Constraining Gas Disk Structure in MY Lupi with UV and Submillimeter Models

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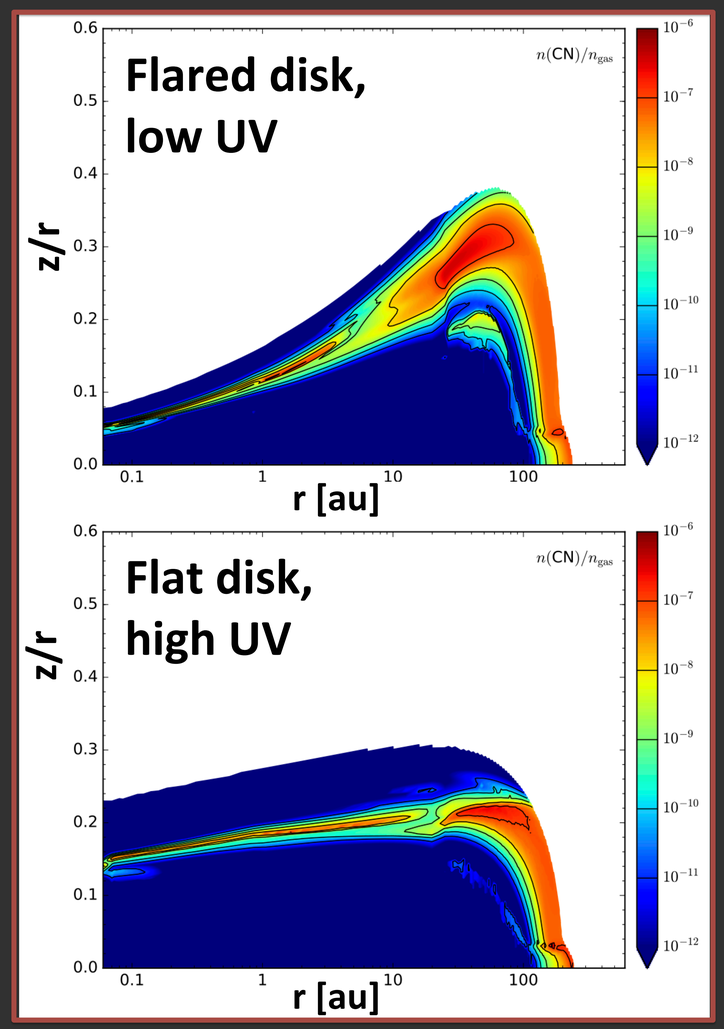
How can we study the composition and distribution of gas in regions of protoplanetary disks where rocky planets form?

Physical-chemical models generate detailed maps of carbon, nitrogen, oxygen, and hydrogen bearing molecules in protoplanetary disks. However, the vertical disk structure in these models is degenerate with the amount of UV flux reaching the gas. Flat, strongly irradiated disk models and flared, weakly irradiated systems produce similar integrated line fluxes, which makes it difficult to examine UV sensitive photochemical pathways at disk radii where submillimeter gas emission cannot yet be spatially resolved.



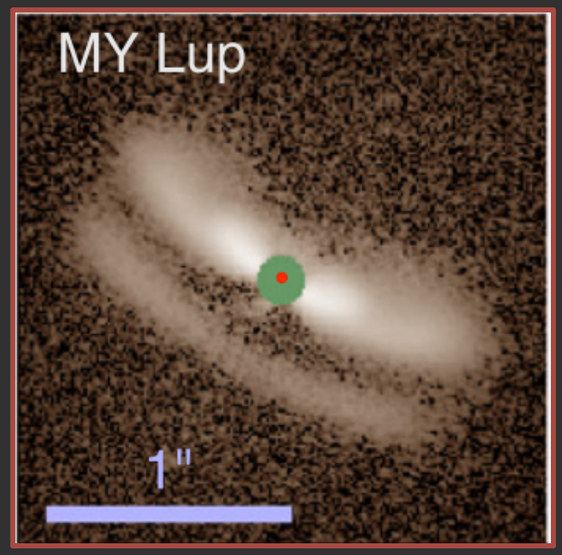
Can multi-wavelength spectroscopy break the degeneracy between vertical disk structure and UV irradiation of the gas?

We investigate whether ultraviolet emission lines from fluorescent molecular hydrogen can be used to break this degeneracy, by using the Dust and LInes (DALI) code (Bruderer et al. 2013) to model CN emission in the disk around MY Lupi. We have chosen MY Lupi as a prototype, since its flaring angle has been directly measured from scattered light observations (see below).

Pumped by Lyα to produce UV-H_2 emission

$$\mathrm{N} + \mathrm{H_2^*} \longrightarrow \mathrm{NH} + \mathrm{H}$$
$$\mathrm{C^+} + \mathrm{NH} \longrightarrow \mathrm{CN^+} + \mathrm{H}$$
$$\mathrm{CN^+} + \mathrm{H} \longrightarrow \mathrm{CN} + \mathrm{H^+}$$

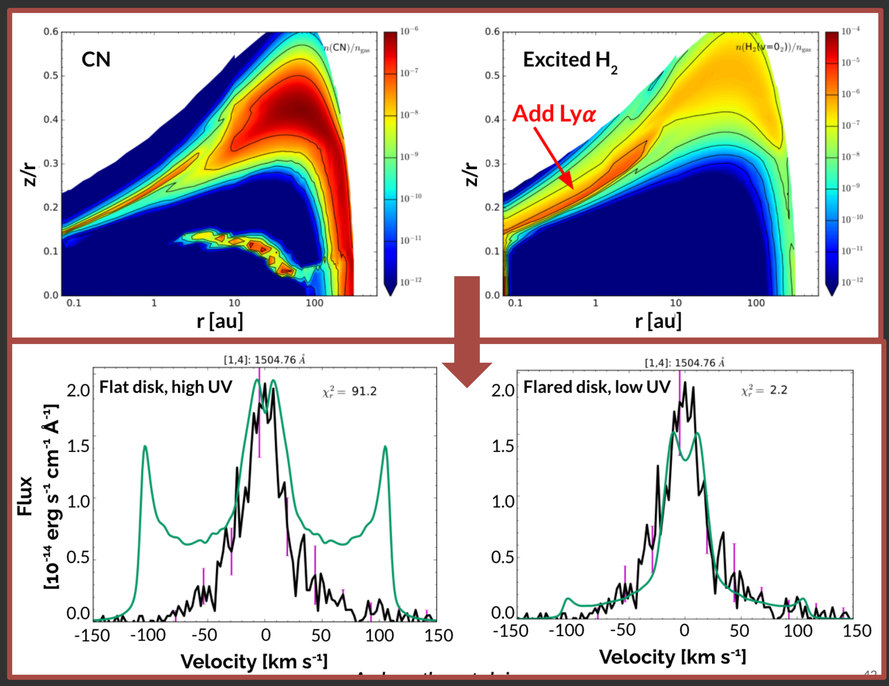
Visser et al. 2017, Cazzoletti et al. 2018



H-band scattered light image of MY Lup (Avenhaus et al. 2018), which constrained the disk flaring angle (ψ = 0.21 ± 0.03)

How does the multi-wavelength modeling approach work?

The 2-D distributions of vibrationally excited molecular hydrogen from each DALI model are irradiated with LyA photons, which pump the gas into excited electronic states. The resulting fluorescent emission lines are compared directly to observed UV features in *HST*-COS spectra of MY Lupi, showing that the H_2 lines are best fit by a flared disk model with strong FUV irradiation and a high gas mass.



Outstanding question: do any disks show UV-H_2 emission lines that look like the flat disk model?

We conclude that molecular emission lines from UV spectra can provide important constraints for physical-chemical models of gas disks. However, further observations are required to determine whether flatter disks produce UV-fluorescent H_2 emission that looks like the models.

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