HST/WFC3 Imaging and Multi-Wavelength Characterization of Edge-On Protoplanetary Disks

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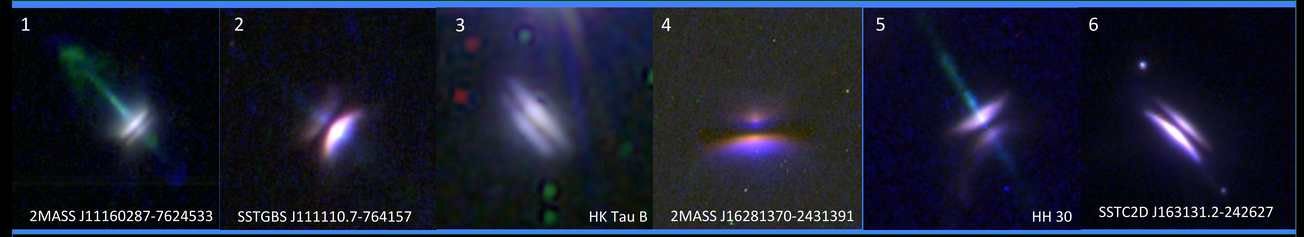
Abstract

In this contribution, we compare seven HST-imaged edge-on protoplanetary disks in the Taurus, Chamaeleon and Ophiuchus star-forming regions, making note the variation in morphology (settled vs flared), dust properties revealed by multiwavelength color mapping, brightness variability over years timescales, and the presence in some systems of a blue-colored atmosphere far above the disk midplane. By using a uniform approach for their analysis, these seven edge-on protoplanetary disk systems can give insights on evolutionary processes and inform future projects that explore this critical stage of planet formation.

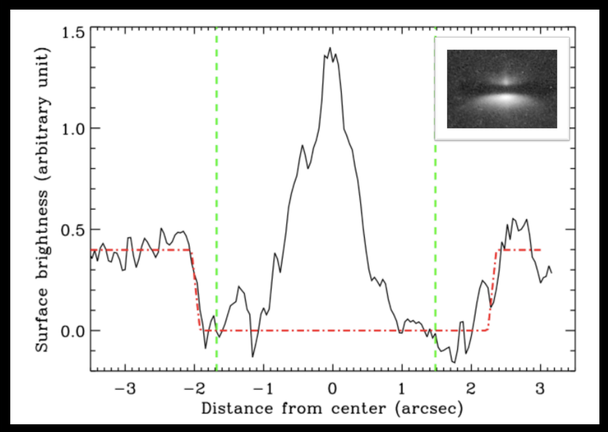
Objects

Here we present preliminary results, including 3-color visible light images of all disks, which were made using only HST observations (WFPC2, ACS, and/or WFC3) and with the filters F475W, F606W, and F814W. Included is the well-studied HH 30 system, and a more detailed analysis of the largest edge-on disk system in our sample.



#	Name	SFR	R_{Disk}	SpT	Jet	Disk	Atmosphere
1	2MASS J11160287-7624533	Cha	75 AU	K8	✔	Flat/Settled	✔
2	SSTGBS J111110.7-764157	Cha	125 AU	M2.5	✔	Flared	✔
3	HK Tau B	Tau	105 AU	M2	✗	Flat/Settled	✗
4	2MASS J16281370-2431391	Oph	300 AU	M	✗	Flared	✔
5	HH 30	Tau	225 AU	M0	✔	Flared	✗
6	SSTC2D J163131.2-242627	Oph	160 AU	M	✗	Flat/Settled	✗
7	SSTTau J042021.4+281349	Tau	450 AU	M1	✔	Flared	✔

A range of targets were selected to emphasize disk diversity, as there is no obvious correlation between a visible atmosphere and stellar or other disk characteristics.



Observing the disk silhouette of 2MASS J1628

An interesting feature in the 2MASS J1628 disk (#4) is that the dark silhouette of the disk itself is visible between the two nebulae in the F475W filter due to the absorption of bright background emission.

Visible to the left is a normalized graph of a cut through the dark midplane of the edge-on disk. While brightest in the middle due to leaking from the central star, background noise is visible at the edges beyond where we detect the scattered light disk (green lines), and troughs are indicative of the true darkness of the density of the vertical midplane. The slope leading from the dark midplane up into the noise, modeled with a step function (in red), gives insight to the opacity of the dust as as function of distance from the star. Worth noting is that the slopes are not identical, the right-hand slope is shallower, which indicates asymmetry in the disk structure itself.

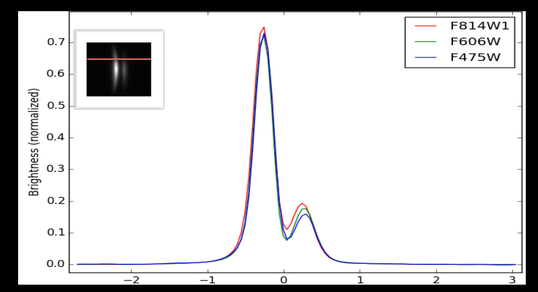
Observing the blue atmosphere in SSTTau J042021.4+281349

(Left) HST 3 color F814W, F606W, and F475W: (Center) 3 color HST and Keck F814W, J, K' : (Right) HST 2 color F606W and F814W and CARMA 1.3mm contours

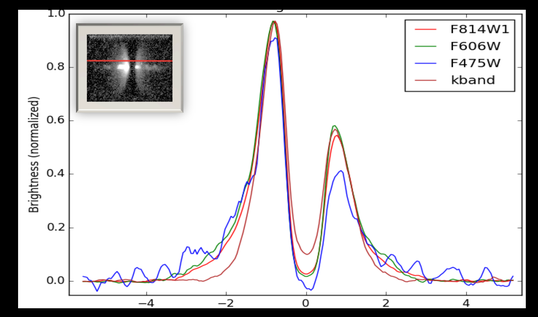
Results

The figures on the right map a map the surface brightness along two disks, C2dj163131 (top) which does not have a prominent blue-band component at the outer edges of the disk, and Tau042021 (bottom), which notably does.

From the Tau042021 figure, we see that the intensity of surface brightness drops faster at longer, redder, wavelengths (F814W) as a function of distance away from the midplane while the blue F475W line drops slower at shorter, bluer, wavelengths. Blue light at large distances from the disk suggests the presence of small dust grains in this region.



C2dj 163131



Tau 042021

Future

Future work will include using radiative transfer modeling to disentangle the observed atmosphere from the disk, as well investigating the relationship with other disk properties including presence of a jet, mass, degree of settling as an indicator of evolution, and newly obtained mm ALMA data.

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