High Mass Planet Spiral Shocks as a Source of Infrared Emission from Protoplanetary Disks

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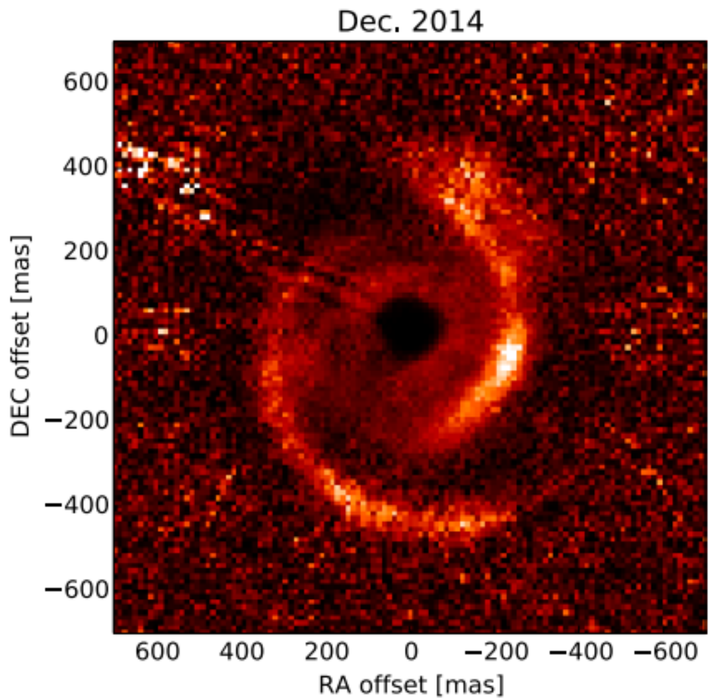
How to Explain Wide Spirals?

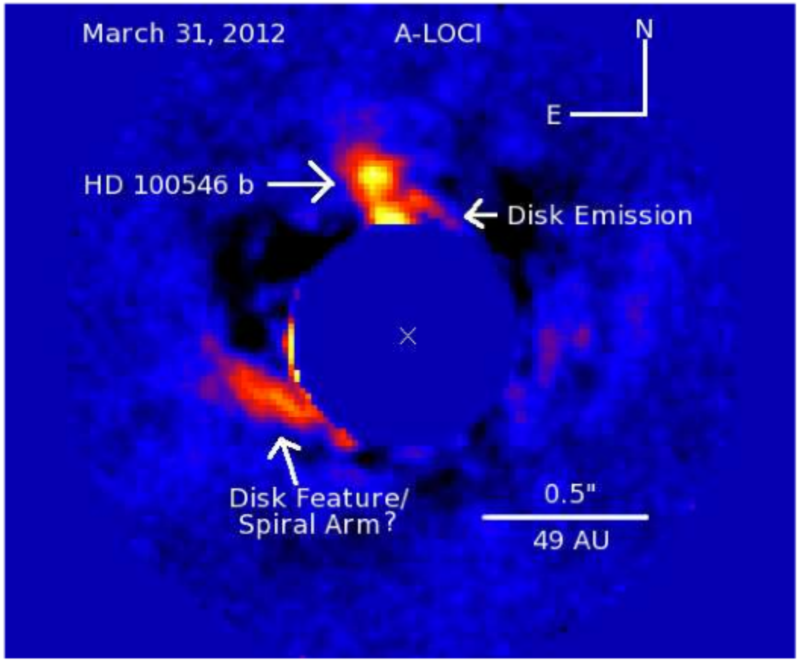
MWC 758



Spirals **hotter (300K)** than ambient gas (50K)

Benisty et al. (2015)

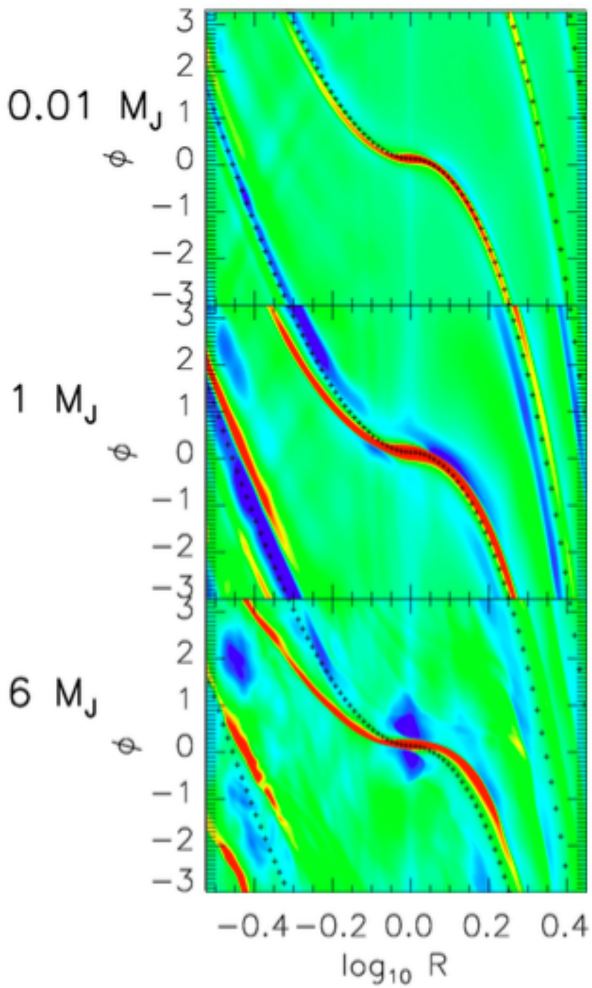
HD 100546



Disk feature not polarized
thermal emission

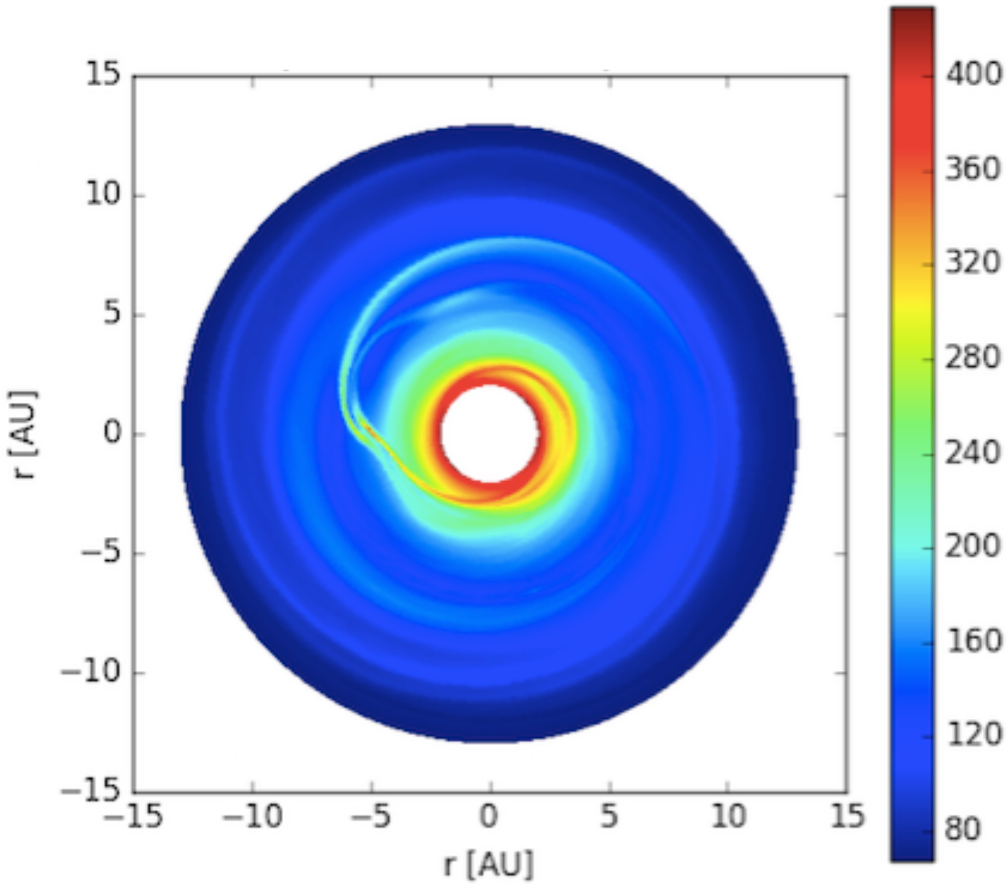
Currie et al. (2014)

Supersonic Wakes of High Mass Planets



Density

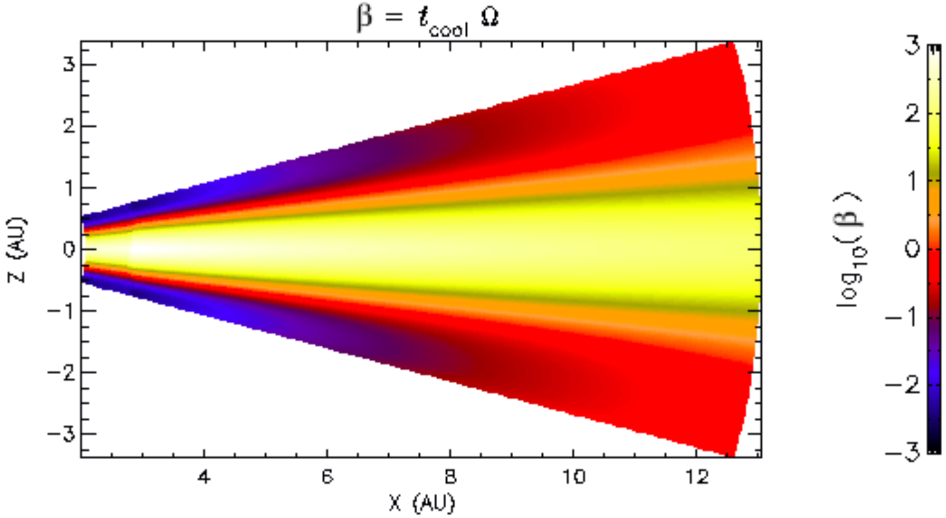
Zhu et al. (2015)

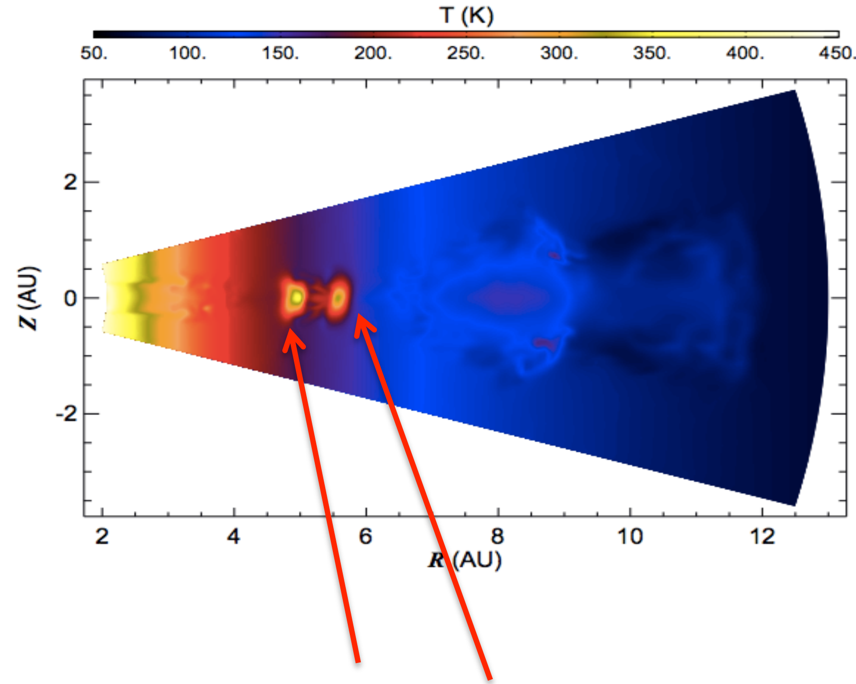


Temperature - **5M$_J$**

Lyra et al. (2016)

Lyra et al. (2016)



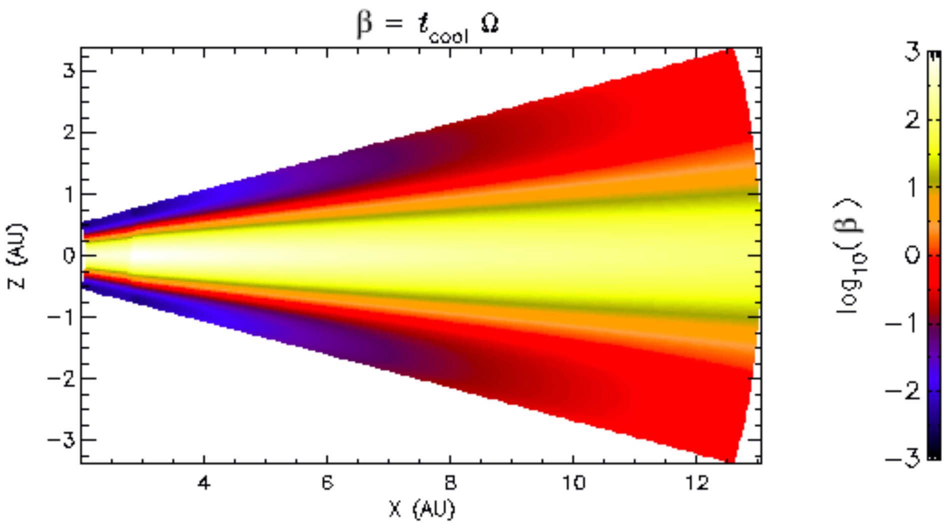


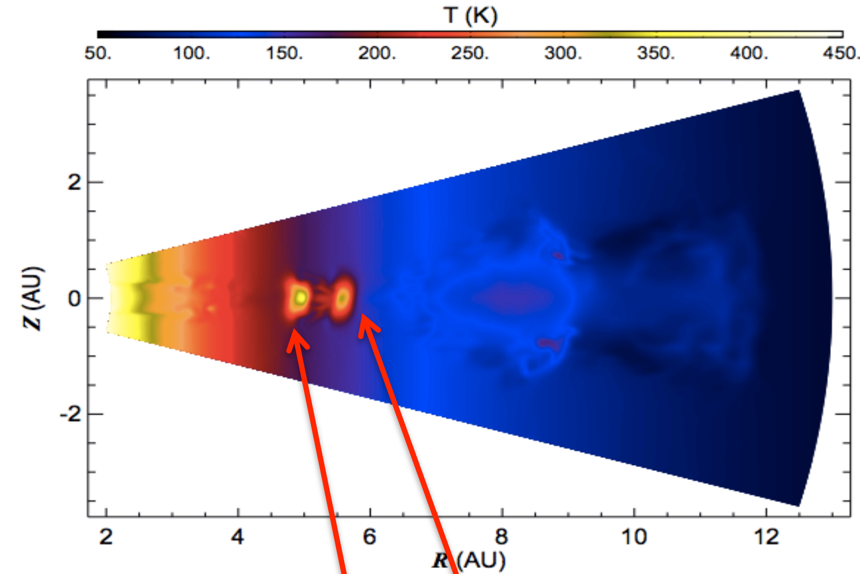
adiabatic in the midplane
isothermal in the atmosphere

~450 K

Hot "Shock Bores" inwards and outwards from planet at Lindblad Resonances

Lyra et al. (2016)





adiabatic in the midplane
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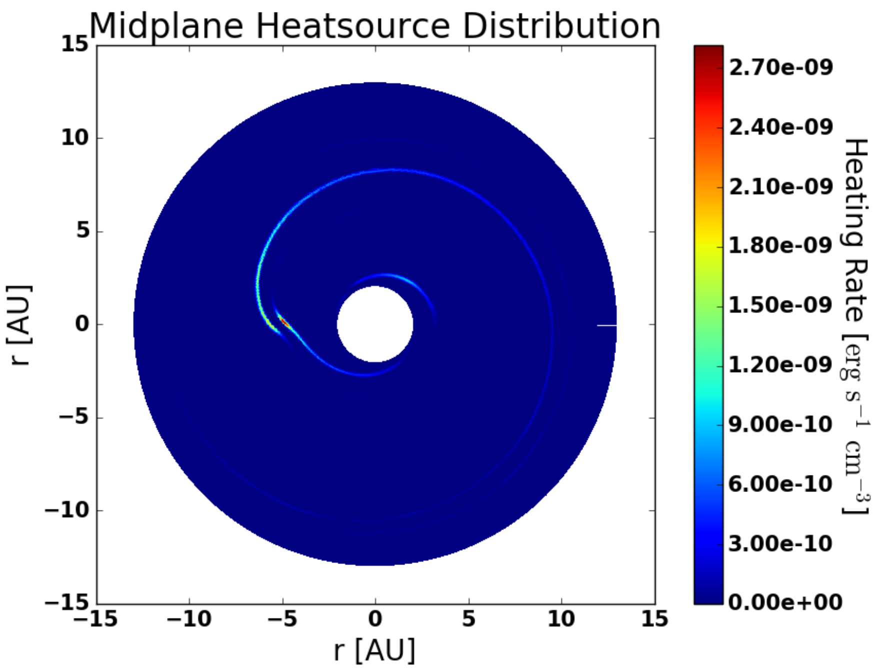
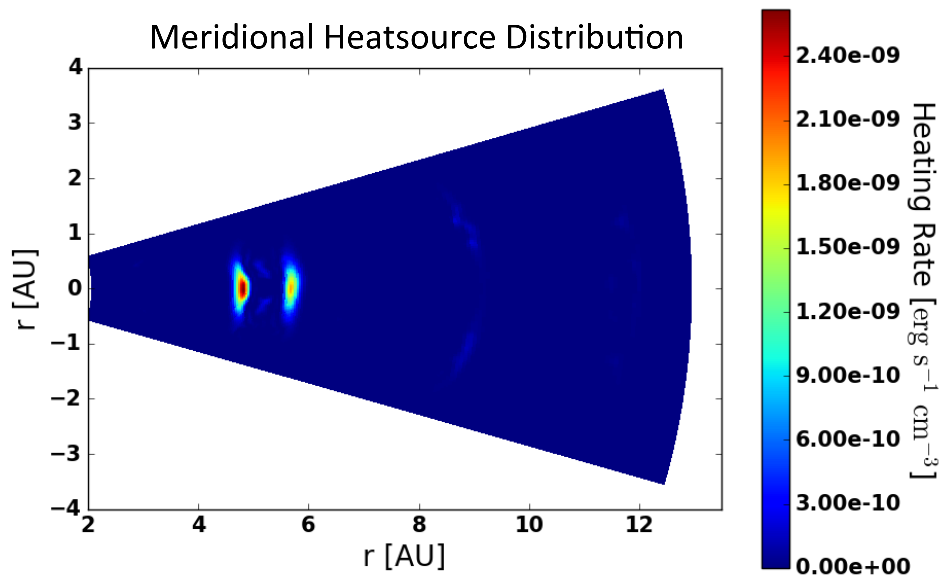
Hot "Shock Bores" inwards and outwards from planet at Lindblad Resonances

Uses on-the-fly Newton cooling function dependent on optical depth (for speed)

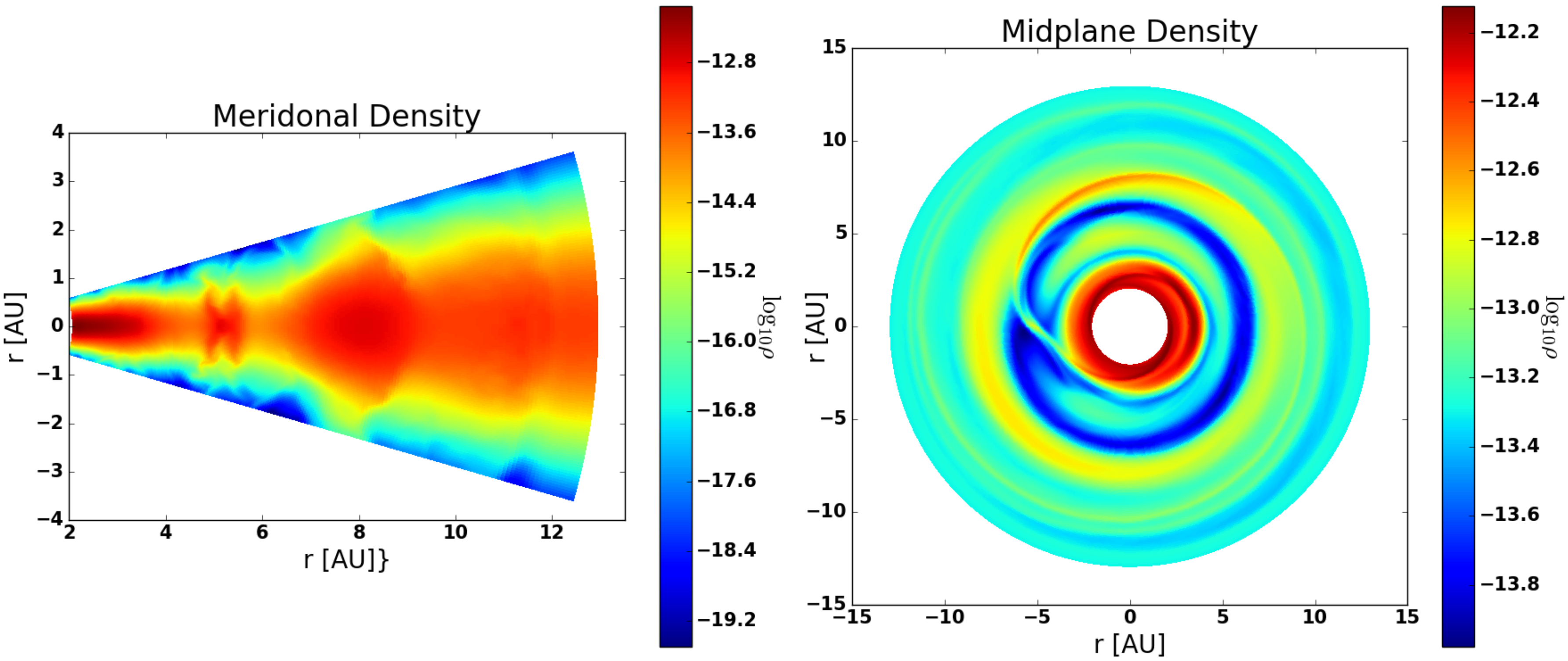
RADMC-3D
(Dullemond 2012)

Radiative Transfer - **Shock heating**



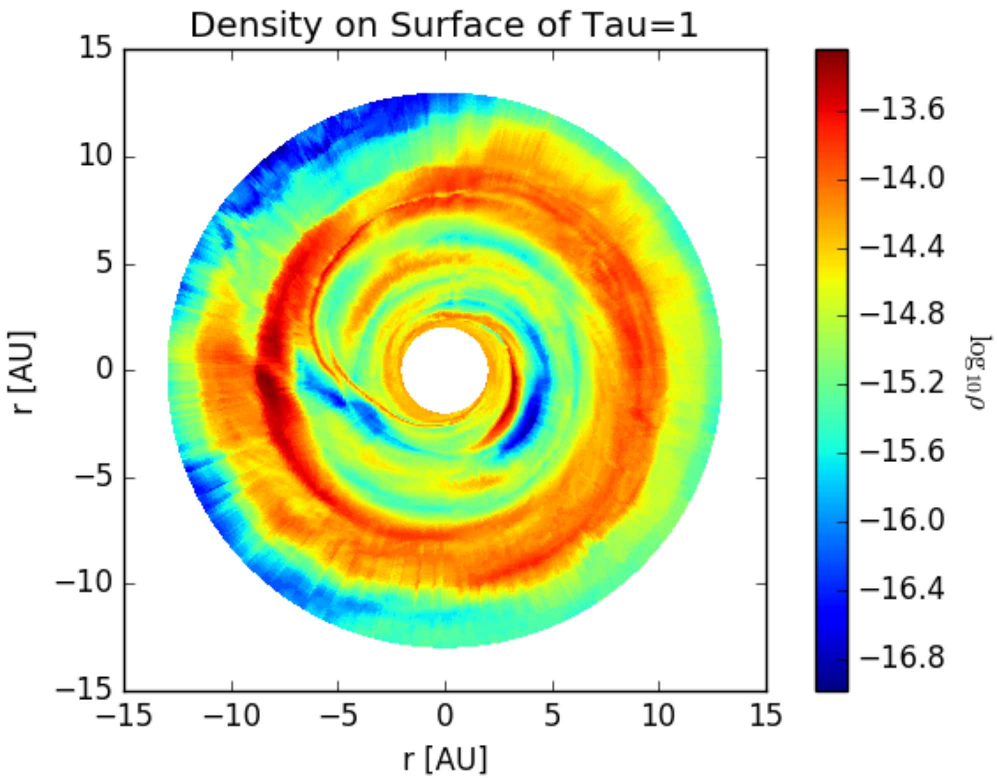


Input into RADMC-3D

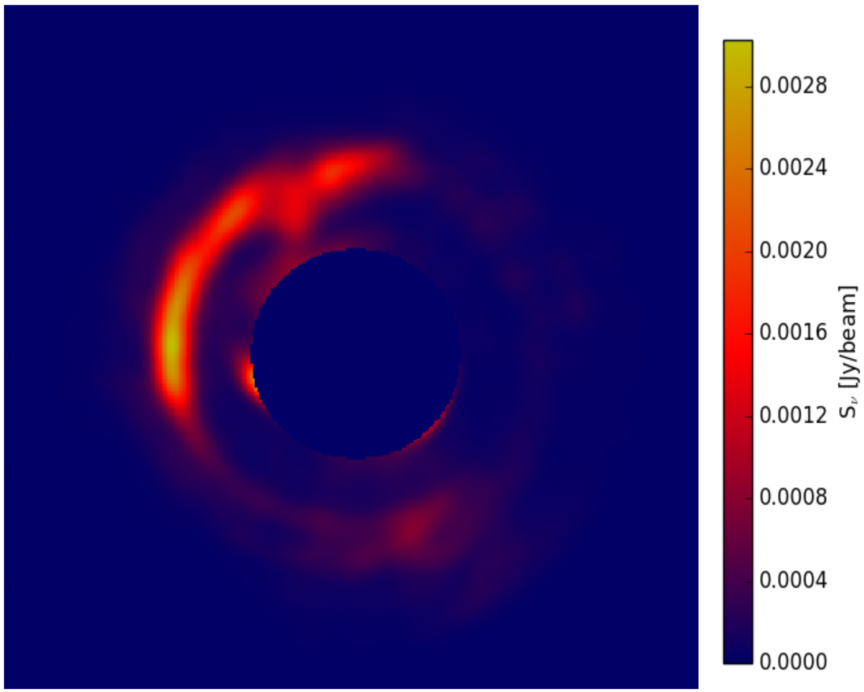


Input directly from the PENCIL CODE – new pipeline created

Scattering in Image

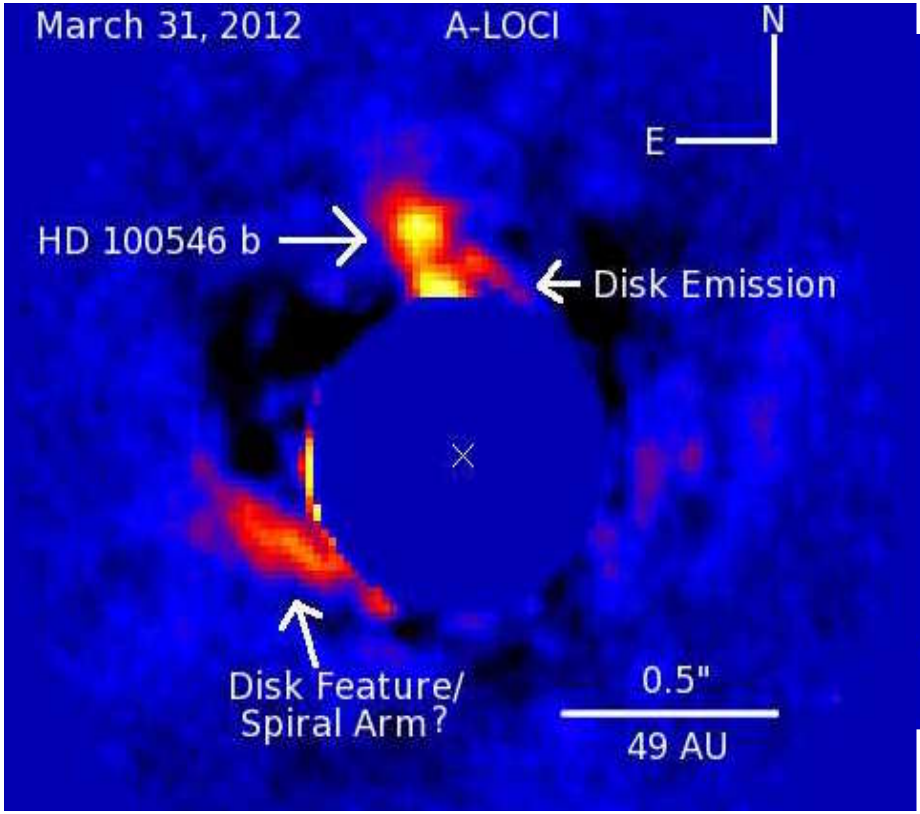


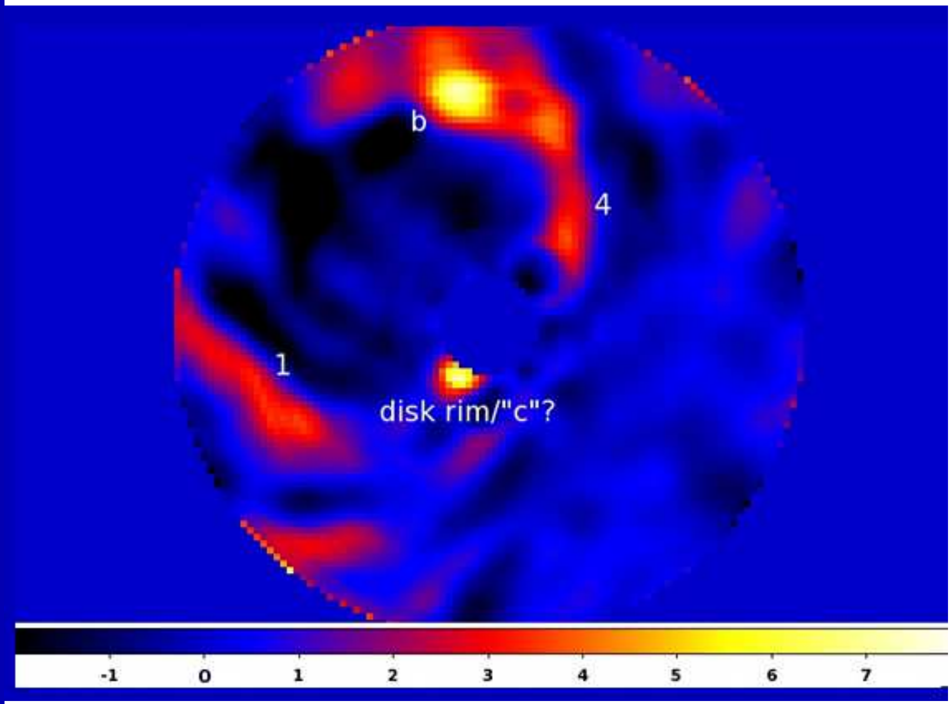
Light scattered off **gap outer edge**



"Bird's eye view" synthetic image

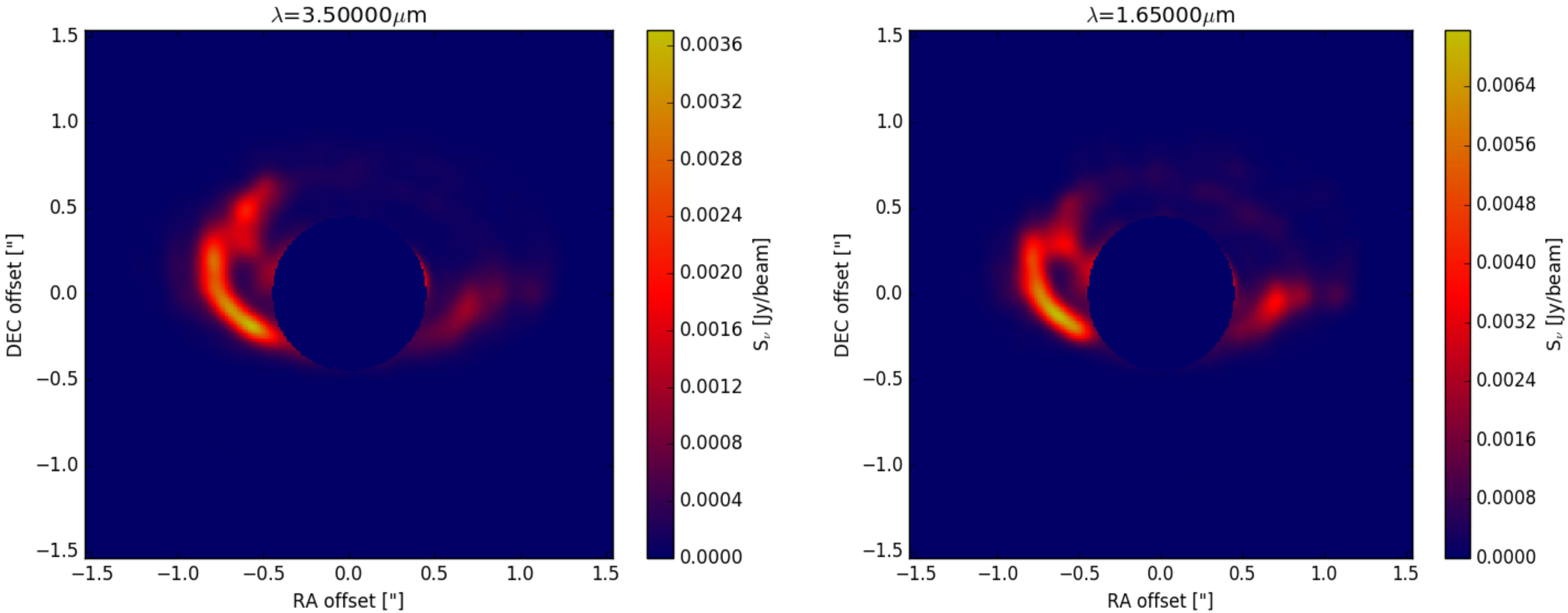
HD 100546





Currie et al. (2014), Currie et al. (2015)

Synthetic Images



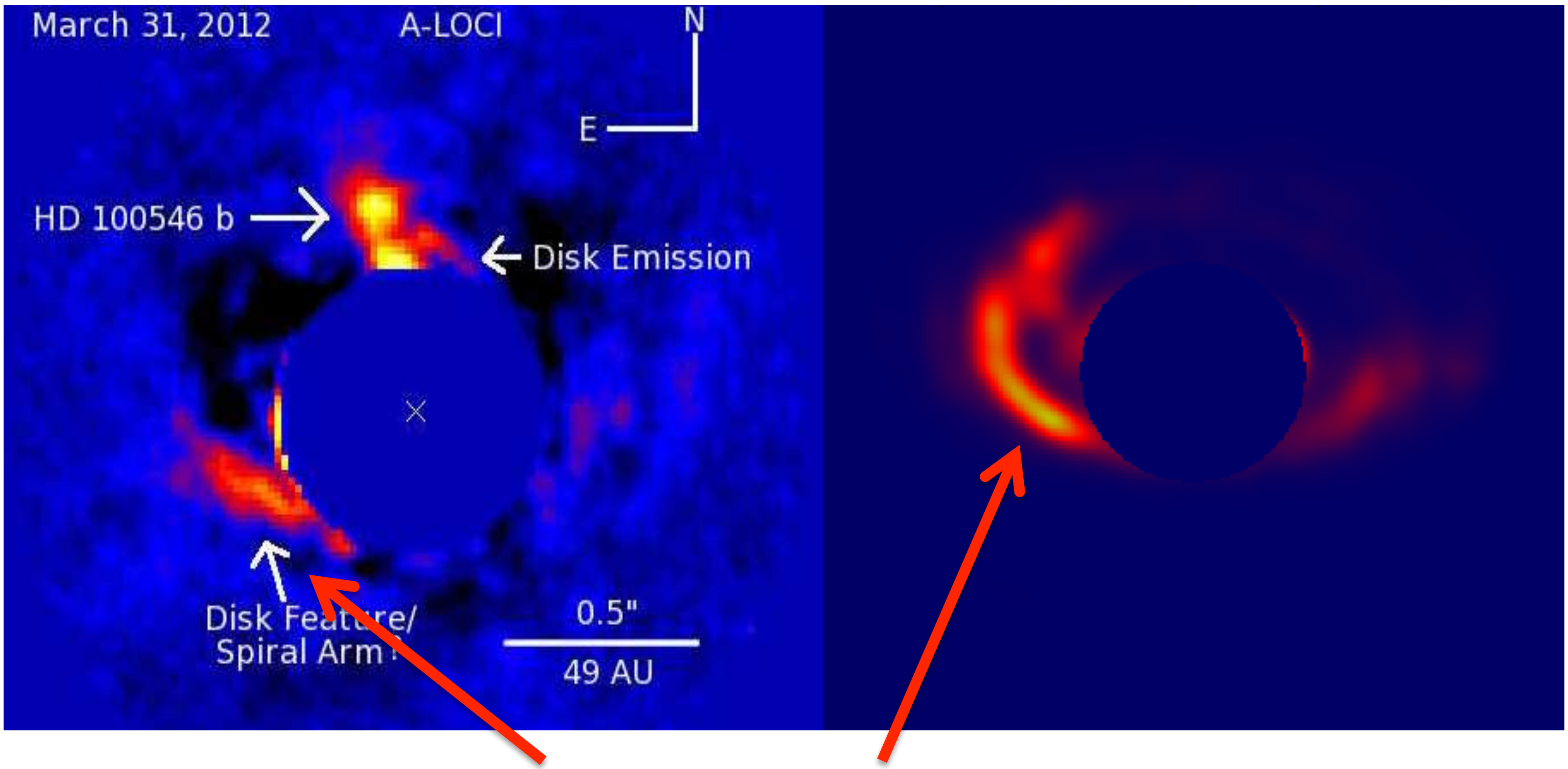
λ = 3.5 microns (**L' Band**)

λ = 1.65 microns (**H Band**)

Made with 138 degree position angles and 50 degree inclination angles to match Currie et al. (2014) observations.

Disk scaled by factor of 10 to map T Tauri 5 AU to Herbig Ae 50 AU

Comparison



Matching general morphologies

Conclusions

- Evidence for second planet inwards of 30 AU
  - Requires more evidence, because emission could also be from residual waves of another source
- High mass planet spiral **shocks** may be **observable**
- Future research into other disks– LkCa 15
- Pipeline between Pencil Code and RADMC-3D can be used to determine observations of other models