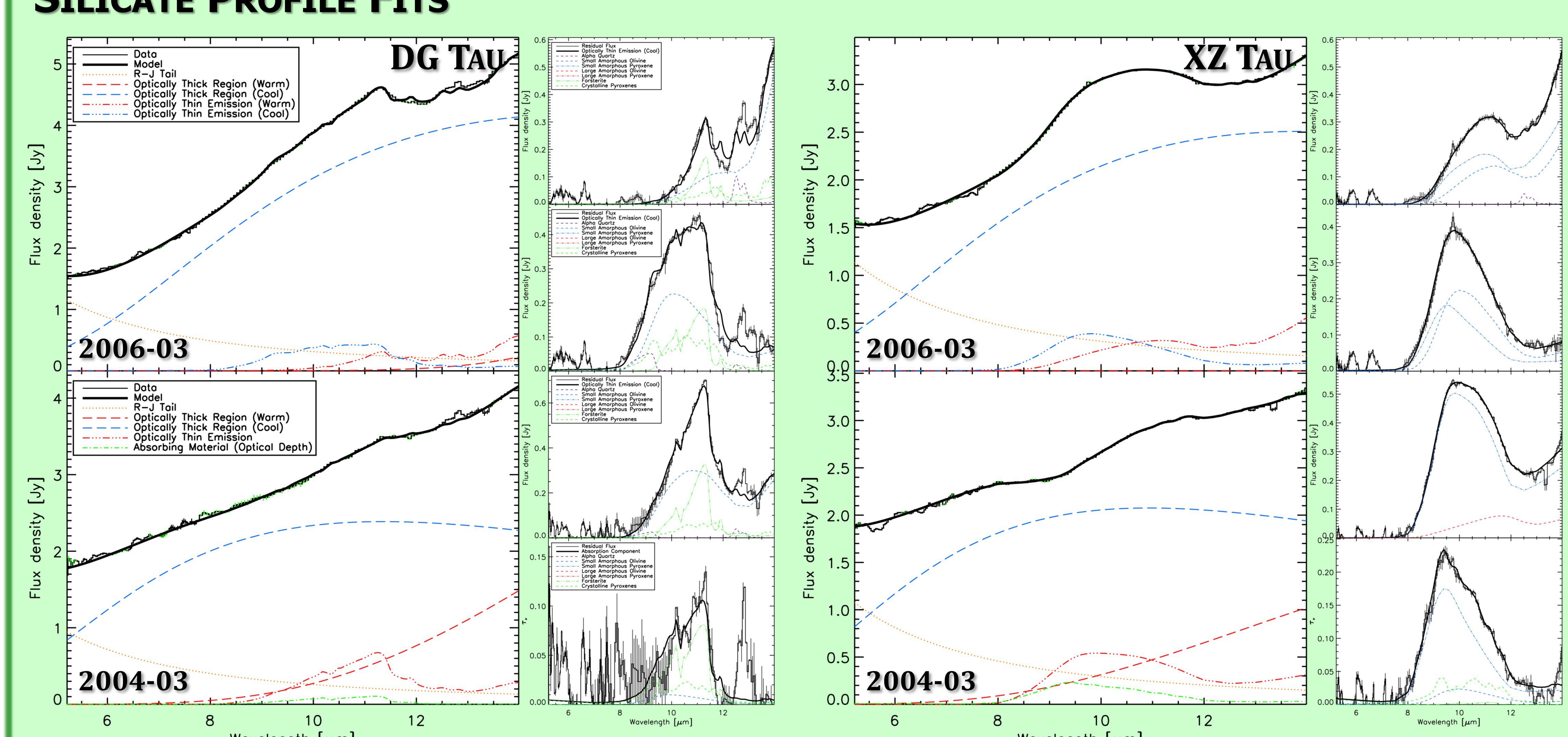
For XZ Tau, the steam band appears to decrease with increasing silicate flux and with increasing color. Also, the silicate flux appears to increase with the continuum color.

For DG Tau, the right-hand plot provides the only obvious correlation. The strength of the water vapor feature does not appear to vary with either the continuum or the silicate feature.

Conclusions

- We detect a water vapor absorption band between 5.6 and 5.8 μm,which exhibits strong variability in its strength and position.
- Significant variations in the silicate feature for DG Tau and XZ Tau can be explained by periodically "puffing-up" of the inner edge of the inner dusty disk. More extreme cases of silicate absorption could be caused by ablation of dustfromthe inner disk region into a halo structure above the disk through outflows such as radiation pressure or magnetocentrifugal winds.
- The lack of correlations between the features in DG Tau may indicate a more chaotic system driving the variability as opposed to XZ Tau, which is a known binary system.

Silicate Profile Fits



Examples of silicate component fits:

- ***Certain epochs well described by two-temperature fit***
- ***Others require silicate absorption***
- ***Various dynamical solutions***

For each object, we show simple model fits for the two epochs having the most extreme silicate variations. The optical properties of amorphous and crystalline silicate particles of small and large sizes are used to fit the observed *emission* profiles through a chi-squared minimization routine (e.g., Sargent et al. 2006, Bouwman et al. 2008).

The absorption feature was modeled by applying an absorption component to an emission model. However, due to the increasing amount of free parameters, we had to limit the number of included dust components. While the above solutions appear to describe the observations decently well, other solutions exist with comparable goodness-of-fit levels, making it difficult to accurately predict the dust compositions of these disks. Regardless, we find that our spectra can be interpreted as a superposition of emitting and absorbing material.

Vinković & Jurkić (2007) suggest many possibilities that might add an absorbing component to the spectrum, including ablation of a portion of in the inner disk rim due to an outburst or outflow of material.

References

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