

A “linha da neve” de discos protoplanetários

Entenda porque está faltando água em São Paulo!

Rodrigo Vieira





Referências

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ROYAL ASTRONOMICAL SOCIETY

LETTERS



Mon. Not. R. Astron. Soc. **425**, L6–L9 (2012)

doi:10.1111/j.1745-3933.2012.01290.x

On the evolution of the snow line in protoplanetary discs

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Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

<http://www.sciencedaily.com/releases/2012/07/120717131217.htm>

<http://astrobites.org/2012/07/25/snow-lines-and-protoplanetary-disks-or-whered-all-the-water-go/>

Objetivo

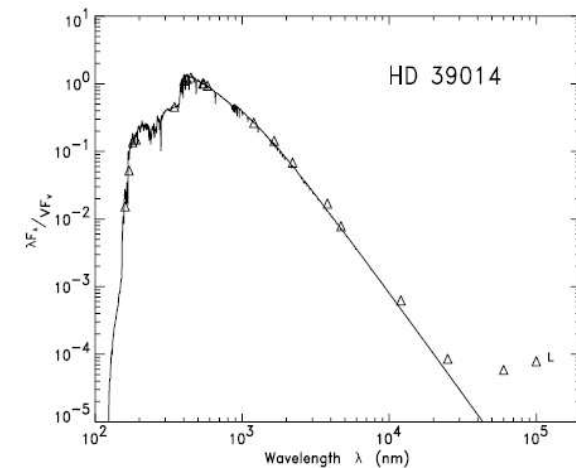
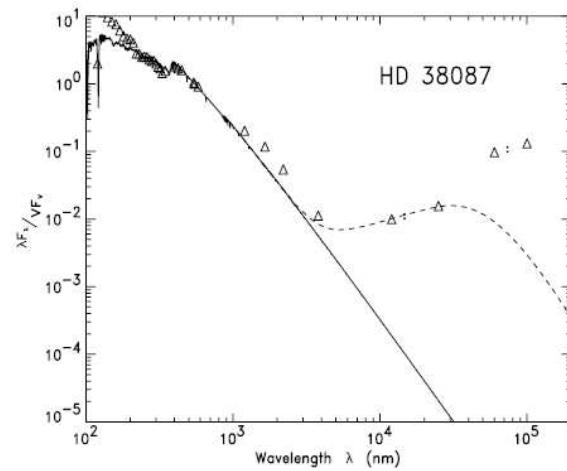
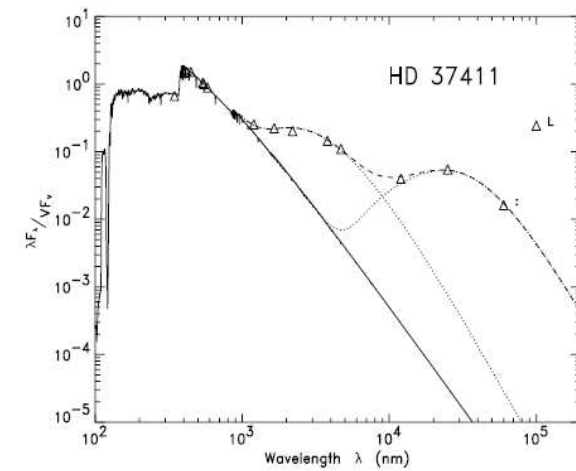
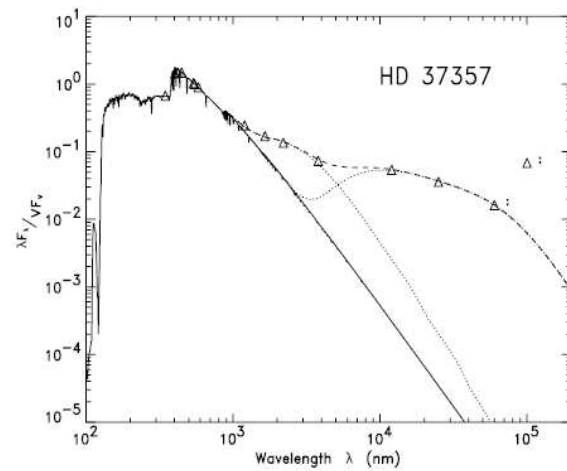
Responder as seguintes perguntas:

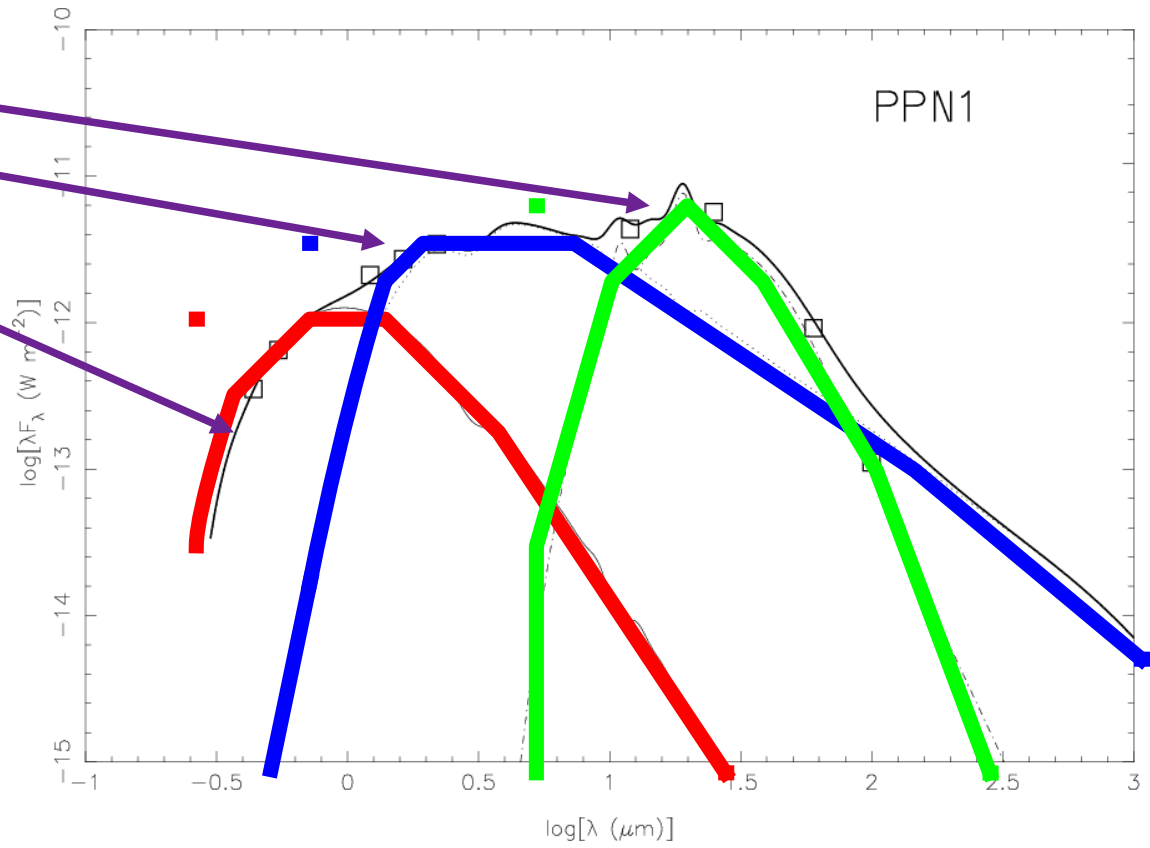
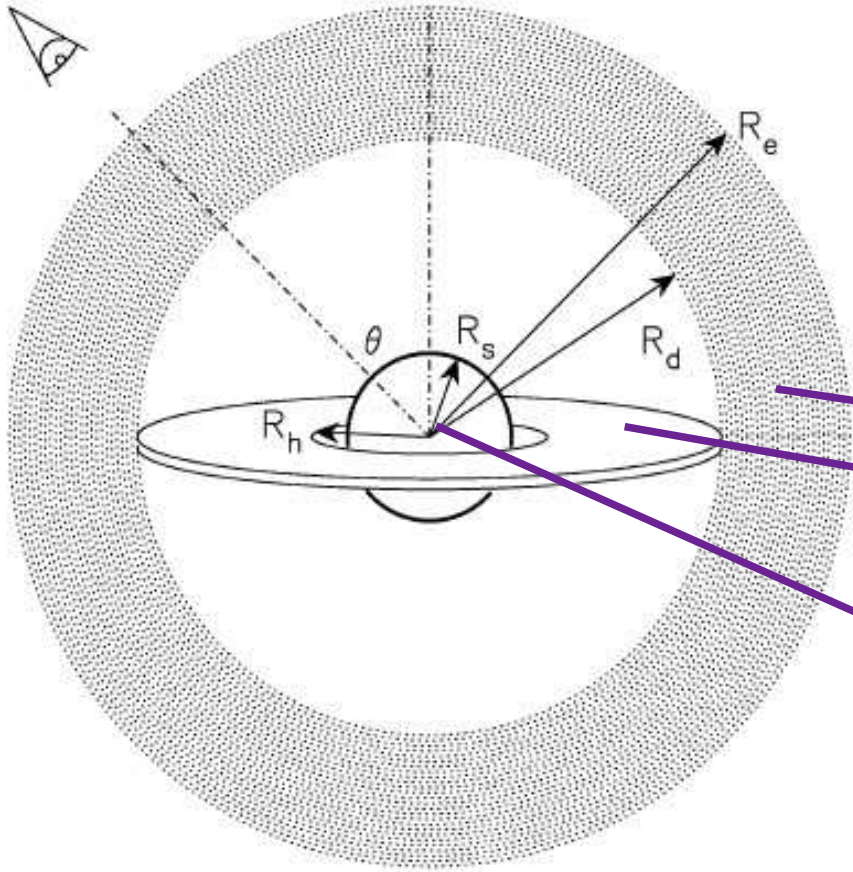
- *O que são discos protoplanetários?*
- *O que é a “linha da neve” e como ela evolui?*
- *Por que está faltando água em São Paulo???*

A detailed image of a protoplanetary disk (proplyd disk) around a young star. The central star is a bright, white-yellow point source. The surrounding disk is composed of dust and gas, appearing as a glowing, orange-brown ring. The disk is tilted, showing a clear edge-on view. The background is a dark, star-filled space.

Discos protoplanetários

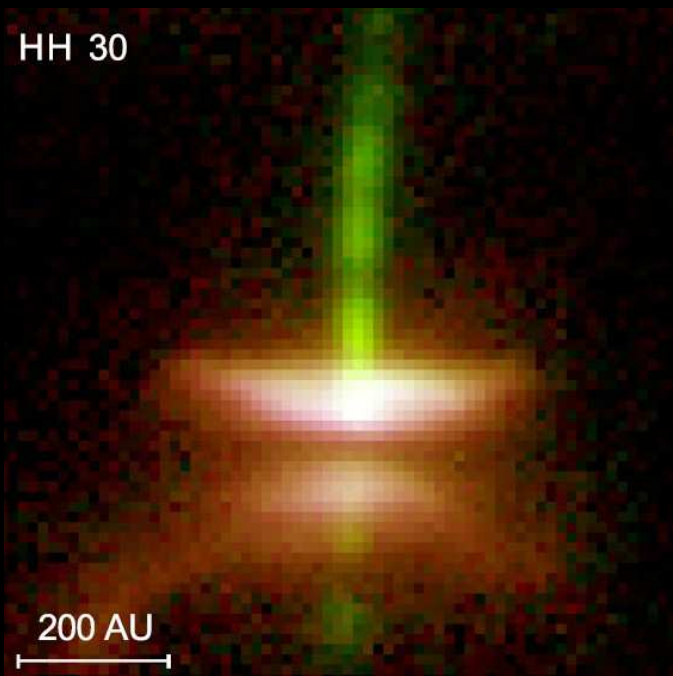
Antigamente...





Hoje!

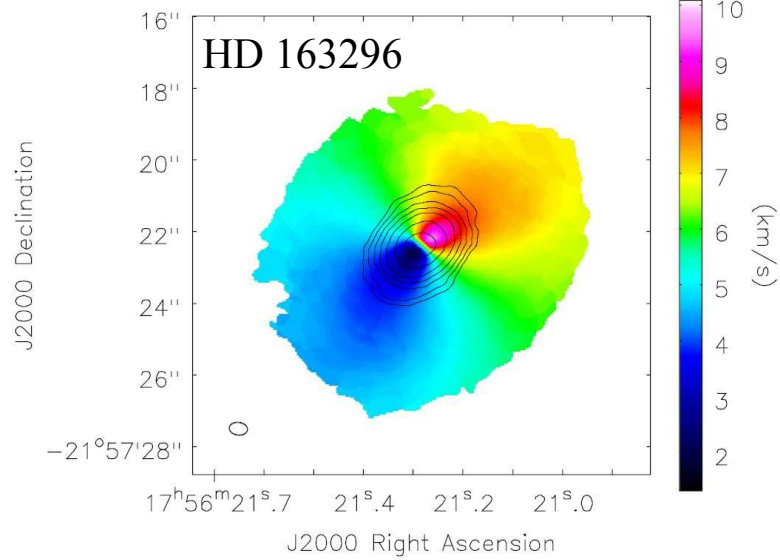
HH 30



Hubble Space Telescope



ALMA



De Gregorio-Monsalvo et al. (2013)

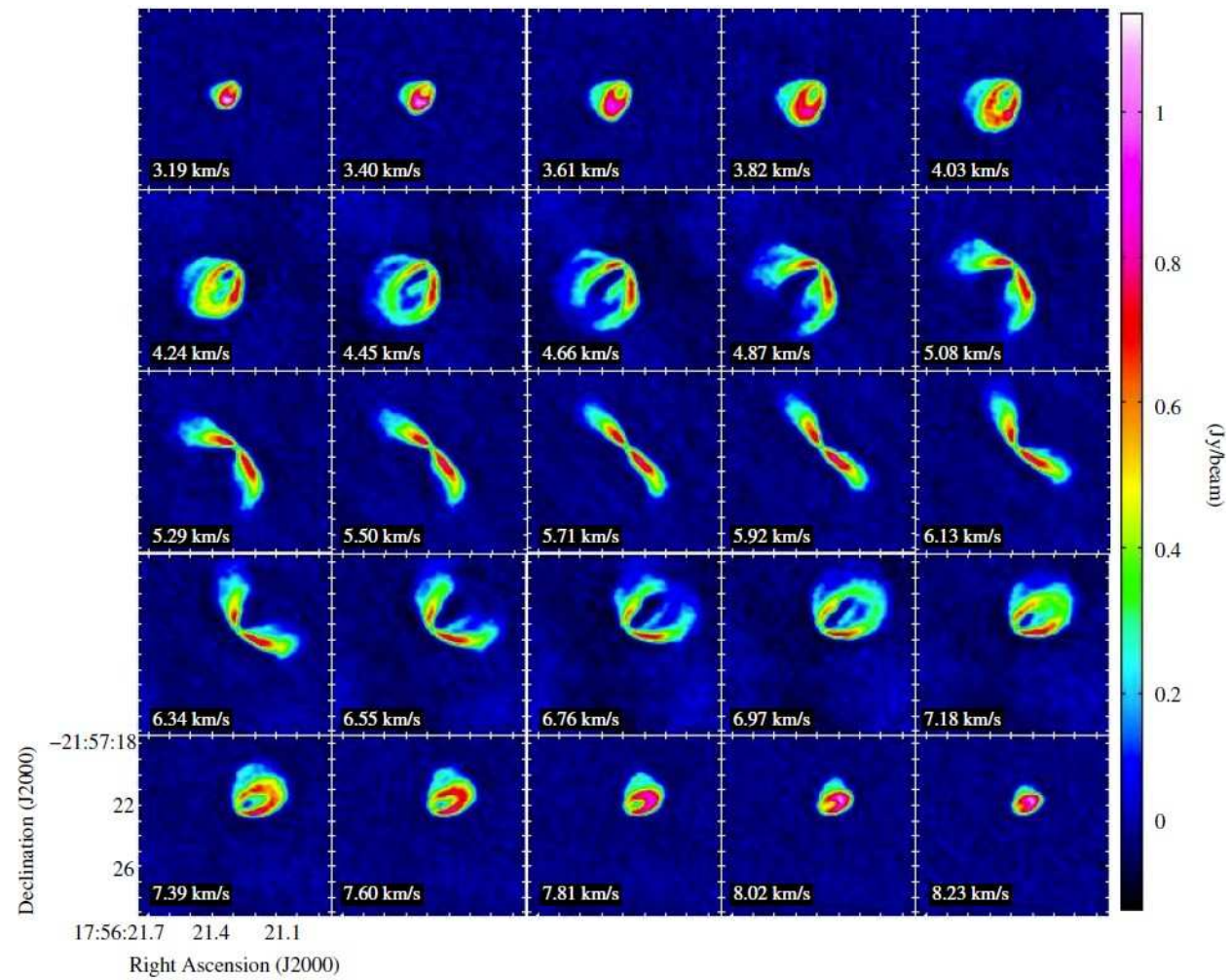
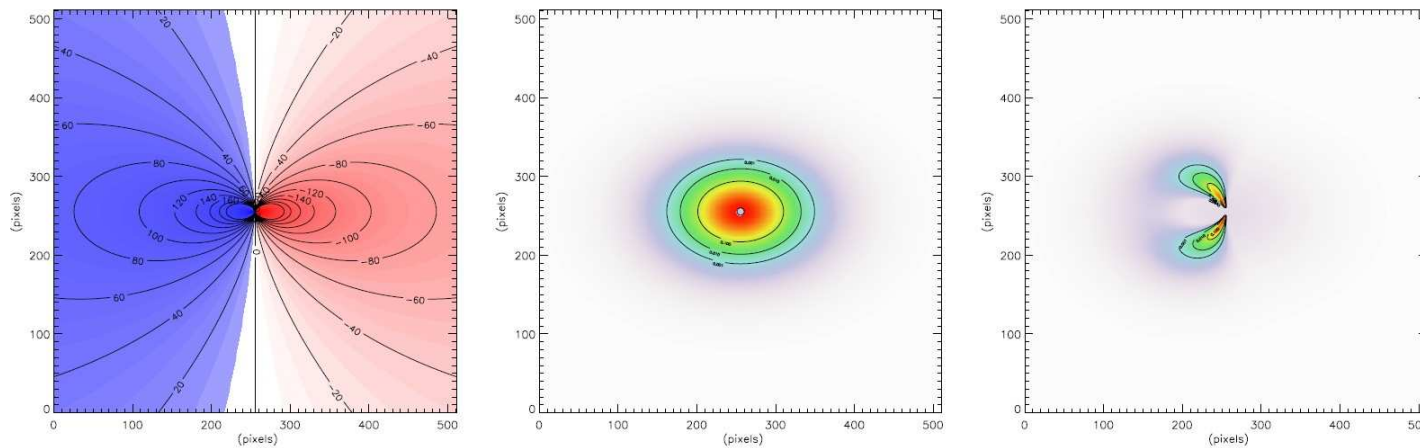
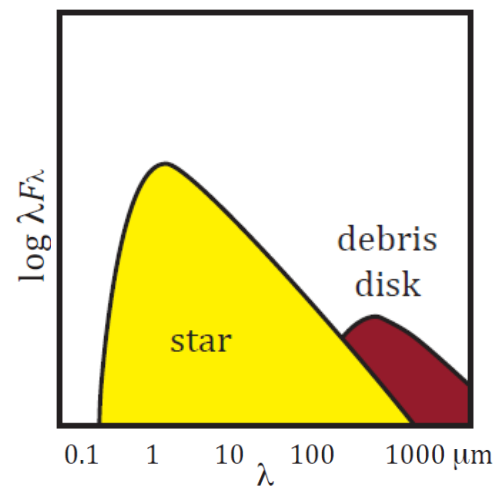
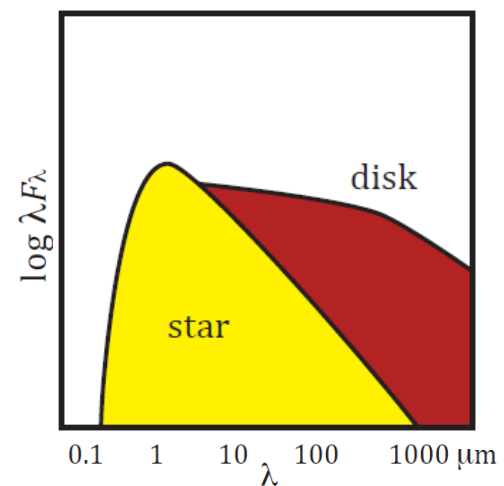
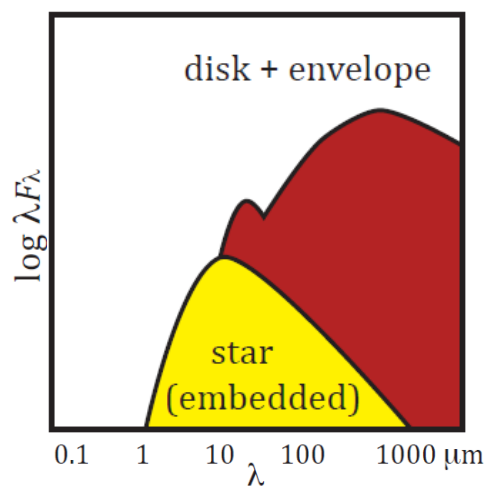
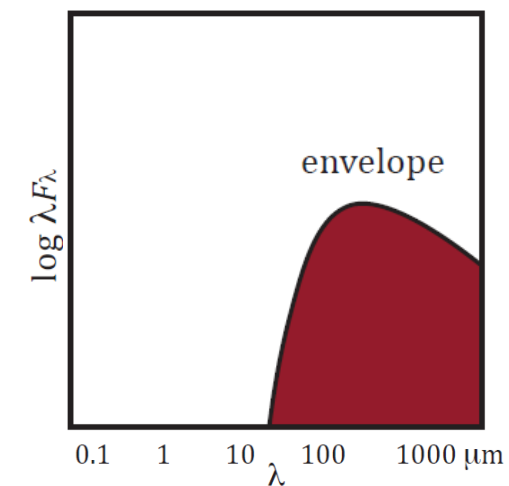
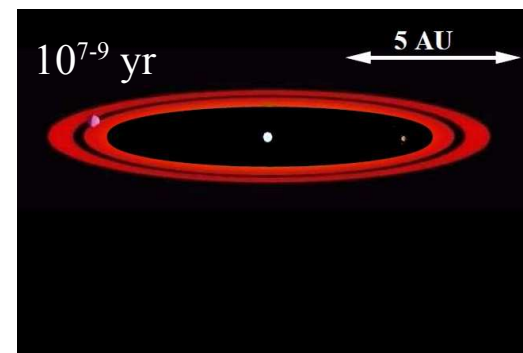
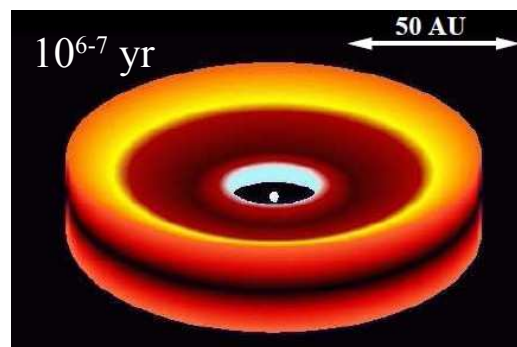
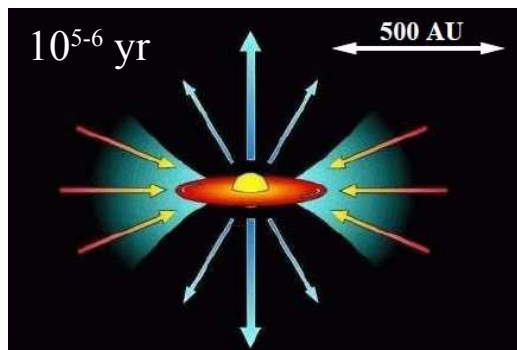
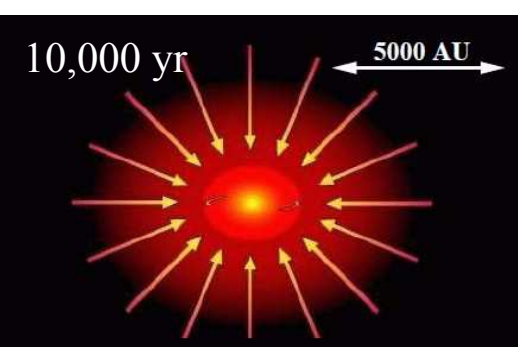
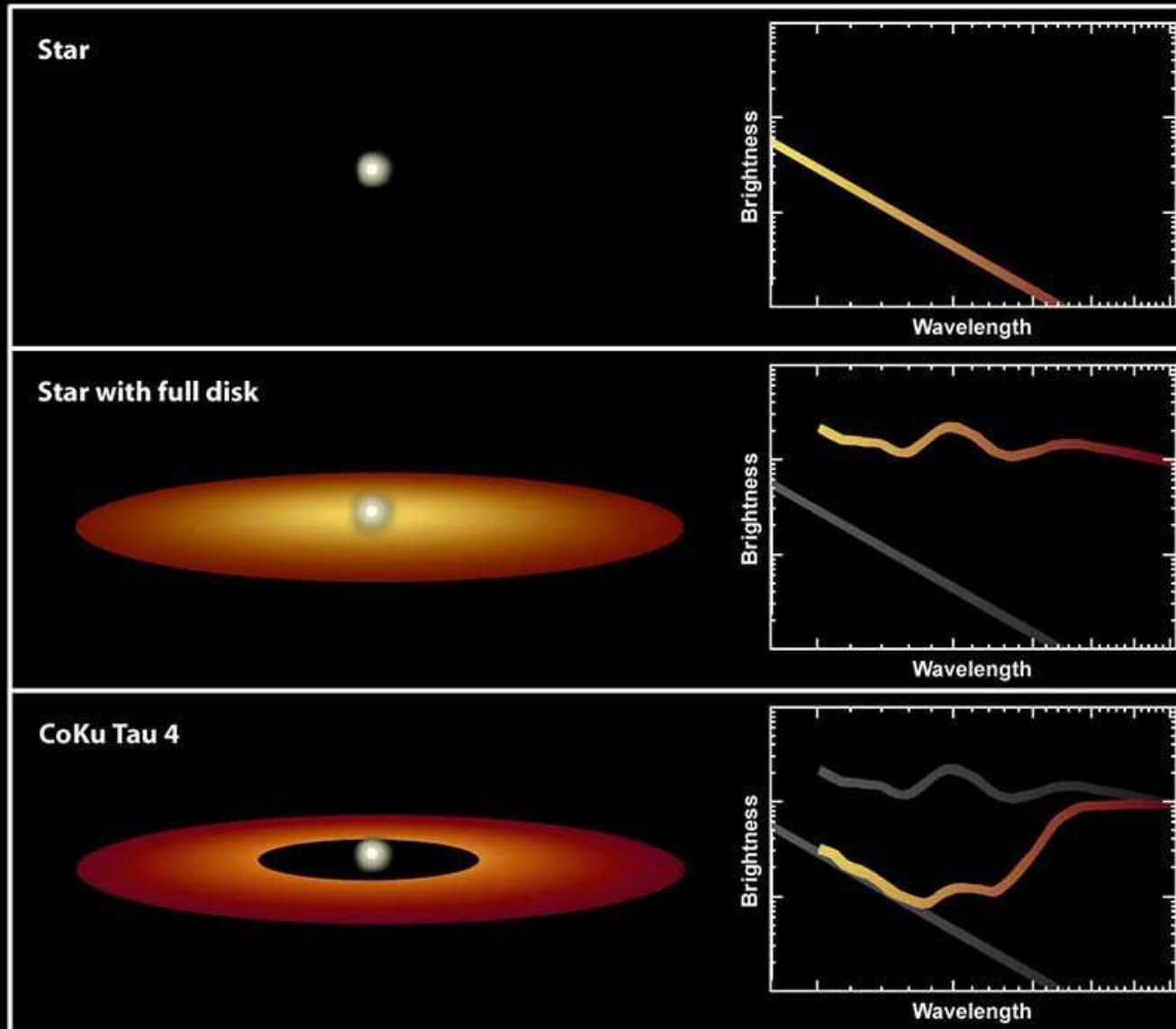


Fig. 3. Channel maps of the CO(3-2) emission in HD 163296 from 3.19 to 8.23 km s⁻¹. The spectral resolution is 0.21 km s⁻¹ and the rms per channel is 14 mJy beam⁻¹.



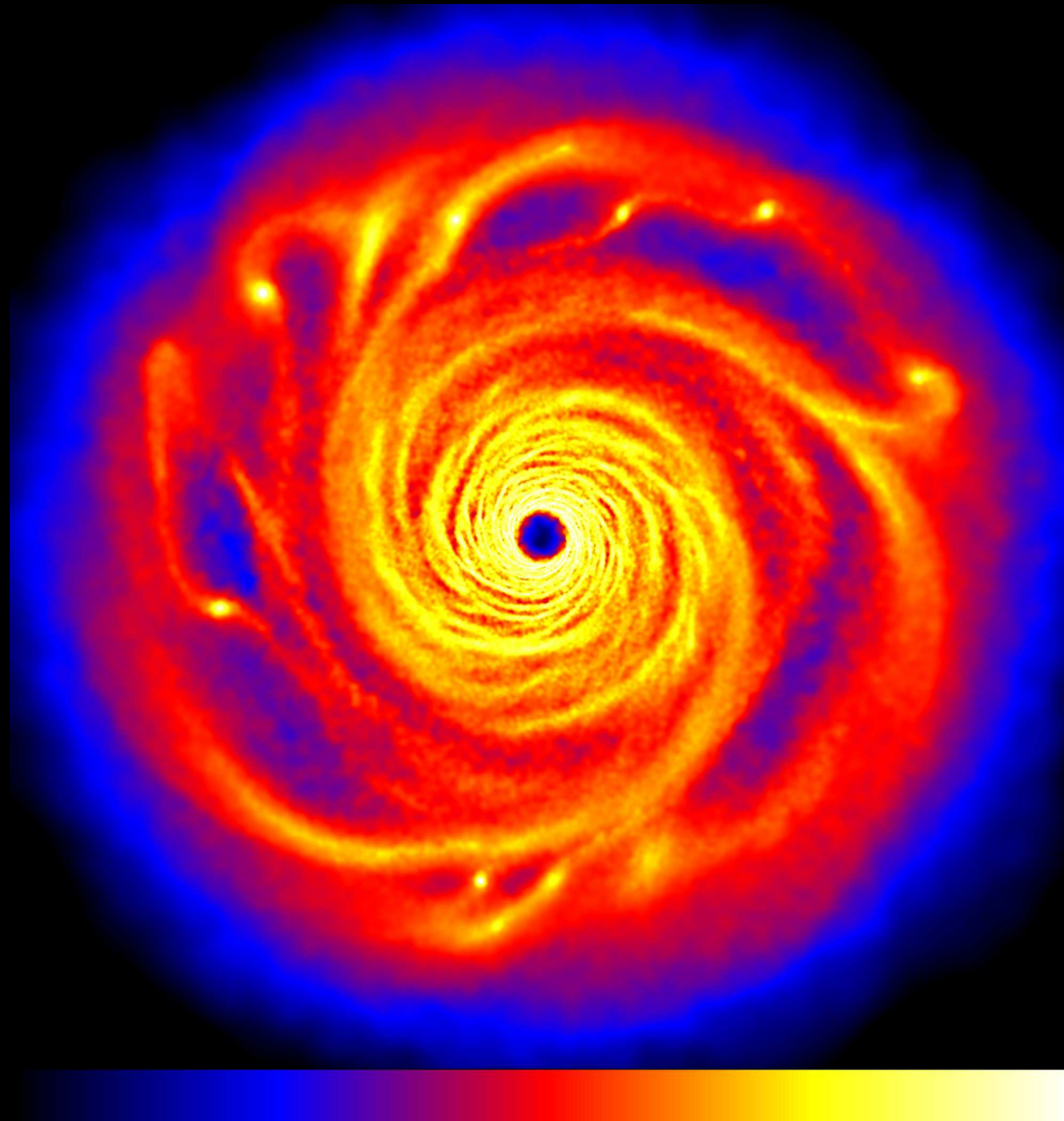
Meilland et al. (2012)





Inner Gap in Circumstellar Disk Spitzer Space Telescope • IRS

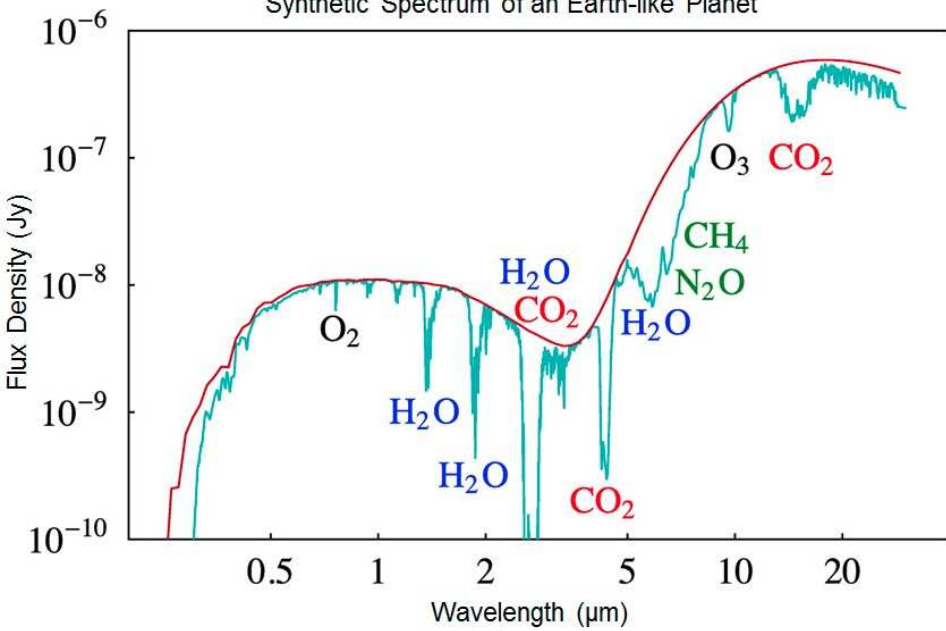
<http://faculty.ucr.edu/~krice/>



A satellite view of Earth from space, showing the Arctic region. The image is oriented vertically, with the top of the frame showing the dark, star-filled sky. The Earth's surface is visible, with a prominent white and light blue area representing the Arctic ice cap. A bright, multi-pointed starburst is visible in the center of the ice cap. The surrounding land and ocean are shown in shades of green and brown. The text "A 'linha da neve'" is overlaid in the center of the image.

A “linha da neve”

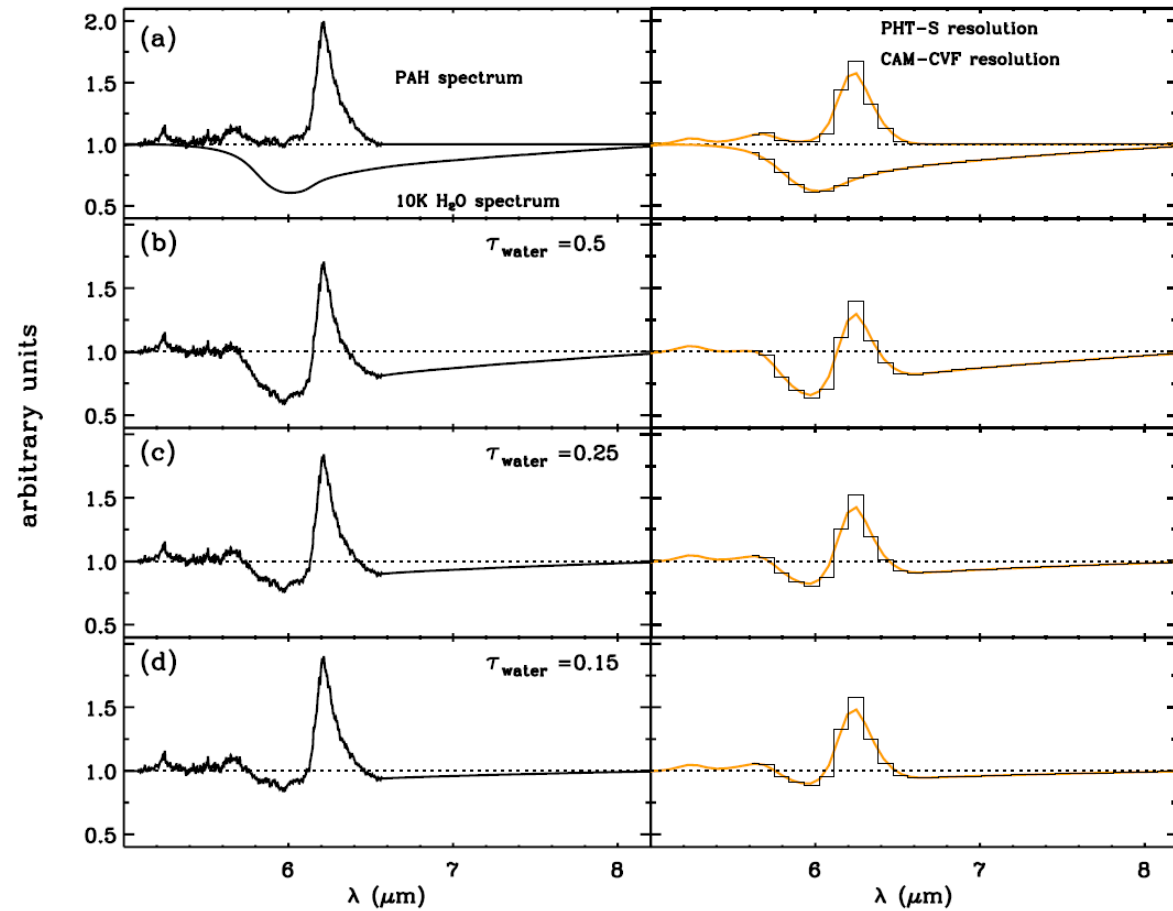
Synthetic Spectrum of an Earth-like Planet

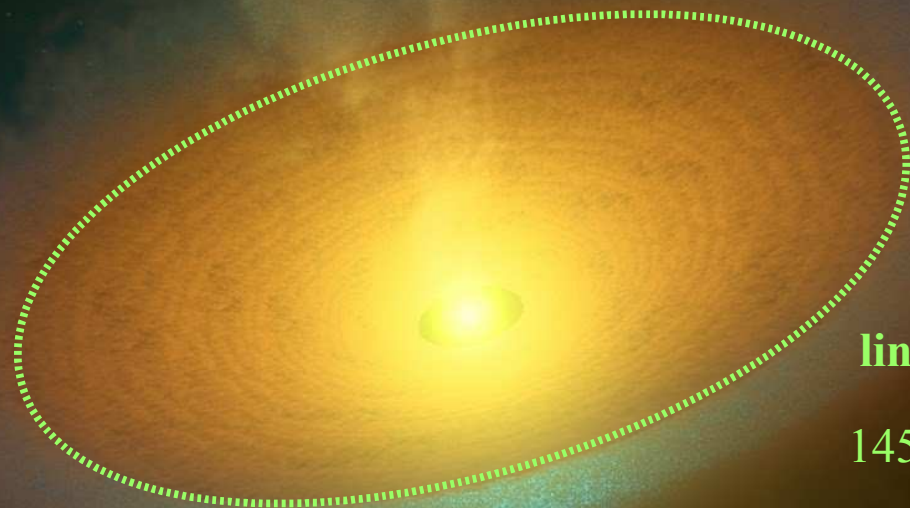


<http://www.markelowitz.com/Hyperspectral.html>

“Ice features in mid-IR spectra of Galactic Nuclei”
Spoon et al. (2002)

Não é bem isso...





linha da neve

145-170 K

~2.7 a.u. hoje



\dot{M} acreção diminui

$10^{-10} M_{\odot} \text{ yr}^{-1}$

dissipação viscosa diminui,
disco esfria

material se torna opt. fino,
disco esquentar



\dot{M} acreção diminui

dissipação viscosa diminui,
disco esfria

$$10^{-10} M_{\odot} \text{ yr}^{-1}$$

material se torna opt. fino,
disco esquentar

Como assim pouca água???



“Blue Marble”, “Pale Blue Dot”

ÁGUA:

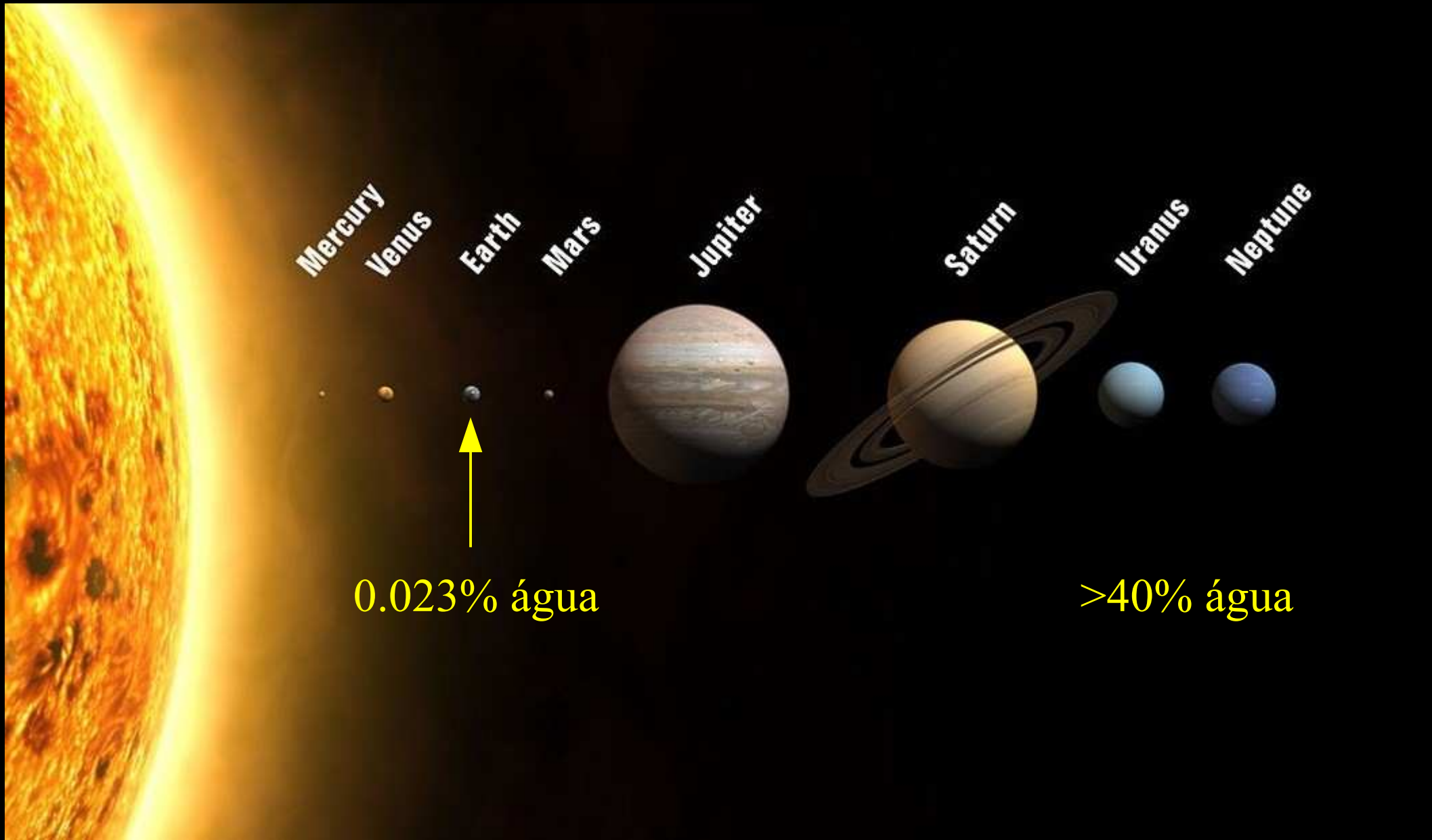
70.8% da superfície

3.7 km de profundidade média

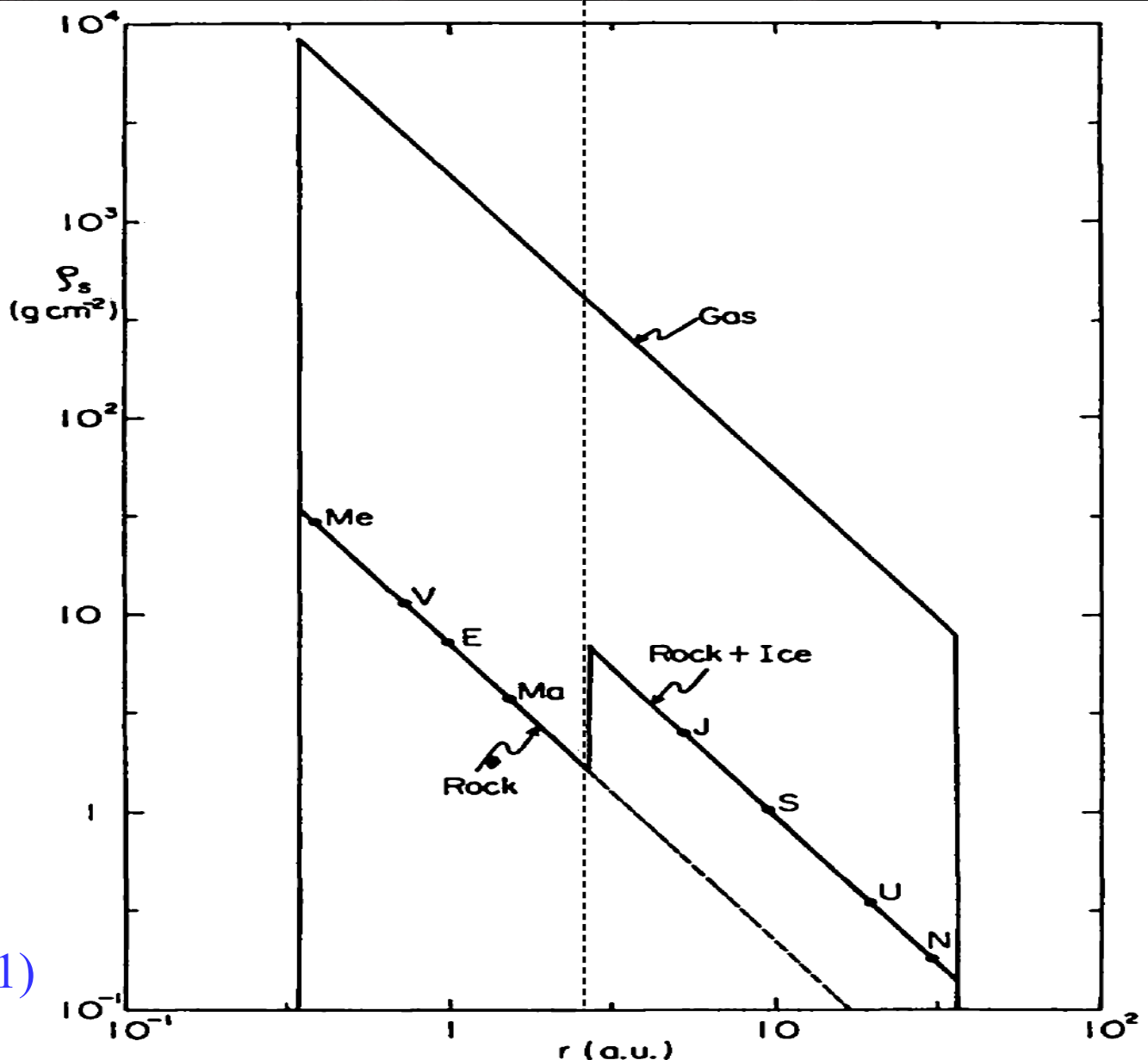
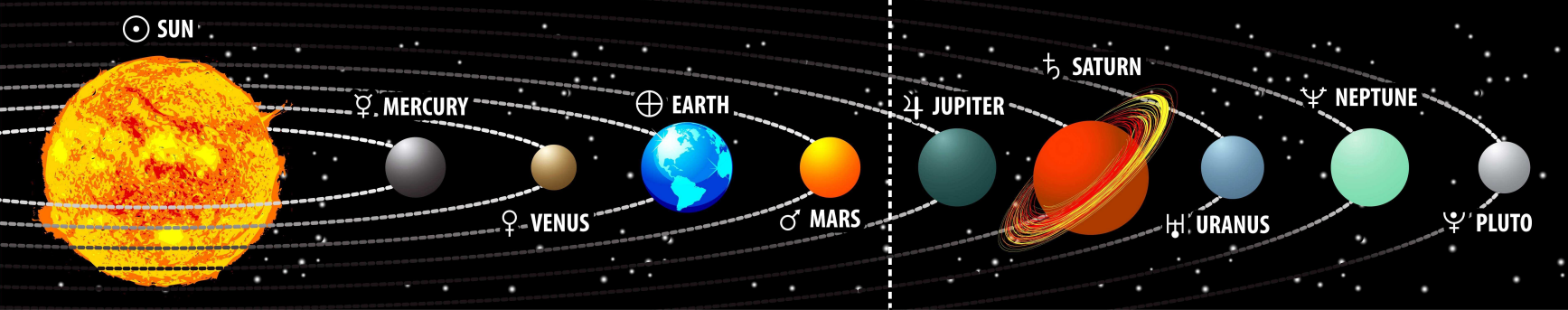
1.35×10^{21} kg

- 97.5% salina

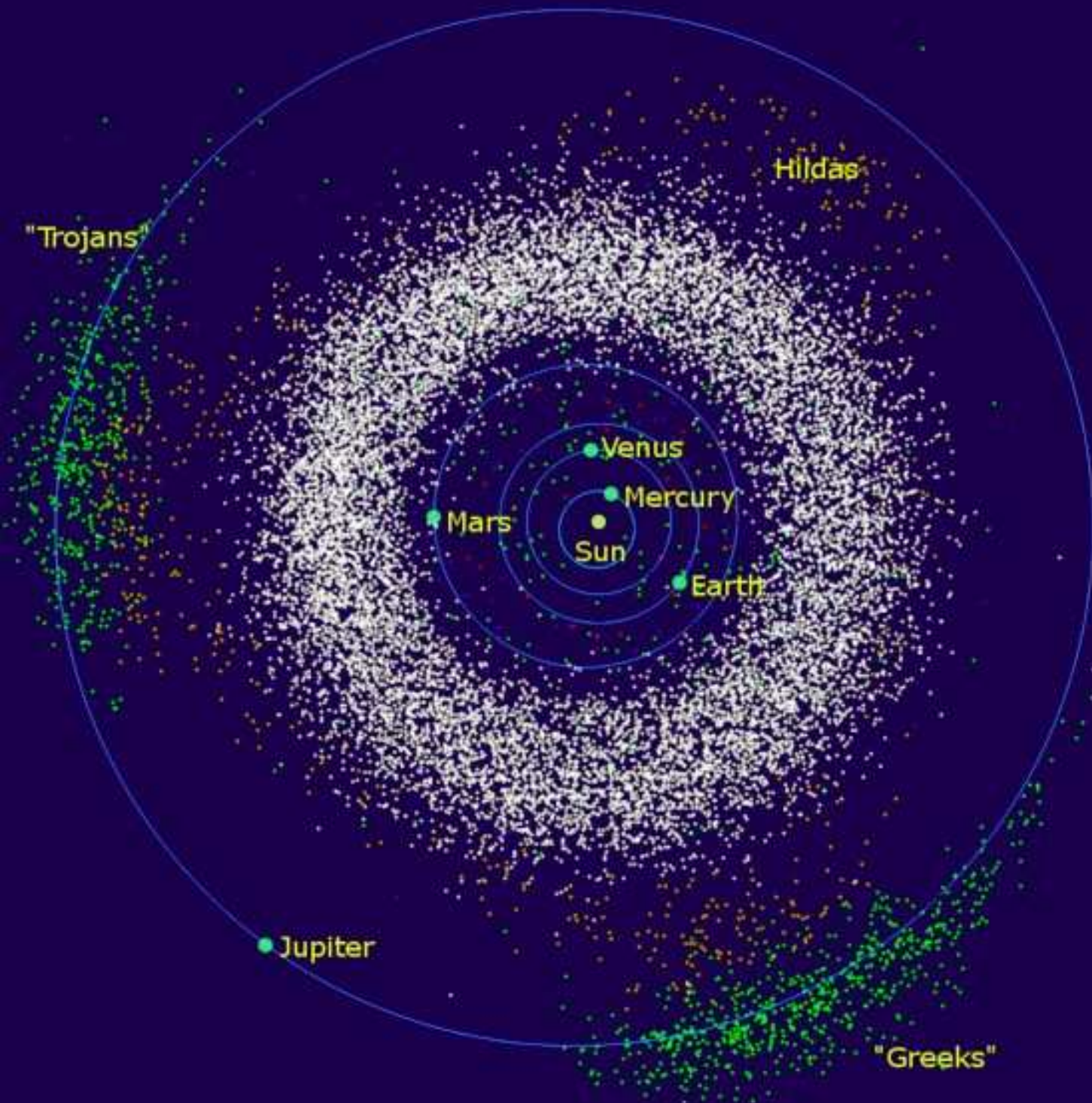
- 2.5% doce (68.7% gelo)



PLANET OF SOLAR SYSTEM

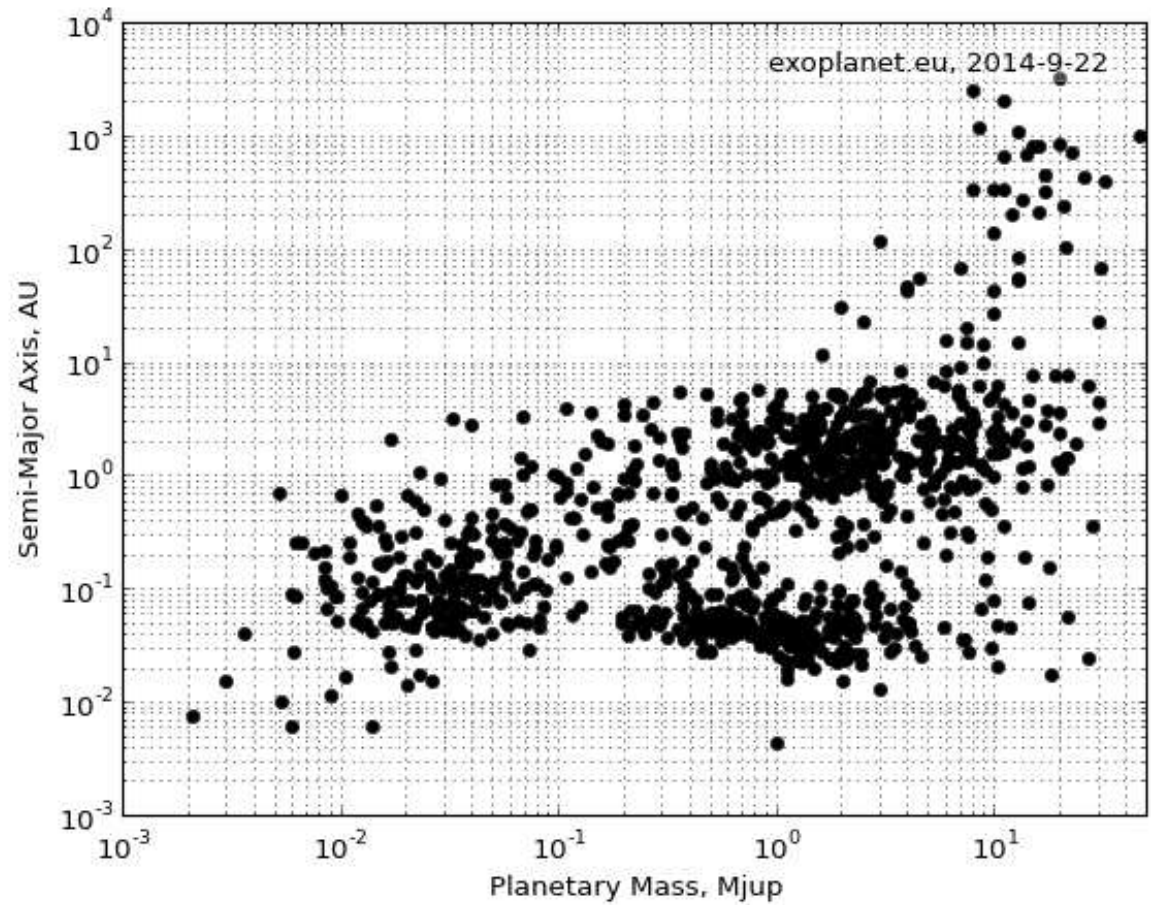
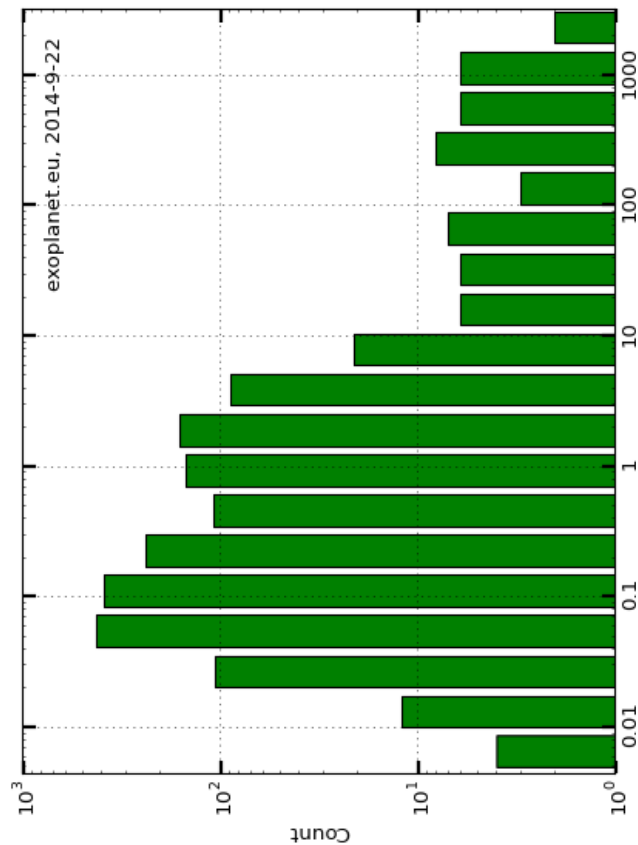
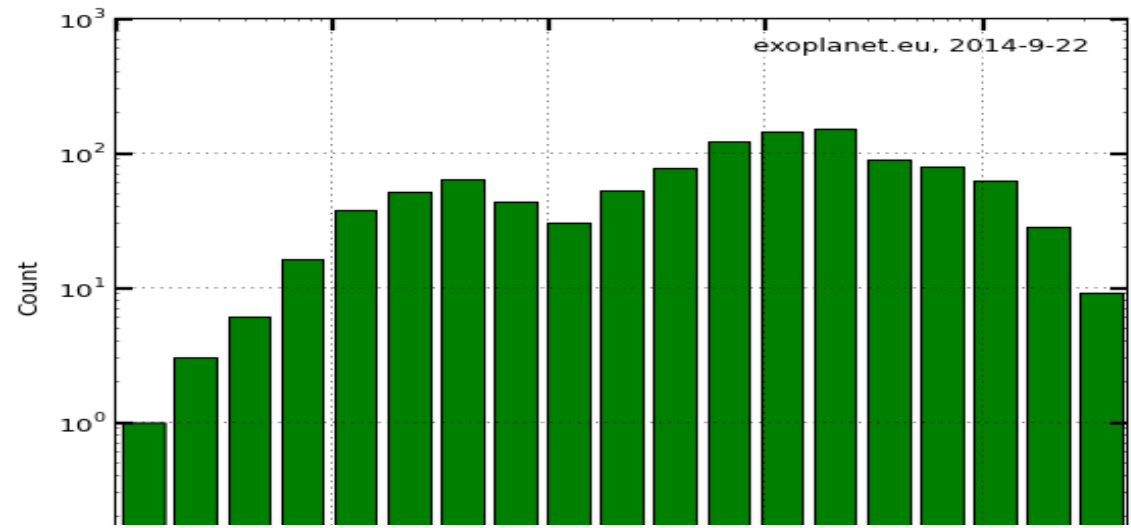


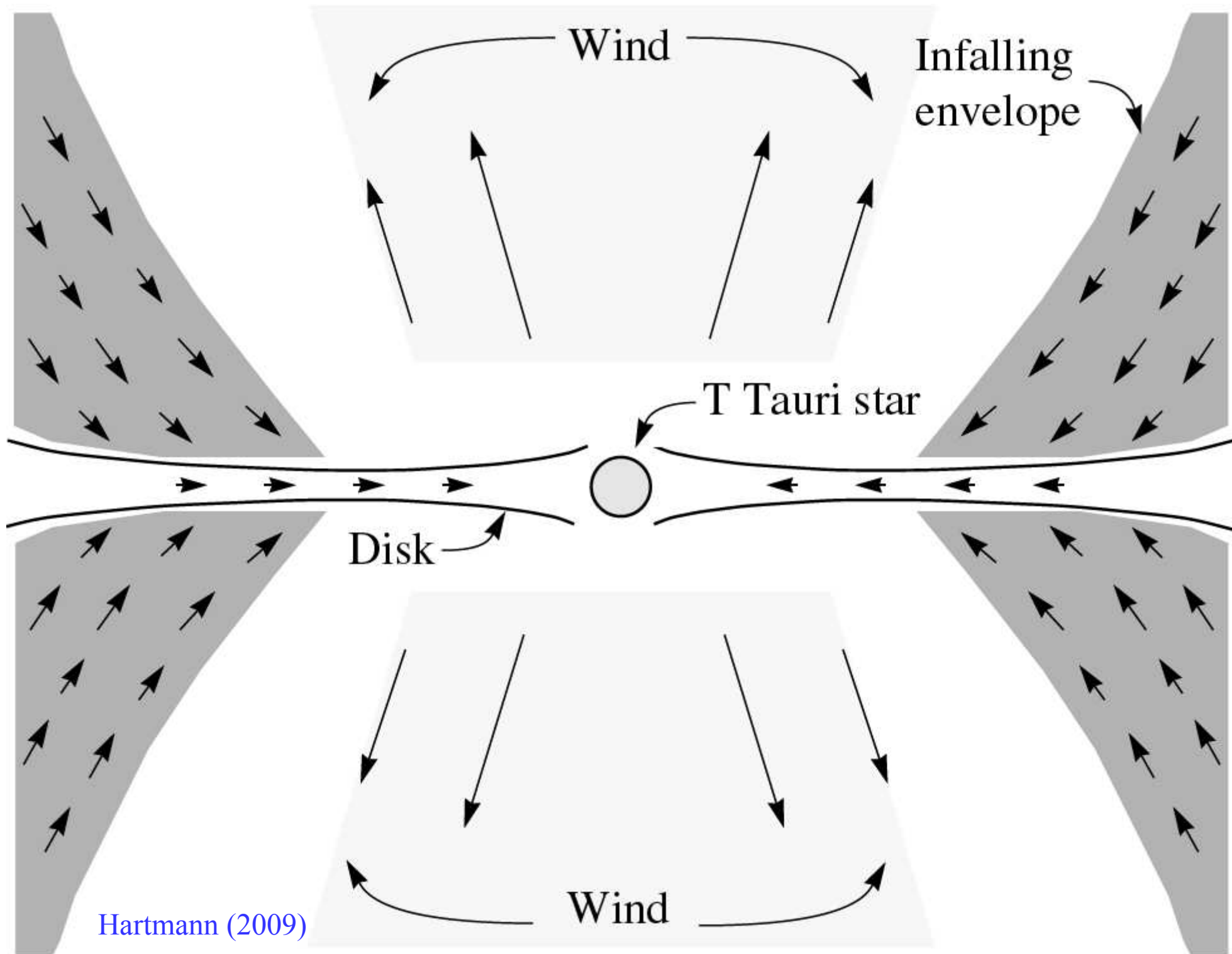
Hayashi (1981)

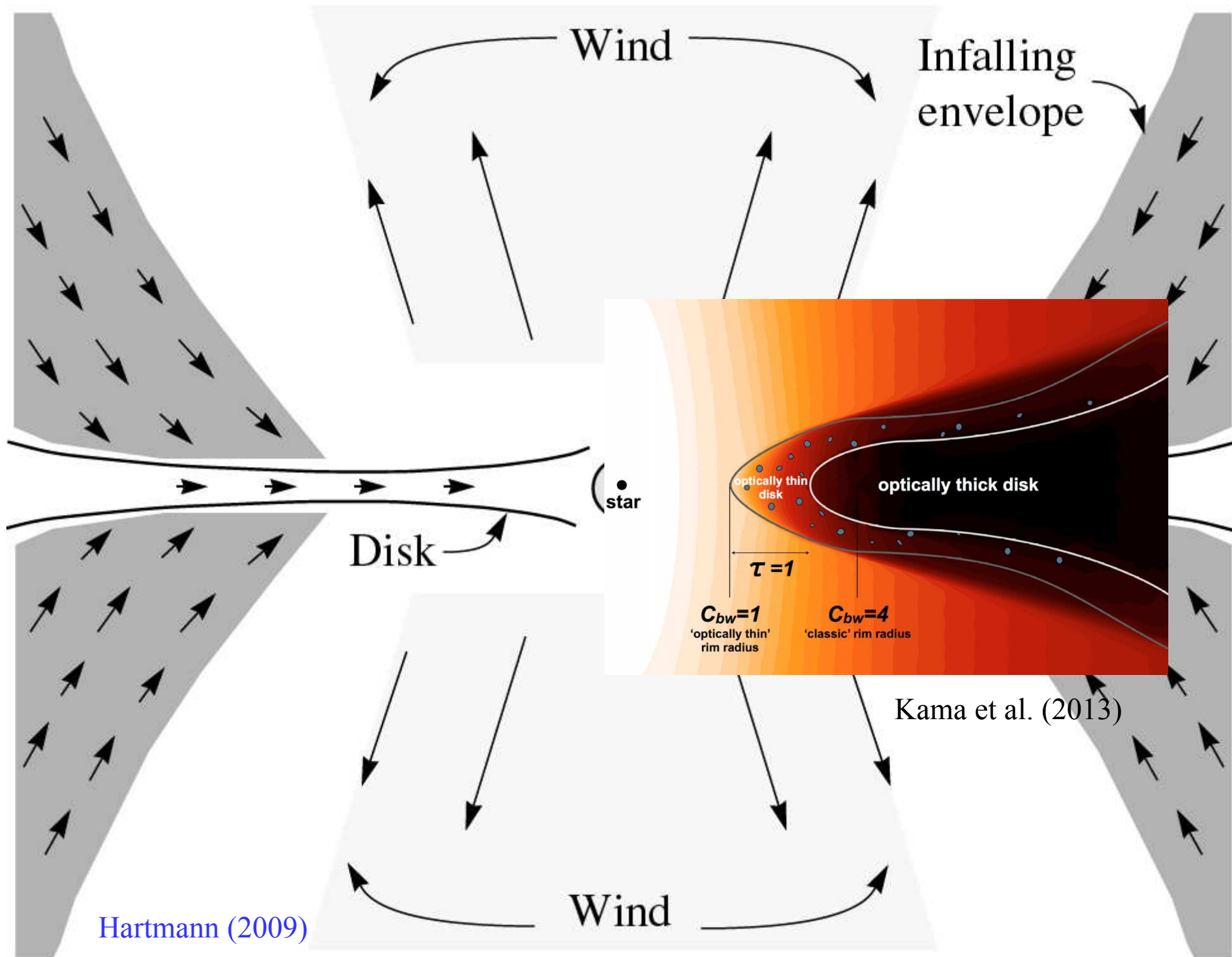


Outro problema...

<http://exoplanet.eu/diagrams/>





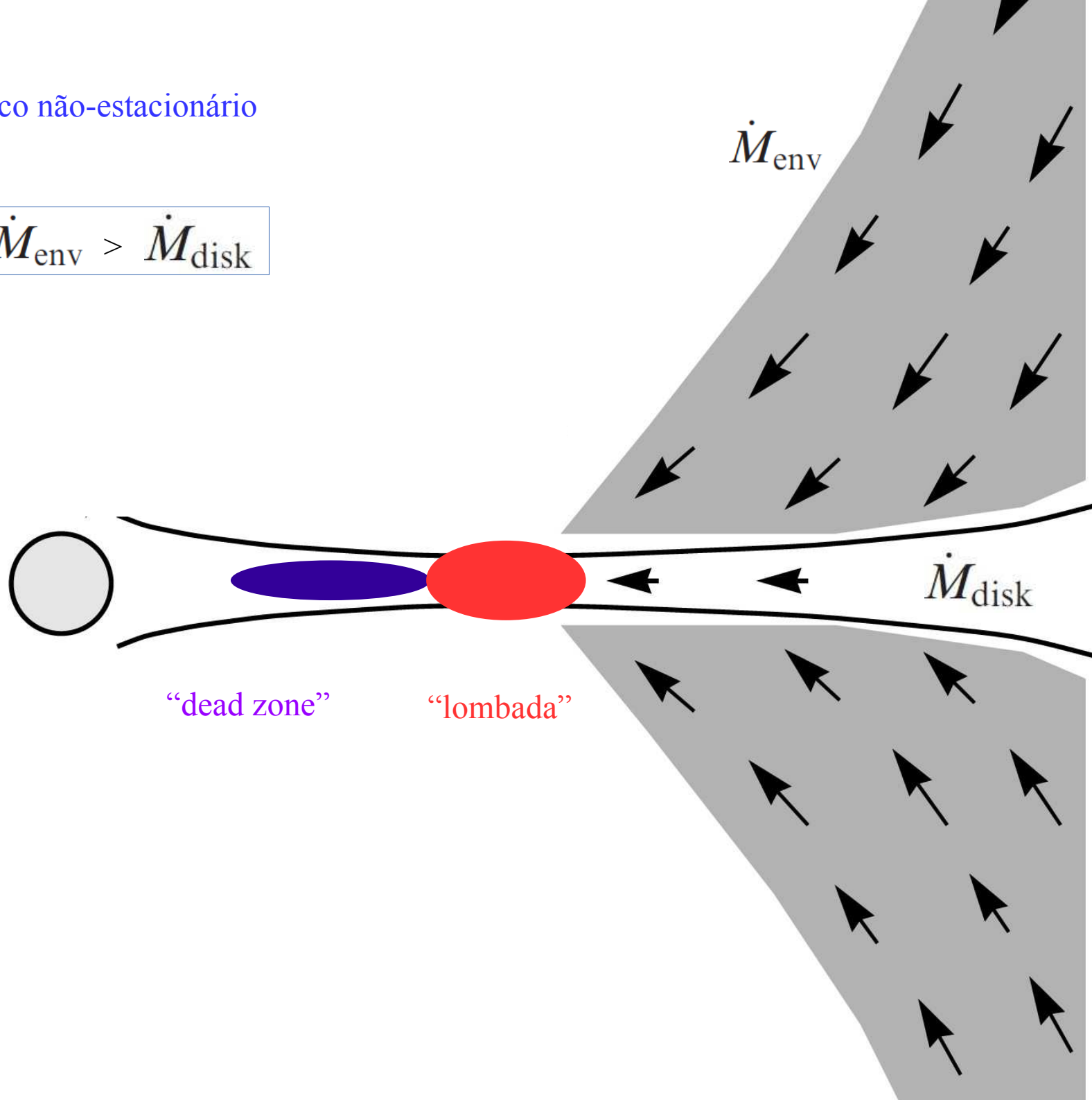


Hartmann (2009)

Kama et al. (2013)

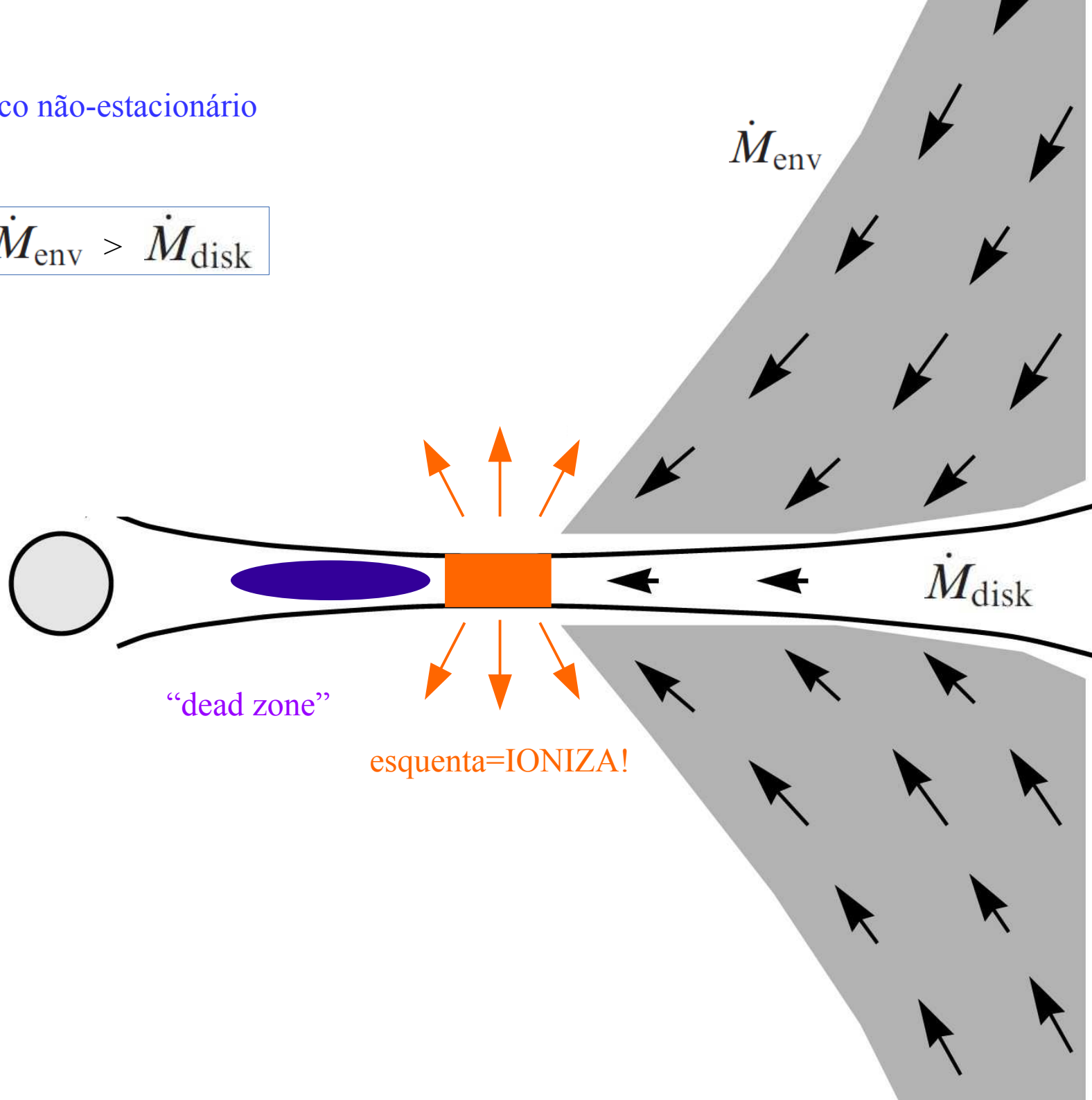
Disco não-estacionário

$$\dot{M}_{\text{env}} > \dot{M}_{\text{disk}}$$



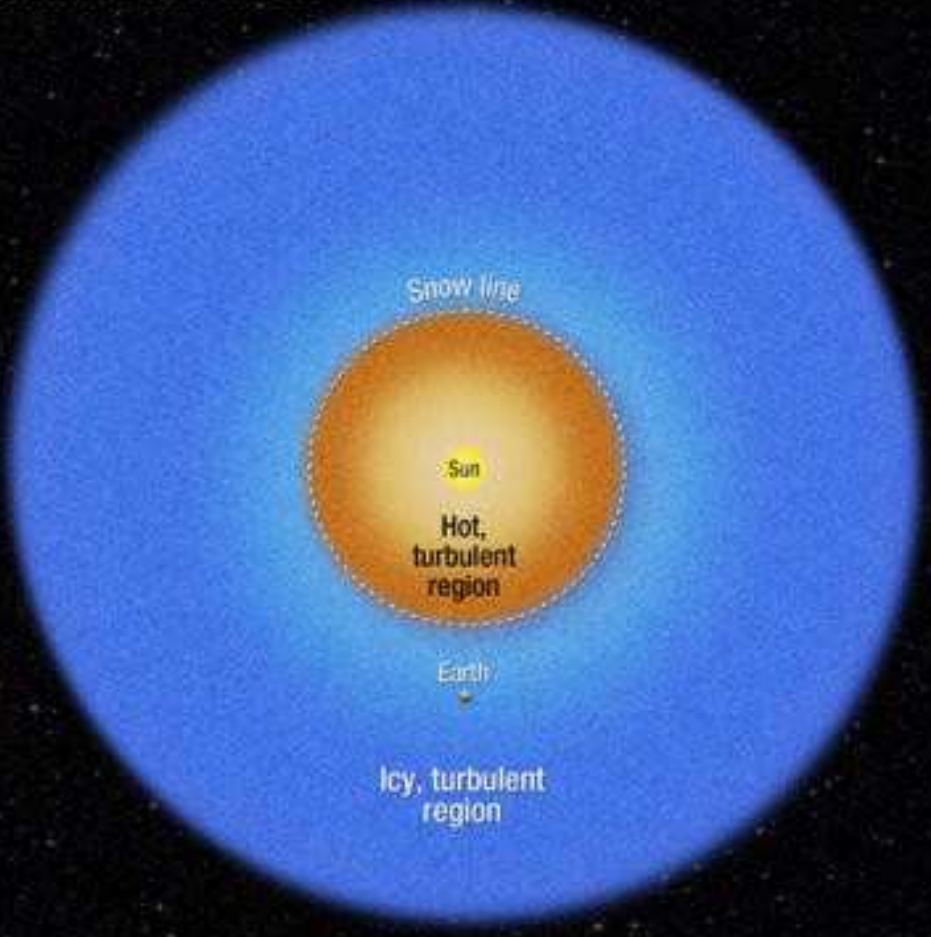
Disco não-estacionário

$$\dot{M}_{\text{env}} > \dot{M}_{\text{disk}}$$

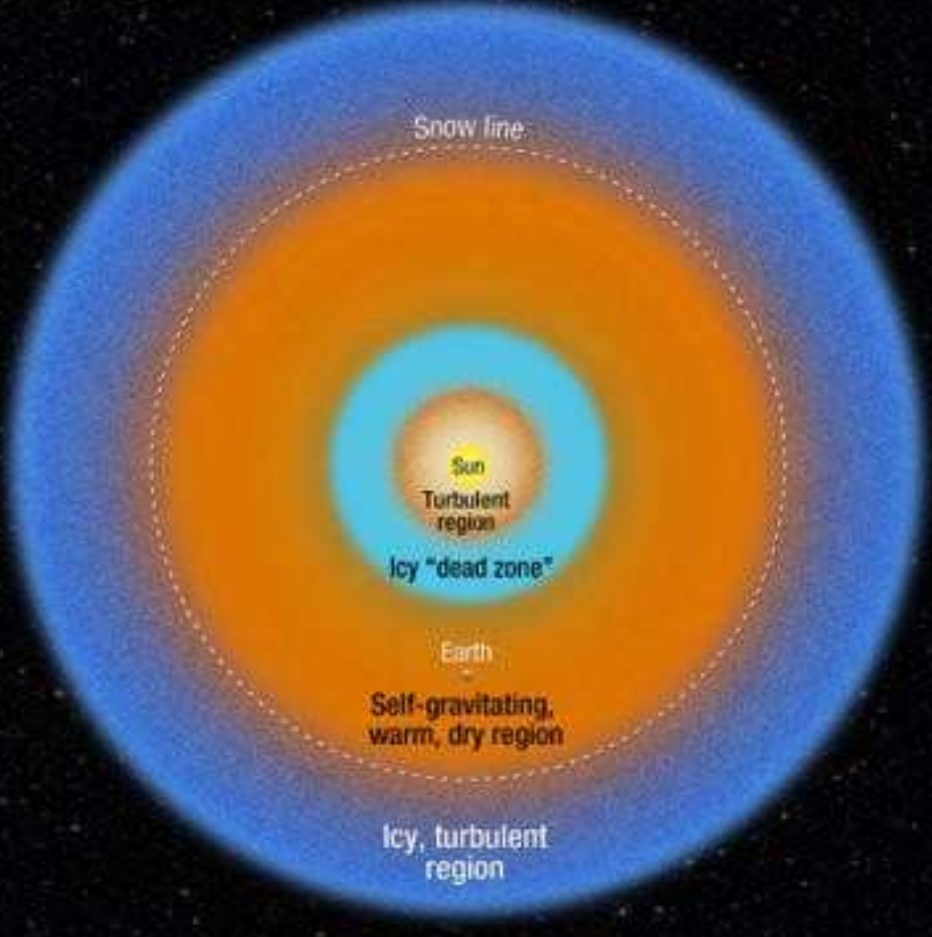


Two models of the Sun's protoplanetary disk

Standard disk model



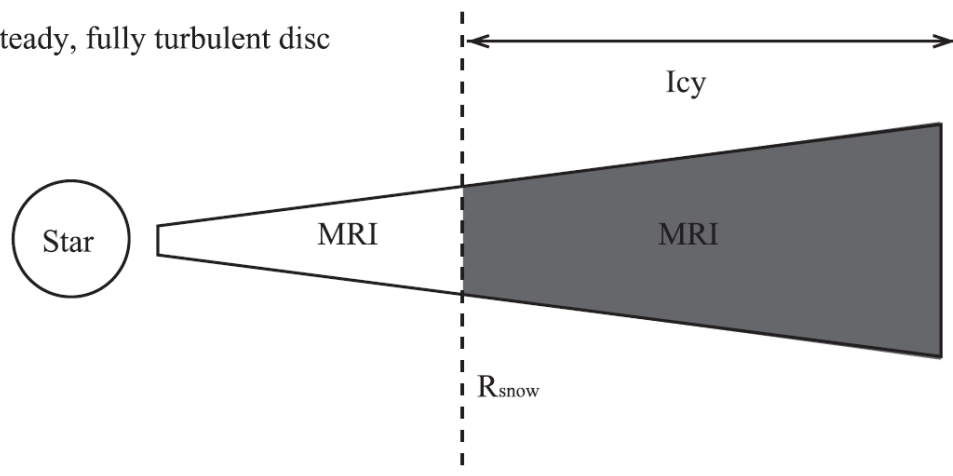
New proposed disk model



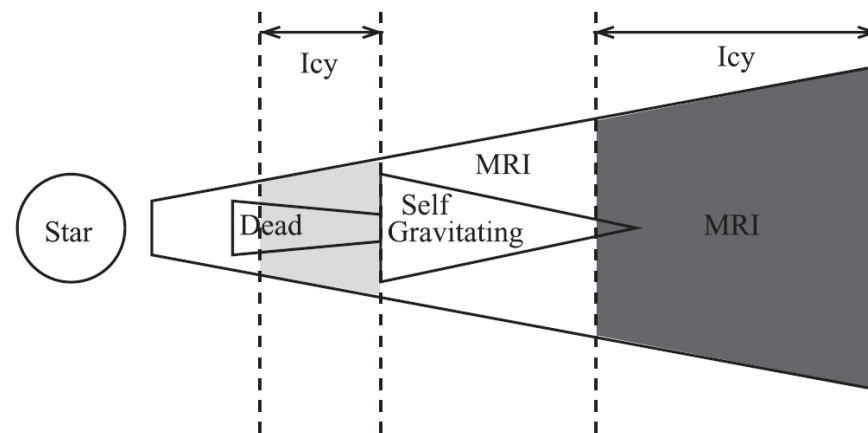
Credit: NASA, ESA, and A. Feild (STScI)

Science: NASA, ESA, and R. Martin and M. Livio (STScI)

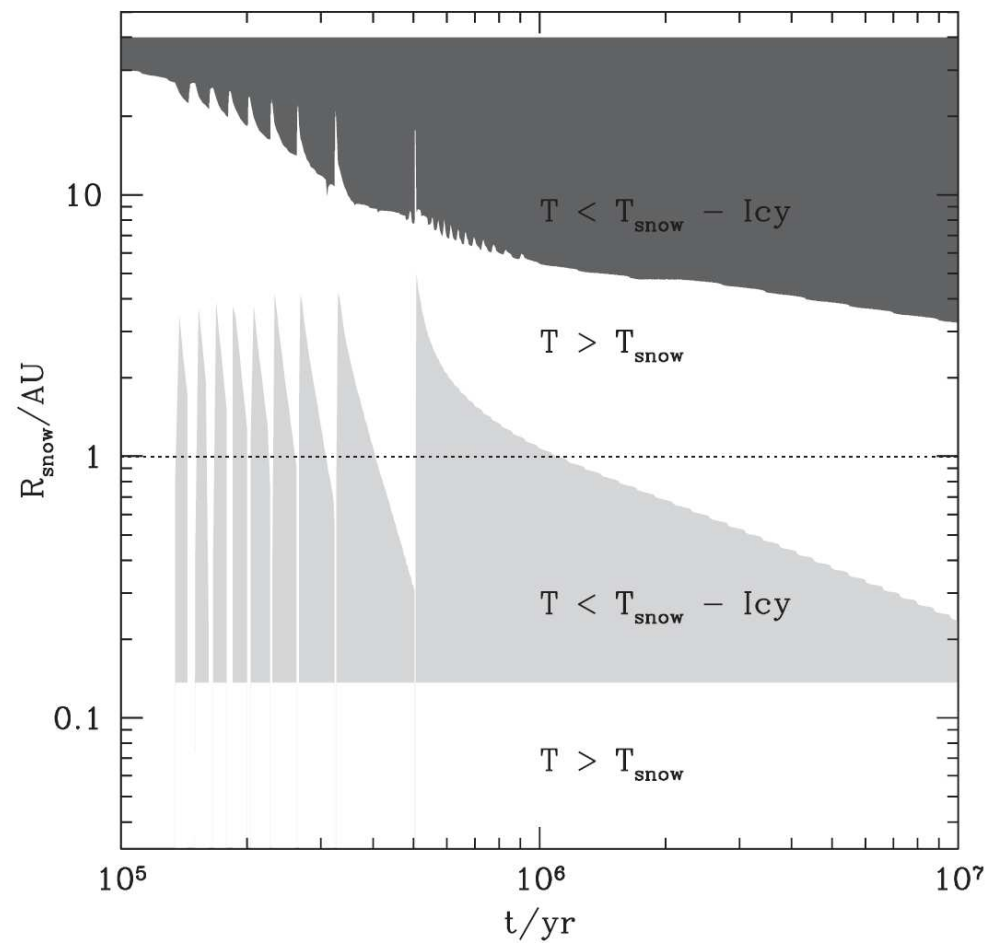
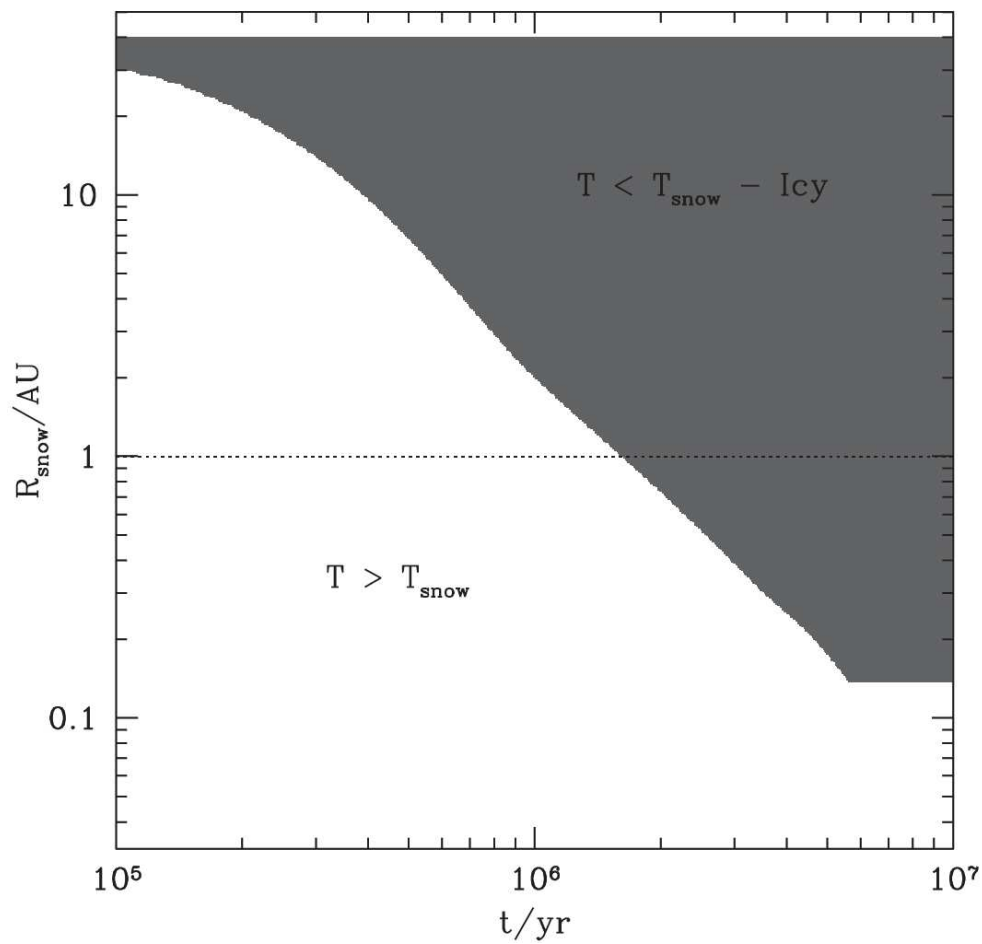
A: Steady, fully turbulent disc



B: Non-steady disc with a dead zone



Martin & Livio (2012)



Conclusões

- Quantidade de água explicada!
- Alternativa à migração de “Júpiteres quentes”
- Episódios tipo Fu Orionis

