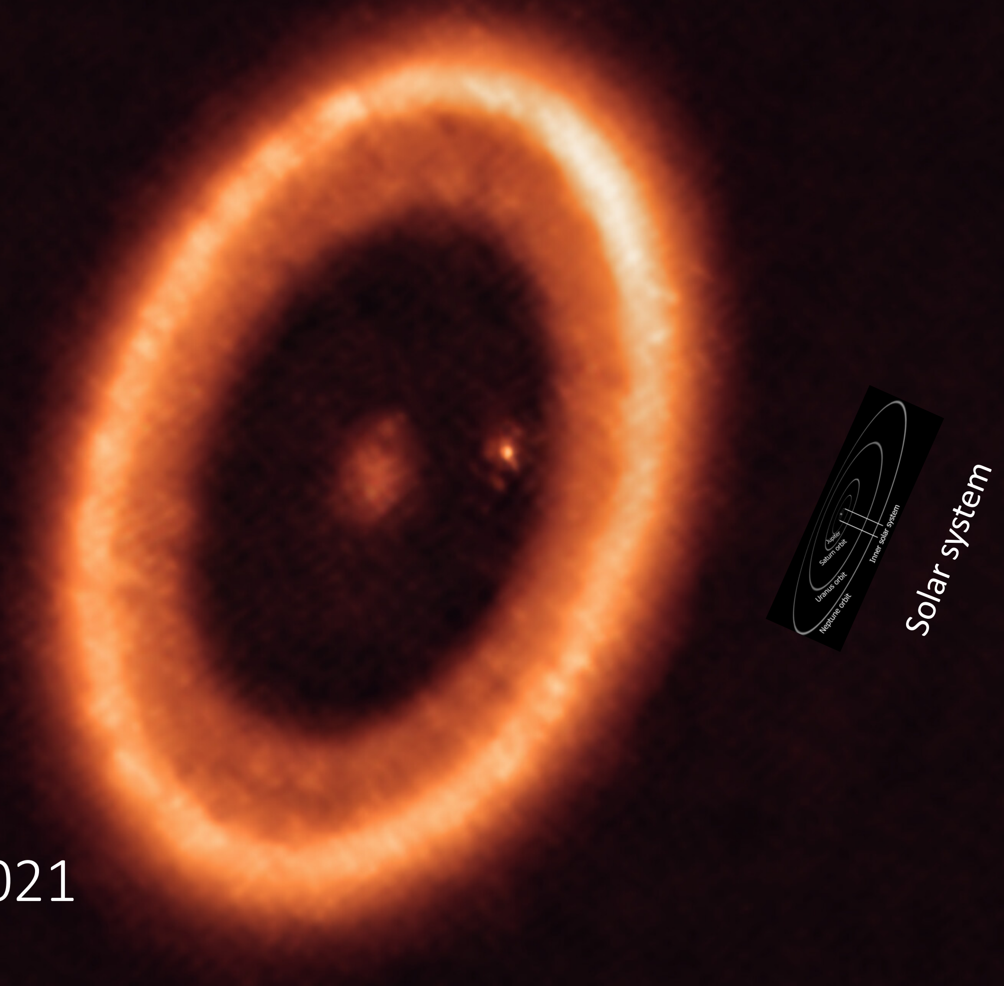
SPIDI
Star-Planets-Inner Disk Interactions

Jérôme Bouvier

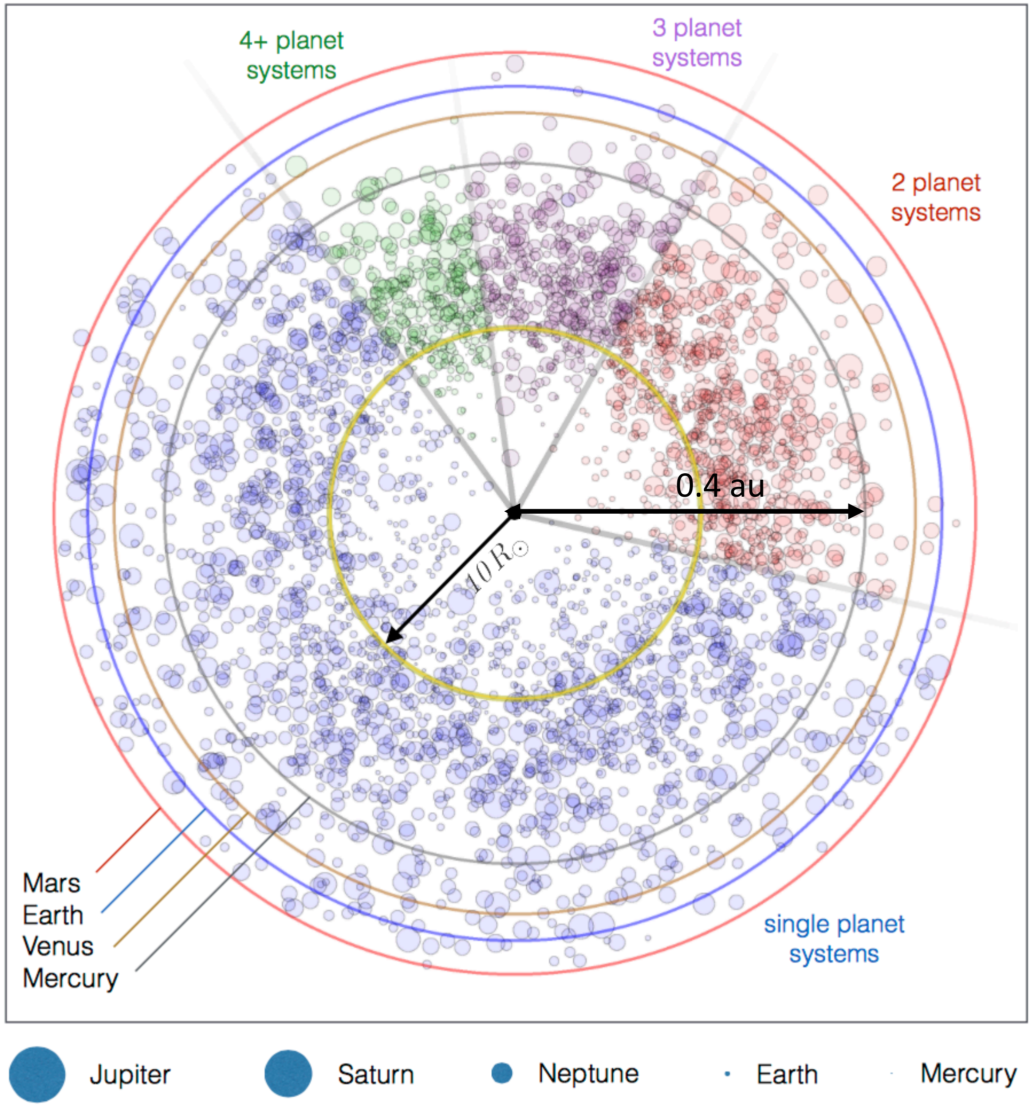
Disk-embedded planets



PDS 70

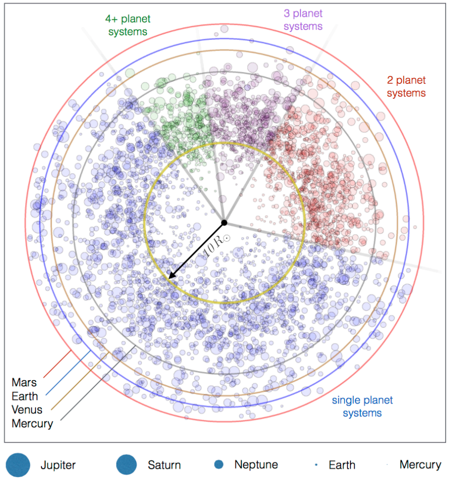
Benisty et al. 2021

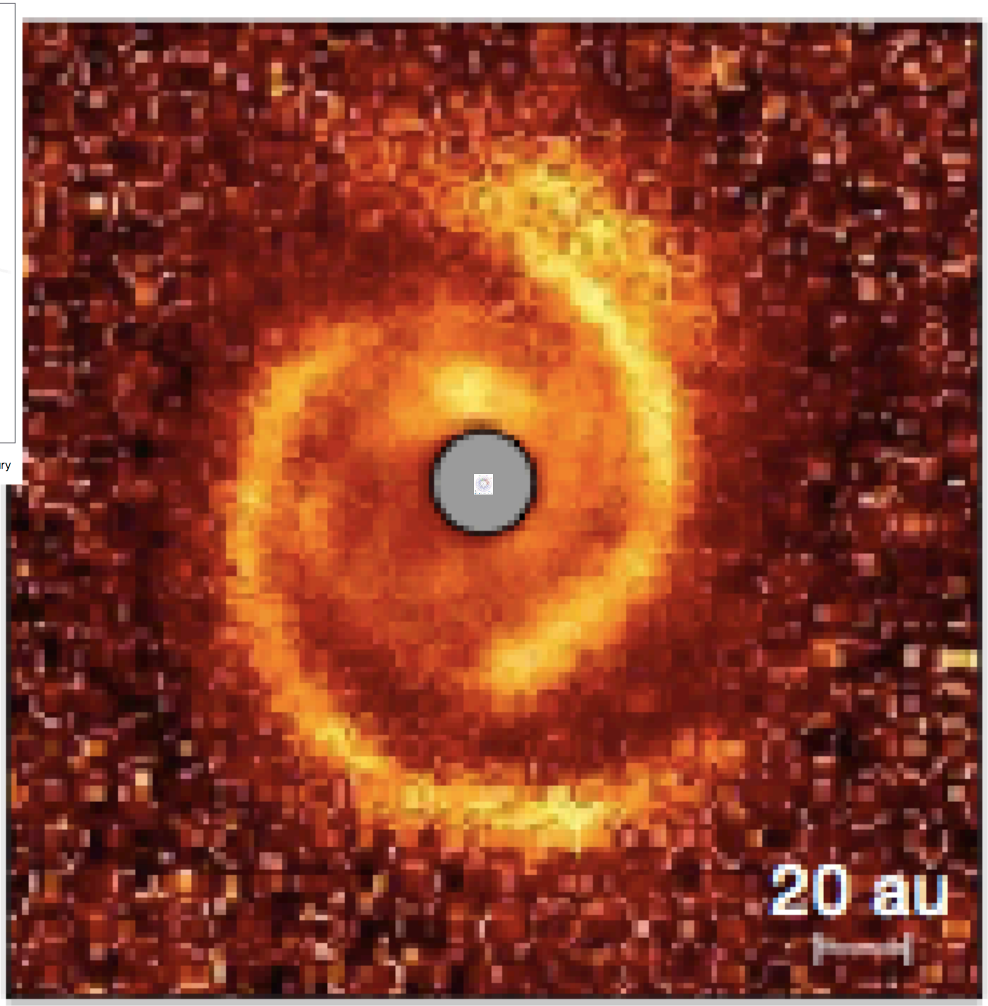
Kepler's legacy: inner planets



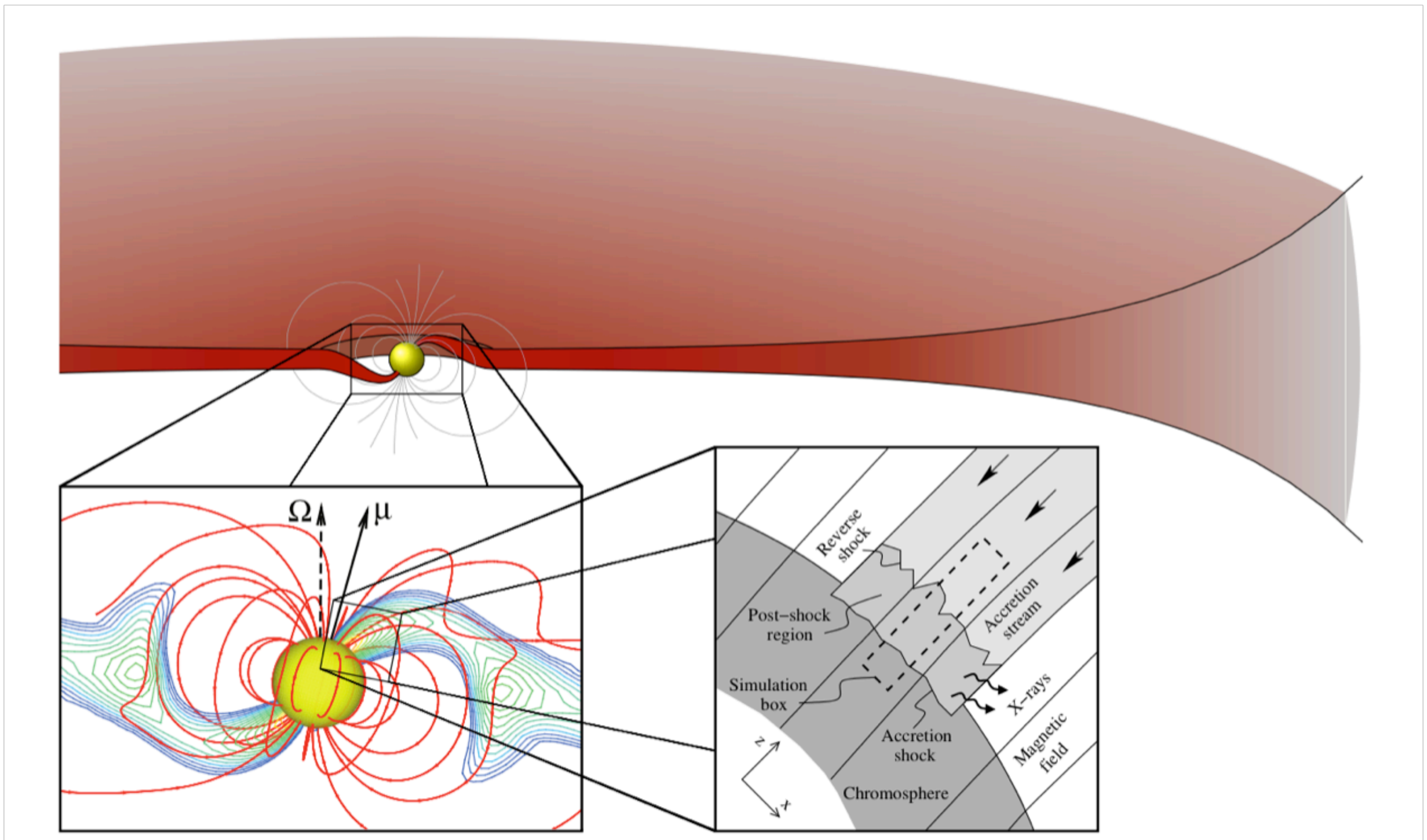
Batigyn & Laughlin 2015

Disk-embedded inner planets?



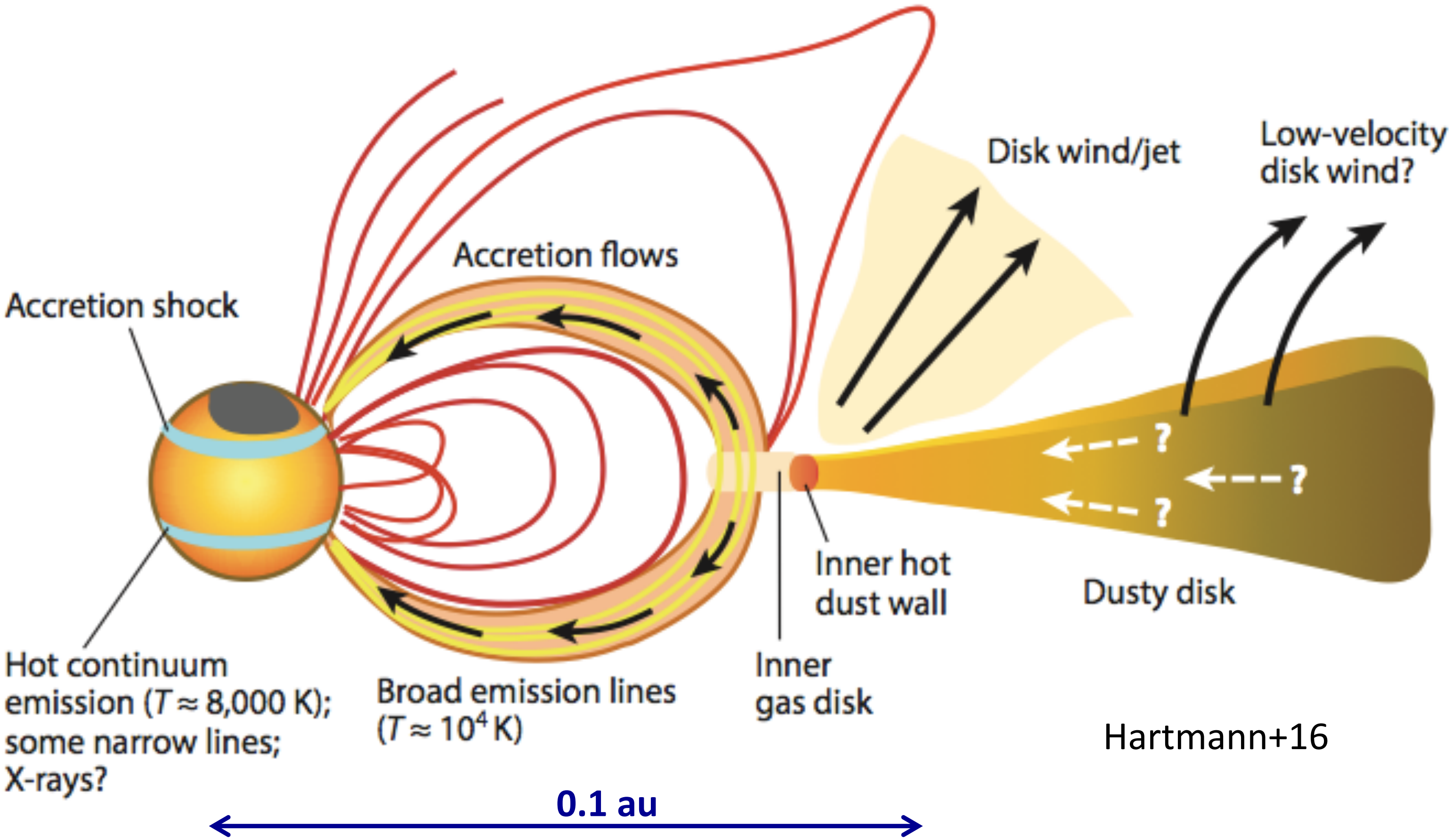


At the heart of young stellar systems: the magnetospheric accretion process



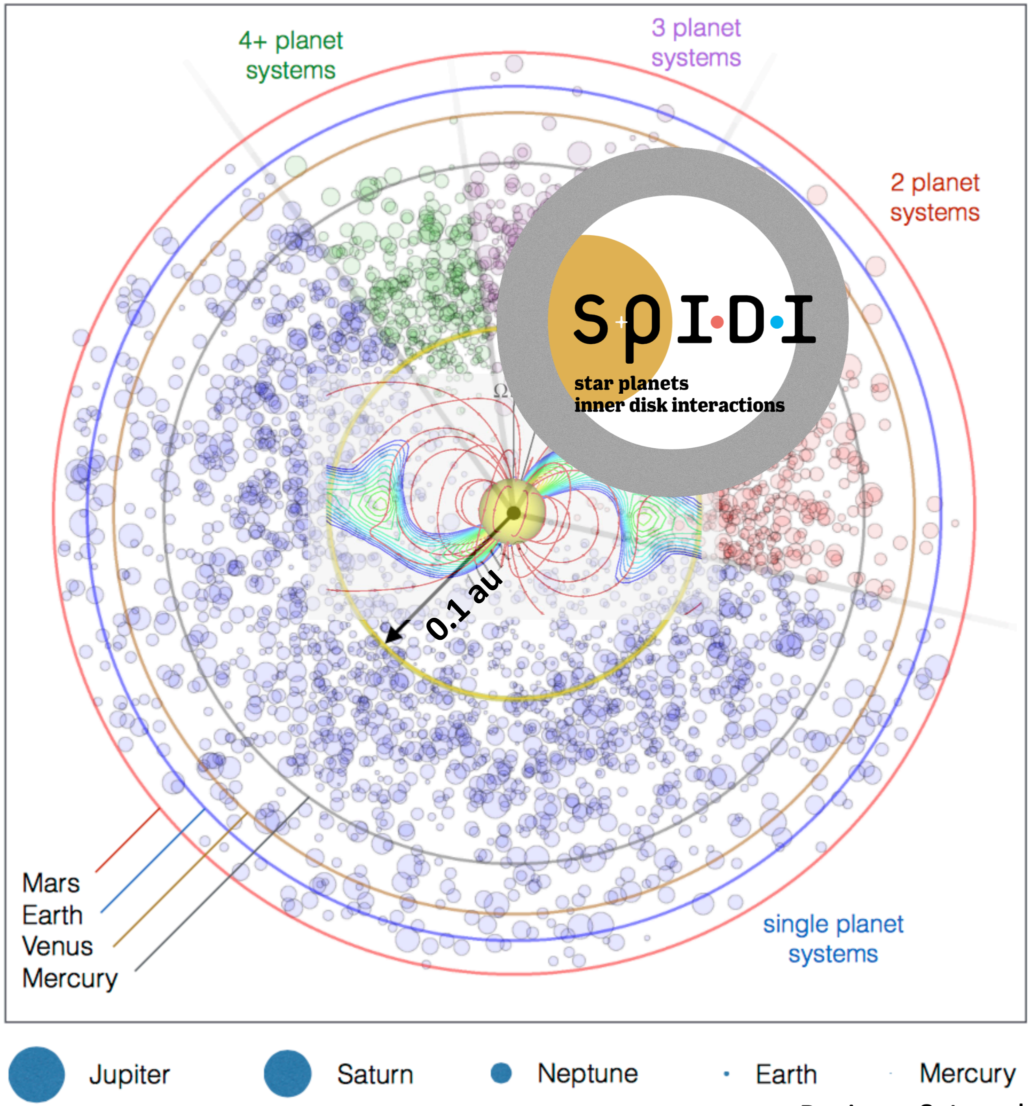
DeSà 2014

Star-disk interaction



Hartmann+16

Star-planet(s)-inner disk interaction



Batigyn & Laughlin 2015
Romanova et al. 2013

SPIDI: how to detect disc-embedded inner planets?

(2 parallel approaches: models and observations)

- **Predict** the observational signatures of star-planet(s)-inner disc interactions
- We need **models**!
  - ➢ MHD simulations + radiative transfer + atmospheric escape models
- PLUTO / MCFOST / EVE GENCI + UGA/GRICAD
  - ✓ *George Pantolmos+ Benjamin Tessore + William Dethier (PhD)*

- **Monitor** young stellar systems to detect these signatures
- We need **telescopes**!
  - ➢ Spectropolarimetry Interferometry Photometry
- CFHT SPIRou-ESPaDOnS + VLTI GRAVITY +LCOGT
  - ✓ *Alana Sousa + Kim Pouilly (PhD) + Anthony Soulain + Noemi Roggero (PhD) + Rajeev Manick*

The SPIDI Core Team

Kim Pouilly (SPIDI PhD student)
Spectroscopy/spectropolatimetry

Noemi Roggero (SPIDI PhD student)
Kepler light curves, models

Benjamin Tessore (SPIDI Postdoc)
Atomic line radiative transfer

George Pantolmos (SPIDI Postdoc)
Star-Planet-Disk interactions, MHD simulations

William Dethier (SPIDI PhD student)
Evaporation of planetary atmospheres

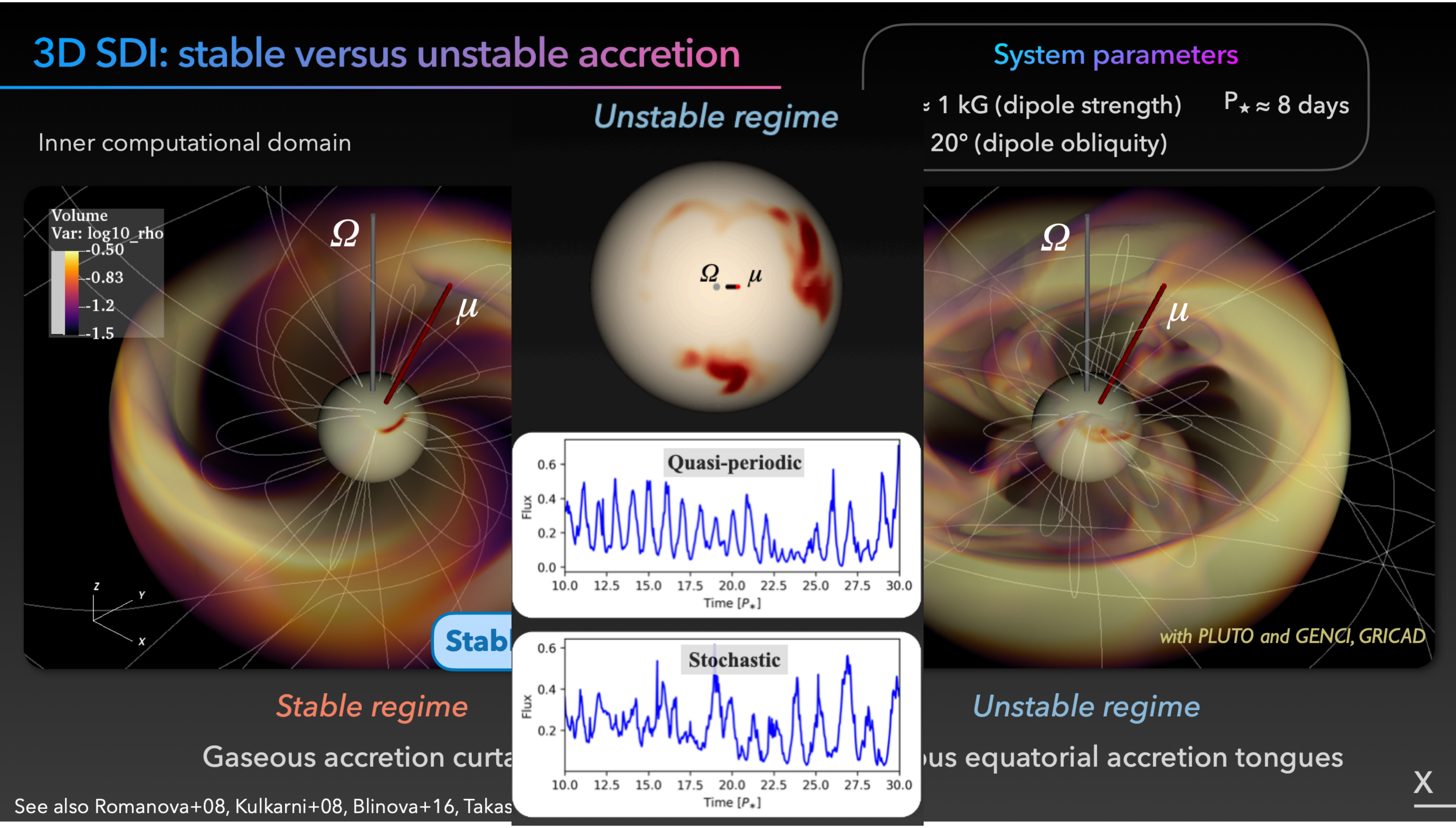
Alana Souza (SPIDI Postdoc)
Accretion process, Optical/IR spectroscopy

Anthony Soulain (SPIDI Postdoc
Interferometry

Rajeev Manick (SPIDI Postdoc)
Time series analysis

3D MHD models

© G. Pantolmos

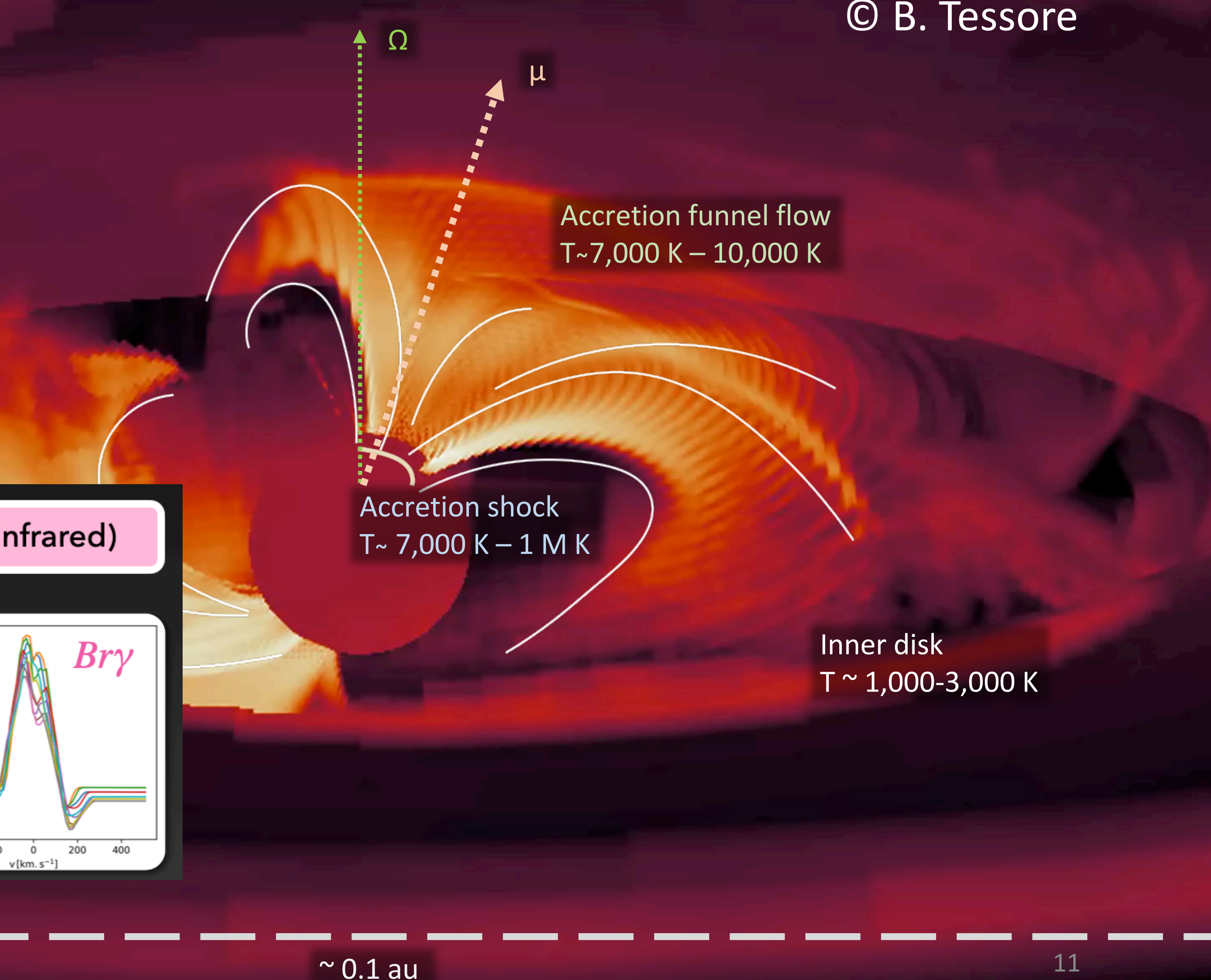


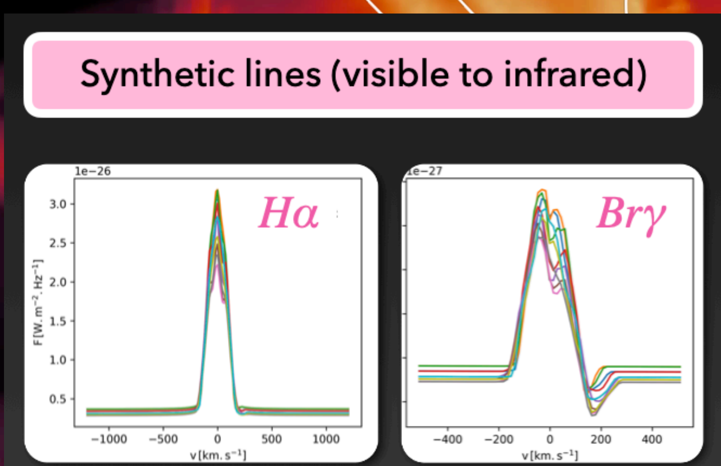
Radiative transfer models

Atomic line radiative transfer now available in MCFOST

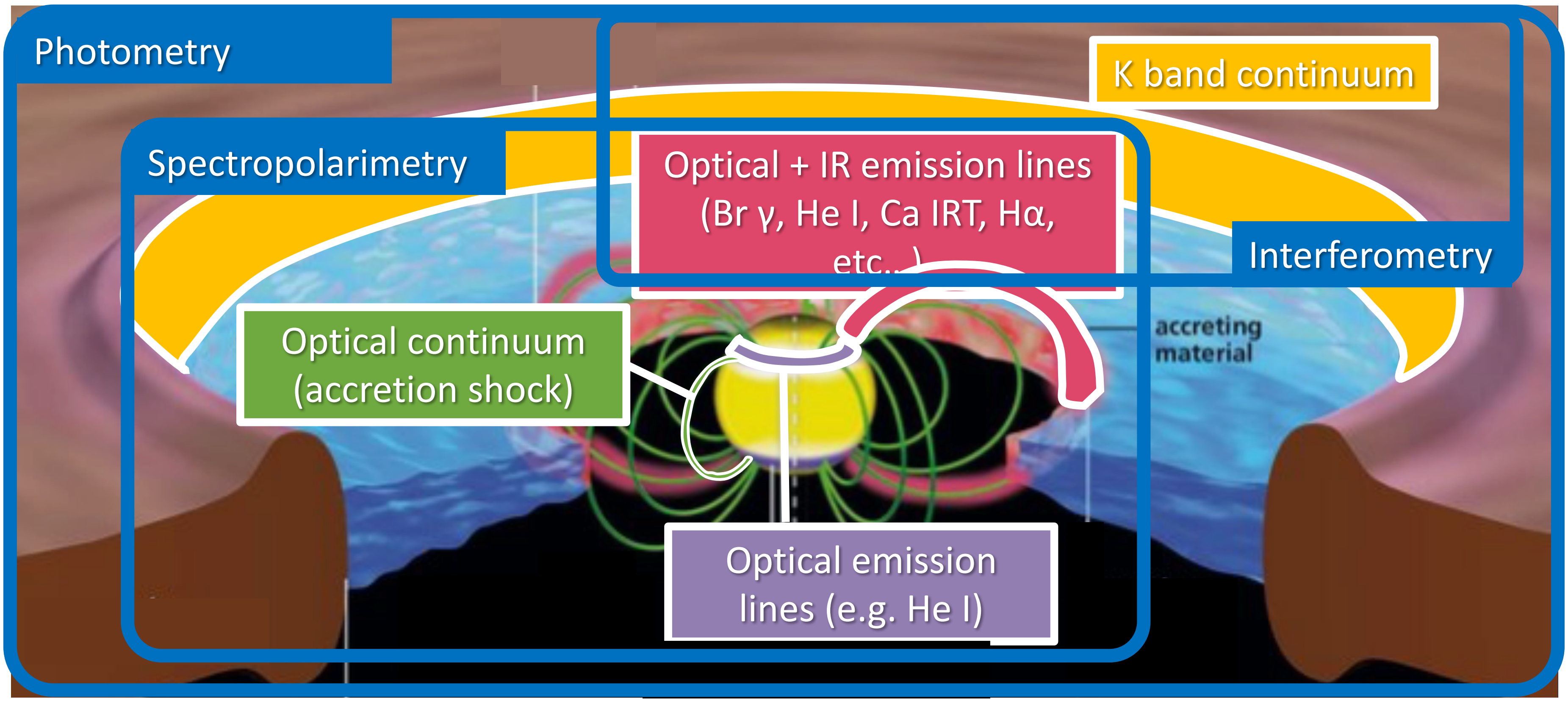
Non-LTE solution of atomic and electronic densities

Open-source code to investigate YSO's close environment





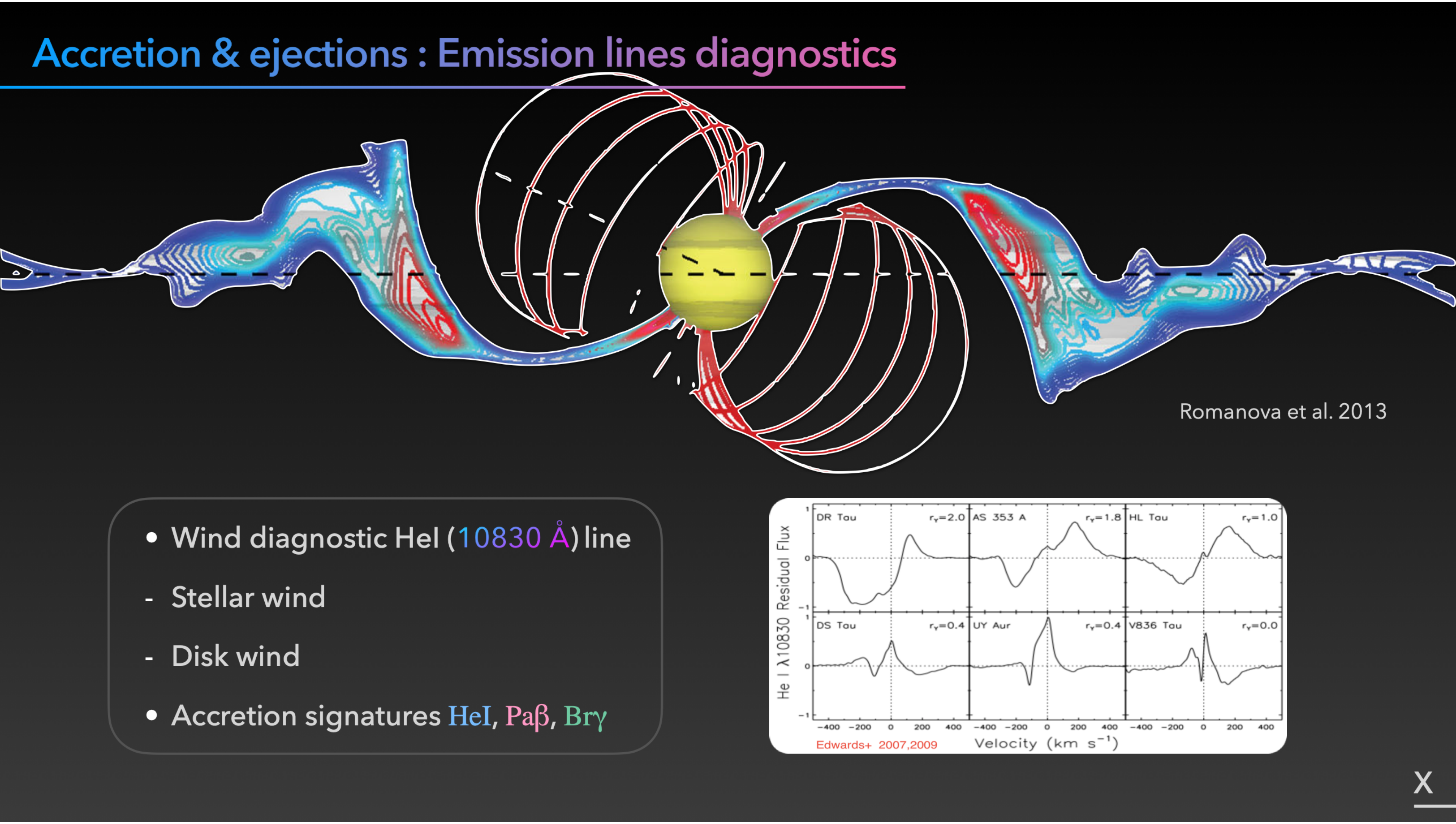
Observational diagnostics



Differential spectro-interferometry: GRAVITY
Highres spectroscopy/polarimetry: CFHT SPIRou/ESPaDOnS
Multicolor photometry: Las Cumbres Observatory

Star-disk interaction

© A. Sousa



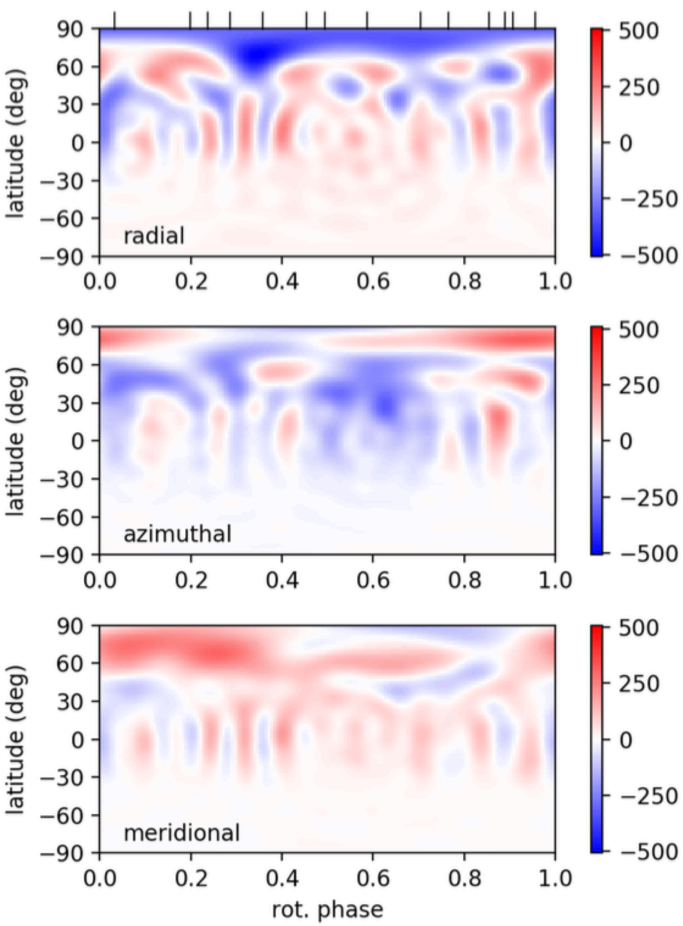
CFHT/SPIRou

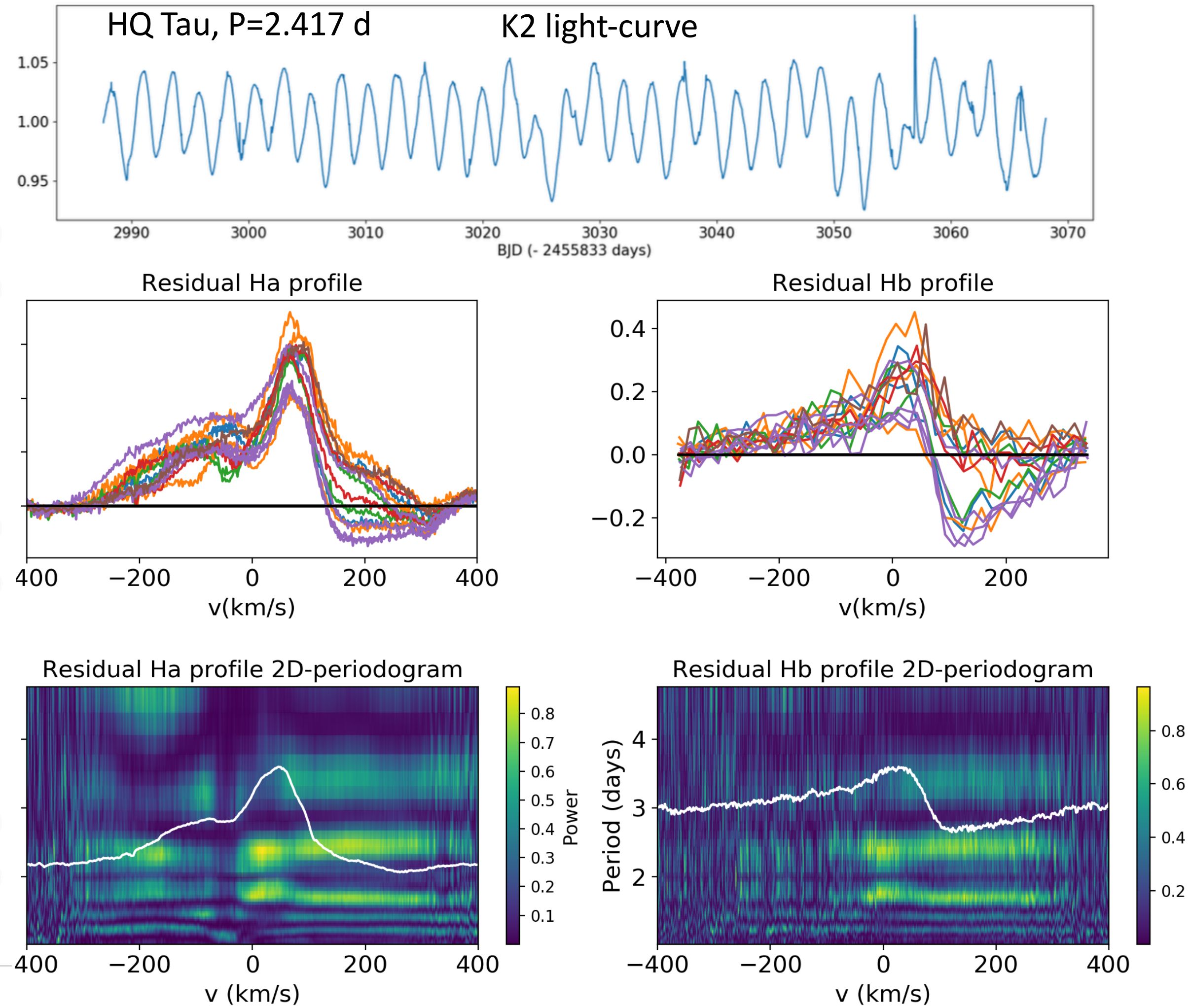
Sousa et al. 2021, 2023

Spectroscopic/polarimetric variability

- Zeeman-Doppler imaging + line profile variability

CFHT/ESPaDOnS



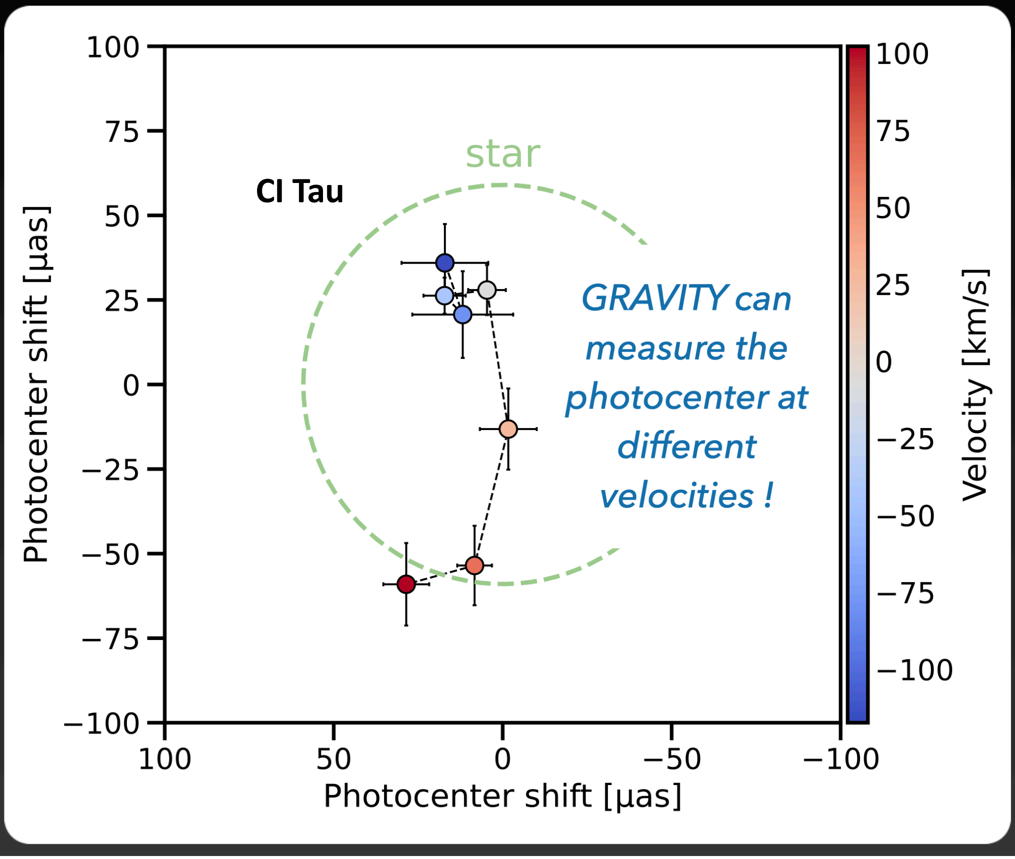


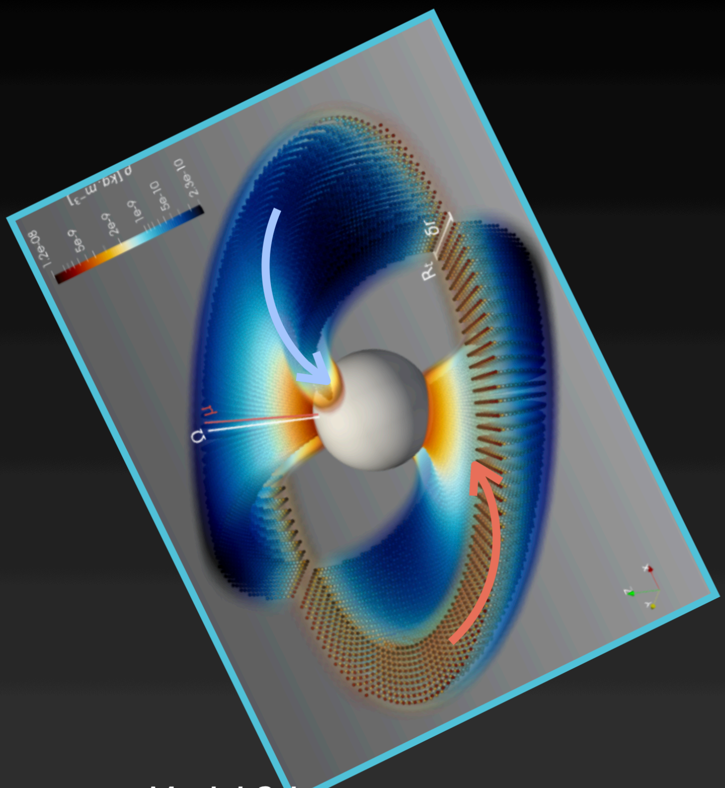
Pouilly et al. 2020, 2021, 2023

K-band and Brϒ spectro-interferometry

© A. Soulain

Temporal follow-up : Power of the phases





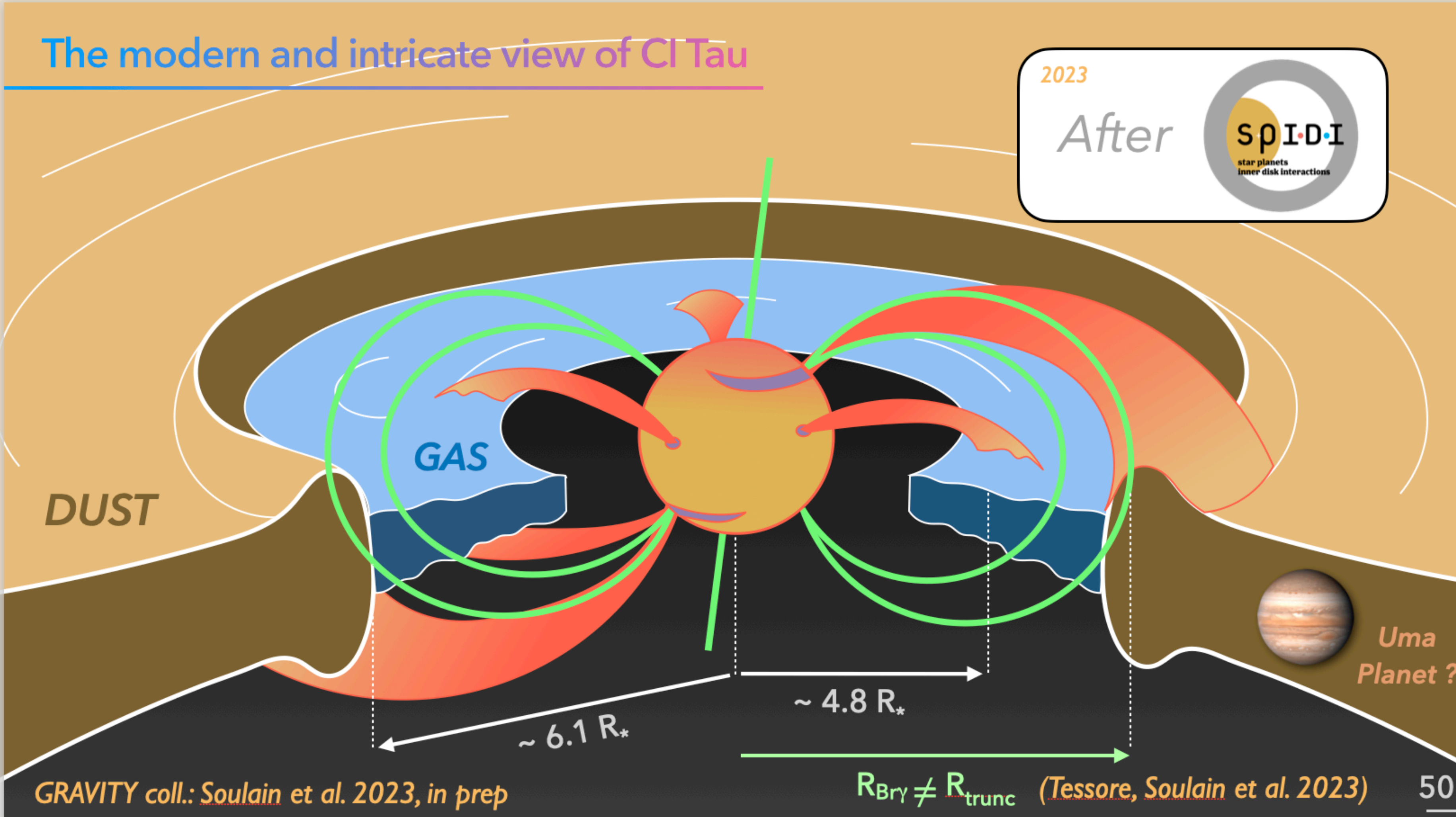
Model 3d non-axisymmetric

Tessore, Soulain et al. 2023

ESO VLTI/GRAVITY

Soulain et al. 2023; Tessore et al. 2023

CI Tau: a complex and promising system



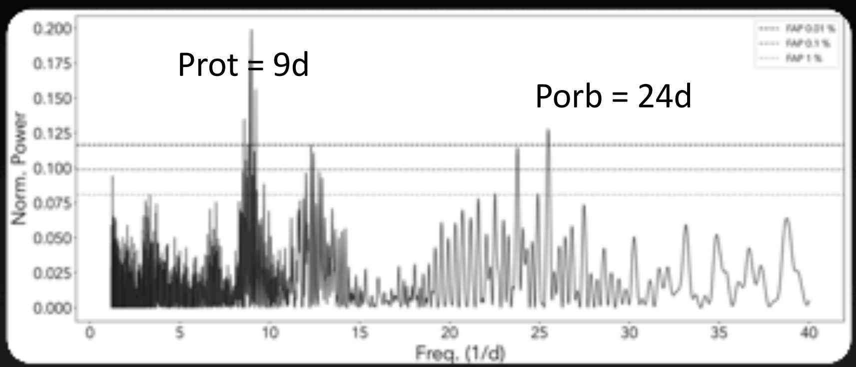
A disk-embedded inner planet?

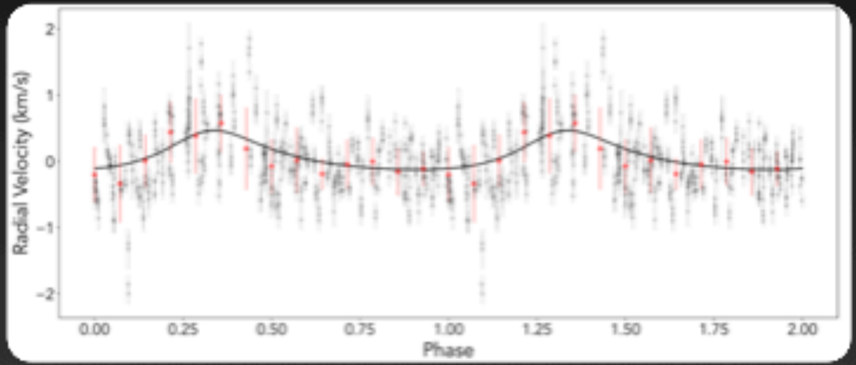
© R. Manick

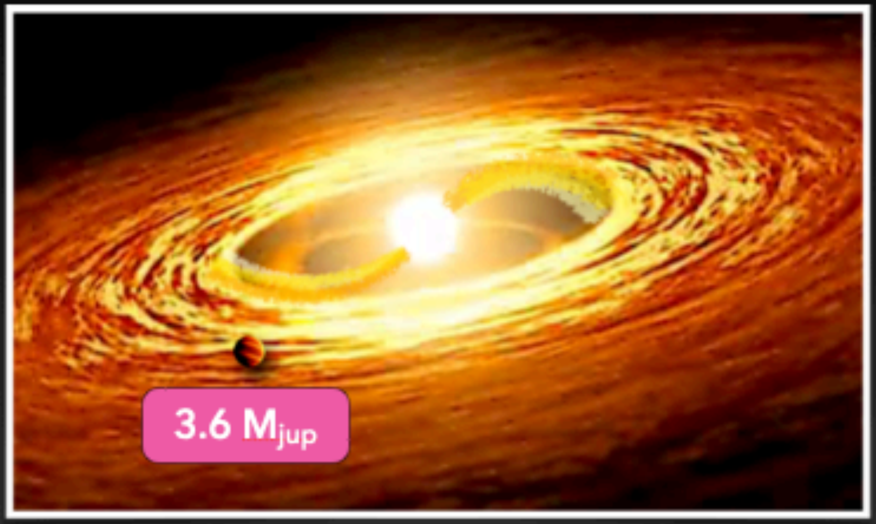
RV orbit and planet mass

Porb=24 days (K2, LCOGT, ESPaDOnS, SPIRou)
a = 0.16 au
M = 3.6 Mjup

Manick et al. 2023, submitted



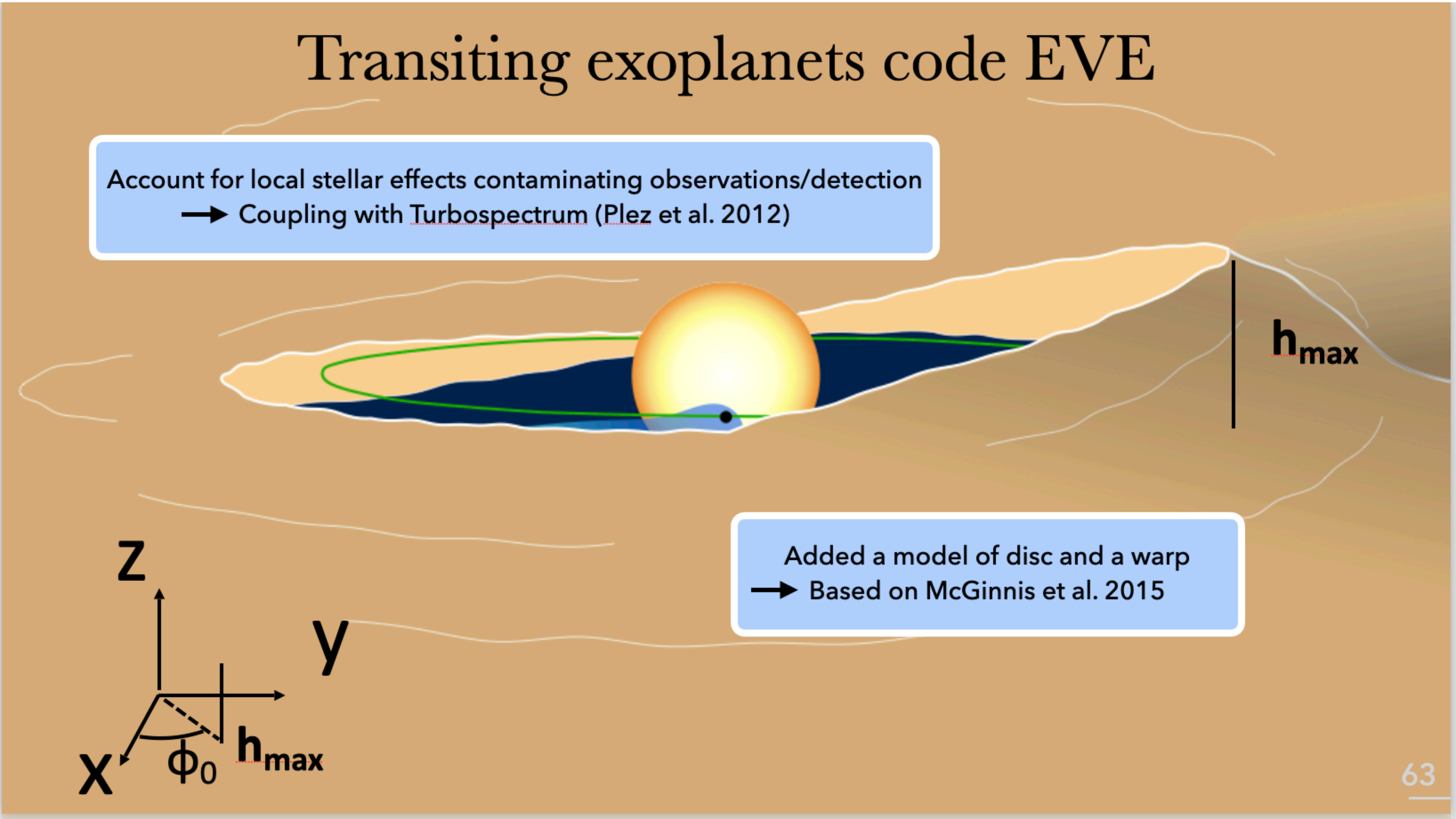




Bisector: periodicity seen as Doppler shift!

Search for exoplanet atmospheric escape signatures

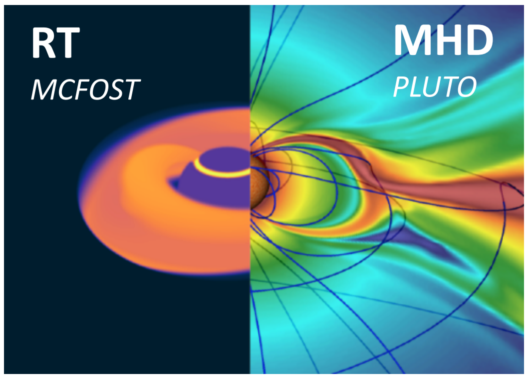
© W. Dethier



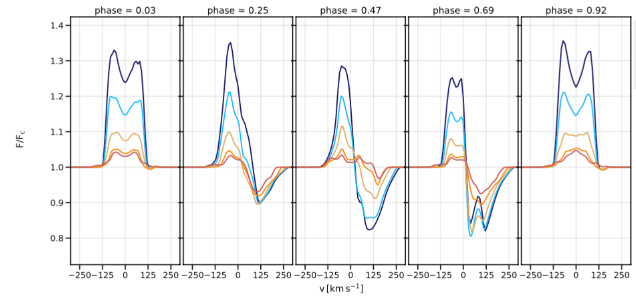
Dethier & Bourrier 2023

The SPIDI project: summary and perspectives

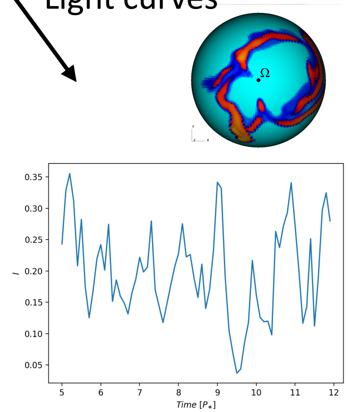
Model summary



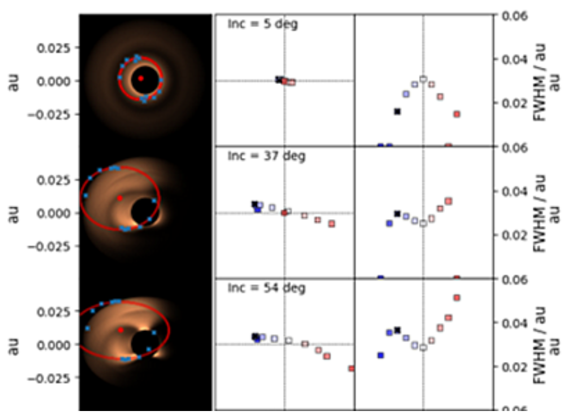
Line profiles



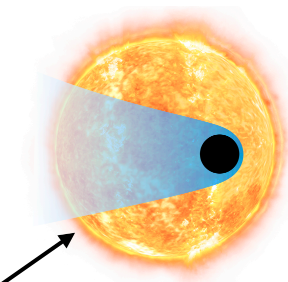
Light curves



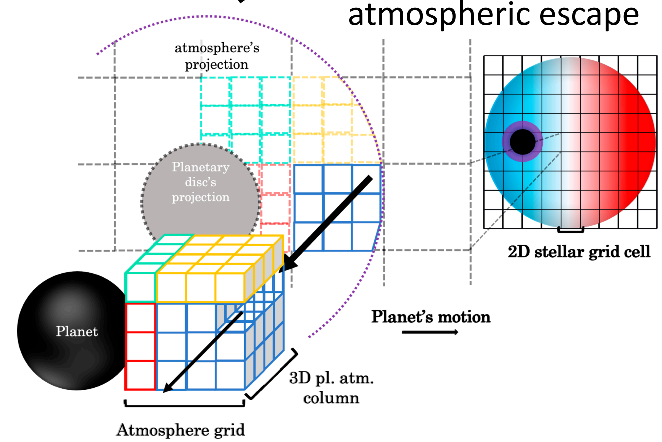
Interferometric
visibilites and phases



EVE

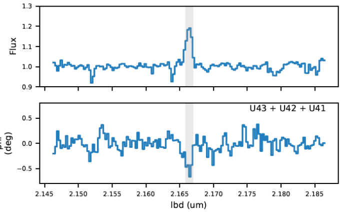


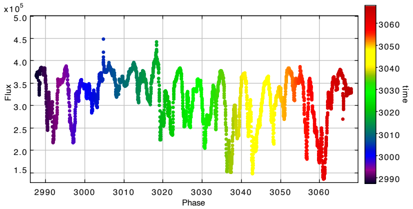
Planetary
atmospheric escape

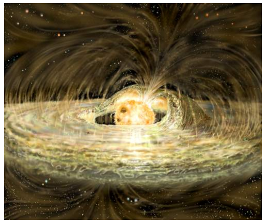


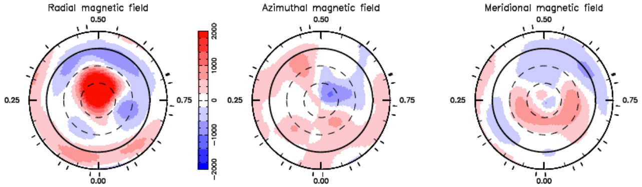
Observing: multi-technique, multi-wavelength monitoring campaigns

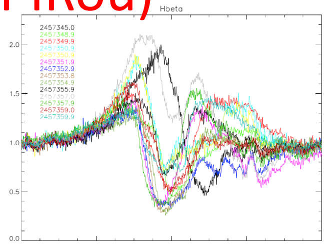
- **Interferometry** (VLTI/Gravity(+), ESO Chili)
- **Space photometry** (K2, Gaia, TESS, Plato)
- **Multicolor** ground-based **photometry** (LCOGT)
- Optical **highres spectroscopy** (ESO HARPS, OHP/SOPHIE)
- Optical and infrared **spectropolarimetry** (CFHT ESPaDOnS, CFHT SPIRou)





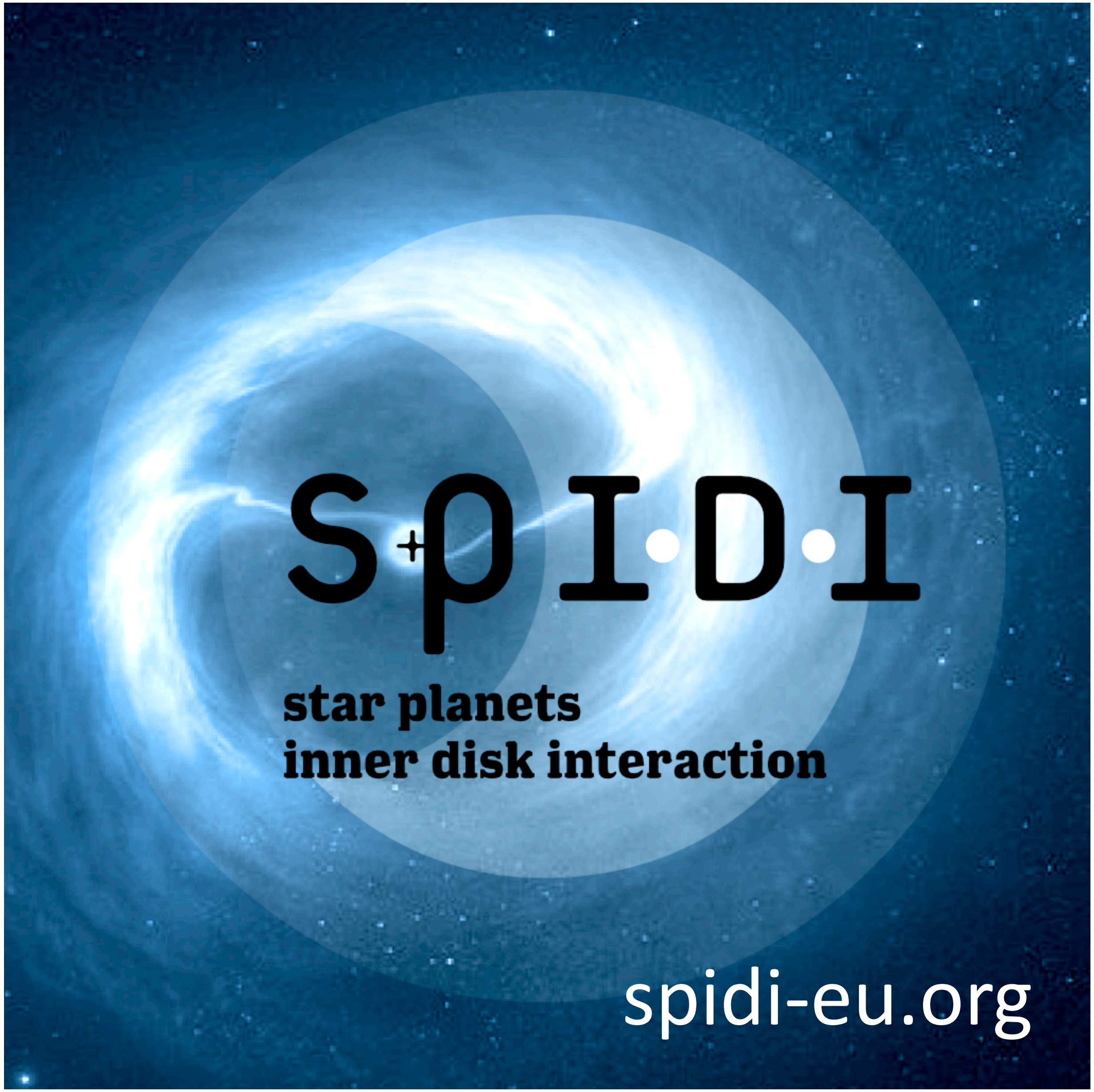






Perspectives

- We achieved a lot, developing the modeling tools and gathering the observations!
- A lot remains to be done, e.g.:
    - Stars –**PLANETS** – Inner Disk Interaction models
    - Modeling additional configurations and diagnostics (e.g. complex magnetic fields, inner disc warps, winds, etc.)
    - Searching for planetary atmospheric escape signatures in the current datasets (e.g. CFHT/SPIRou time series)
    - Detecting more embedded inner planets: we've got 1, that's a start!



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