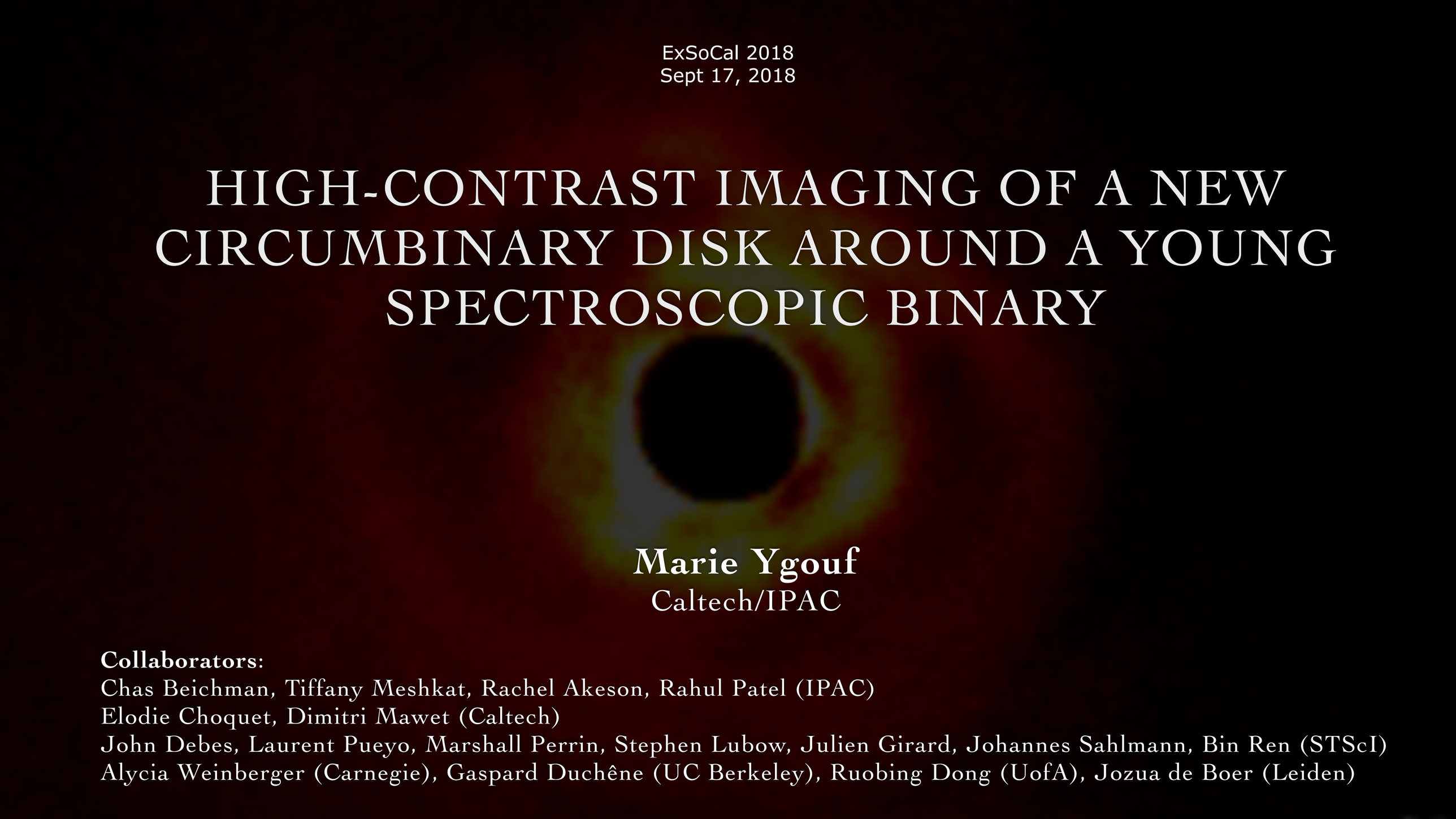
ExSoCal 2018
Sept 17, 2018

HIGH-CONTRAST IMAGING OF A NEW CIRCUMBINARY DISK AROUND A YOUNG SPECTROSCOPIC BINARY

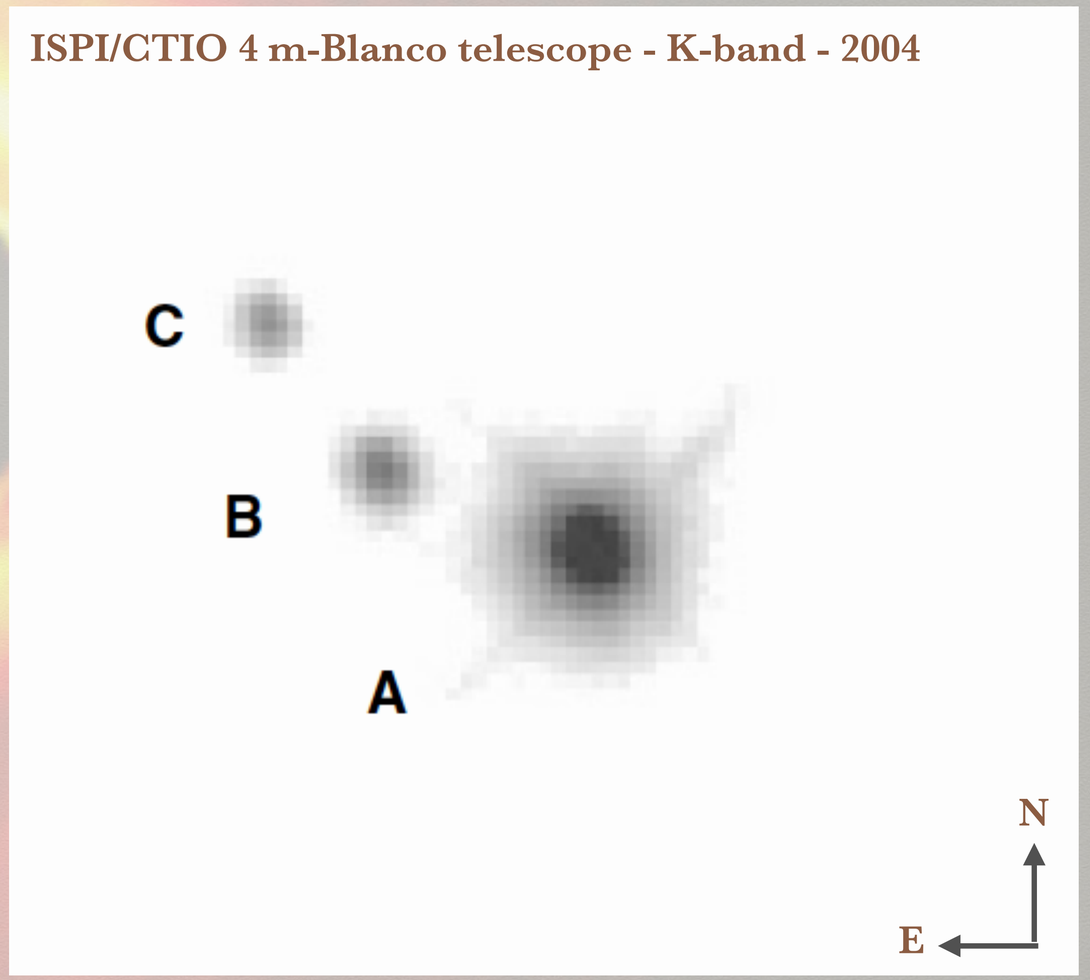


Marie Ygouf
Caltech/IPAC

Collaborators:
Chas Beichman, Tiffany Meshkat, Rachel Akeson, Rahul Patel (IPAC)
Elodie Choquet, Dimitri Mawet (Caltech)
John Debes, Laurent Pueyo, Marshall Perrin, Stephen Lubow, Julien Girard, Johannes Sahlmann, Bin Ren (STScI)
Alycia Weinberger (Carnegie), Gaspard Duchêne (UC Berkeley), Ruobing Dong (UofA), Jozua de Boer (Leiden)

Your typical high-contrast imaging target

- Quadruple star system



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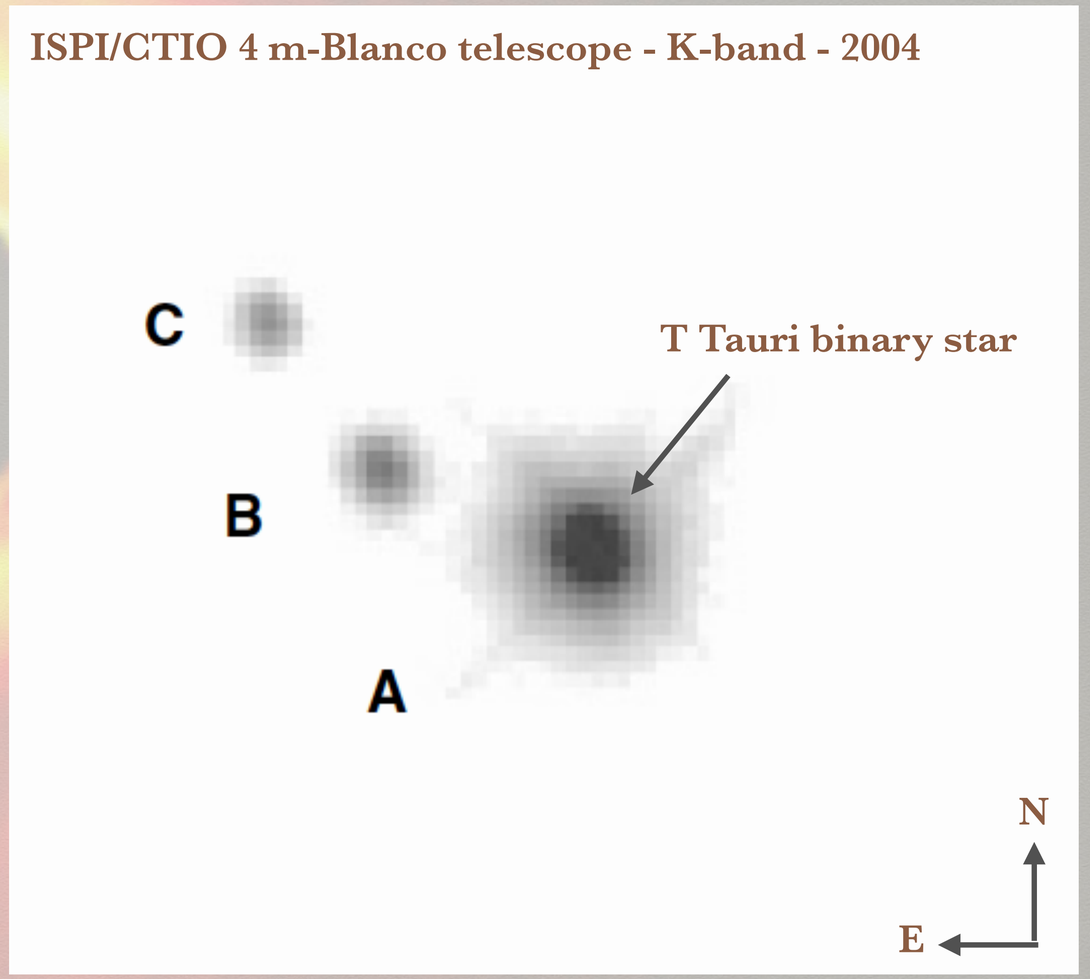

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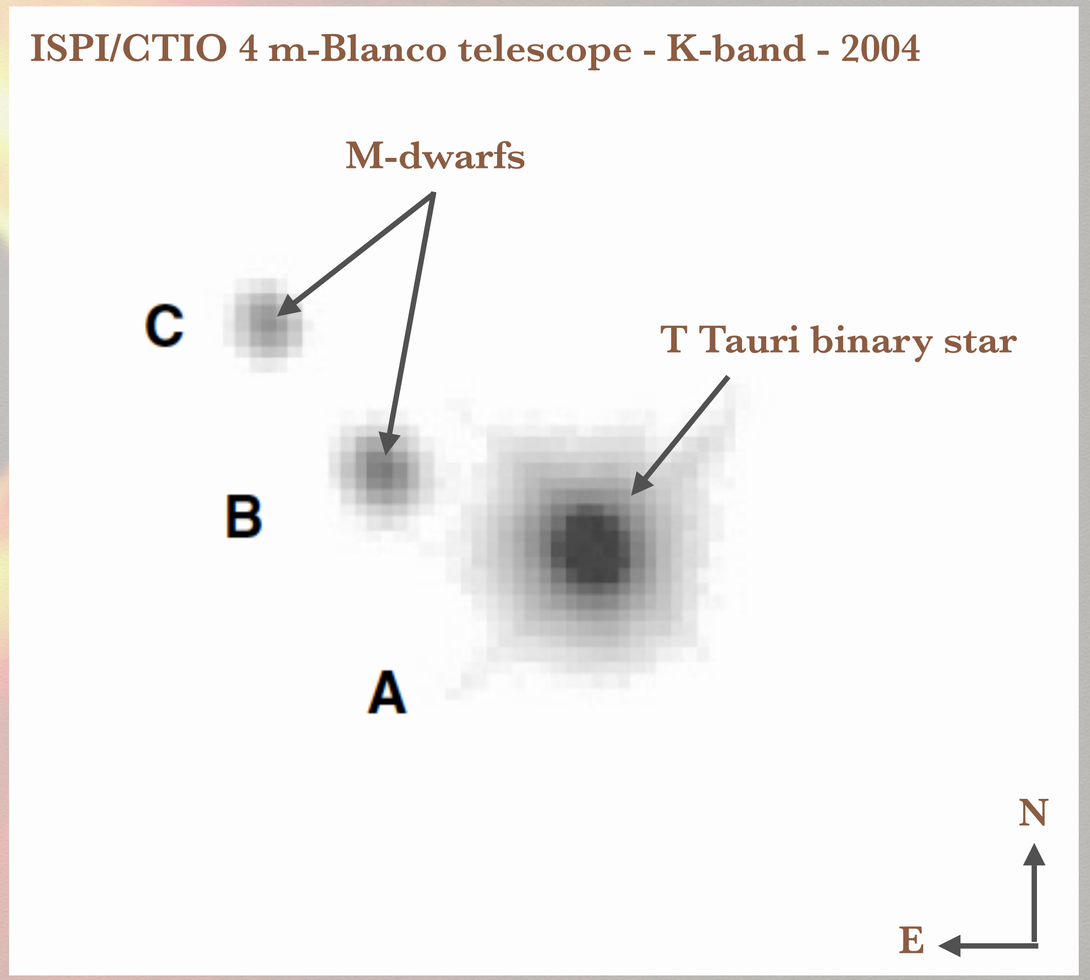

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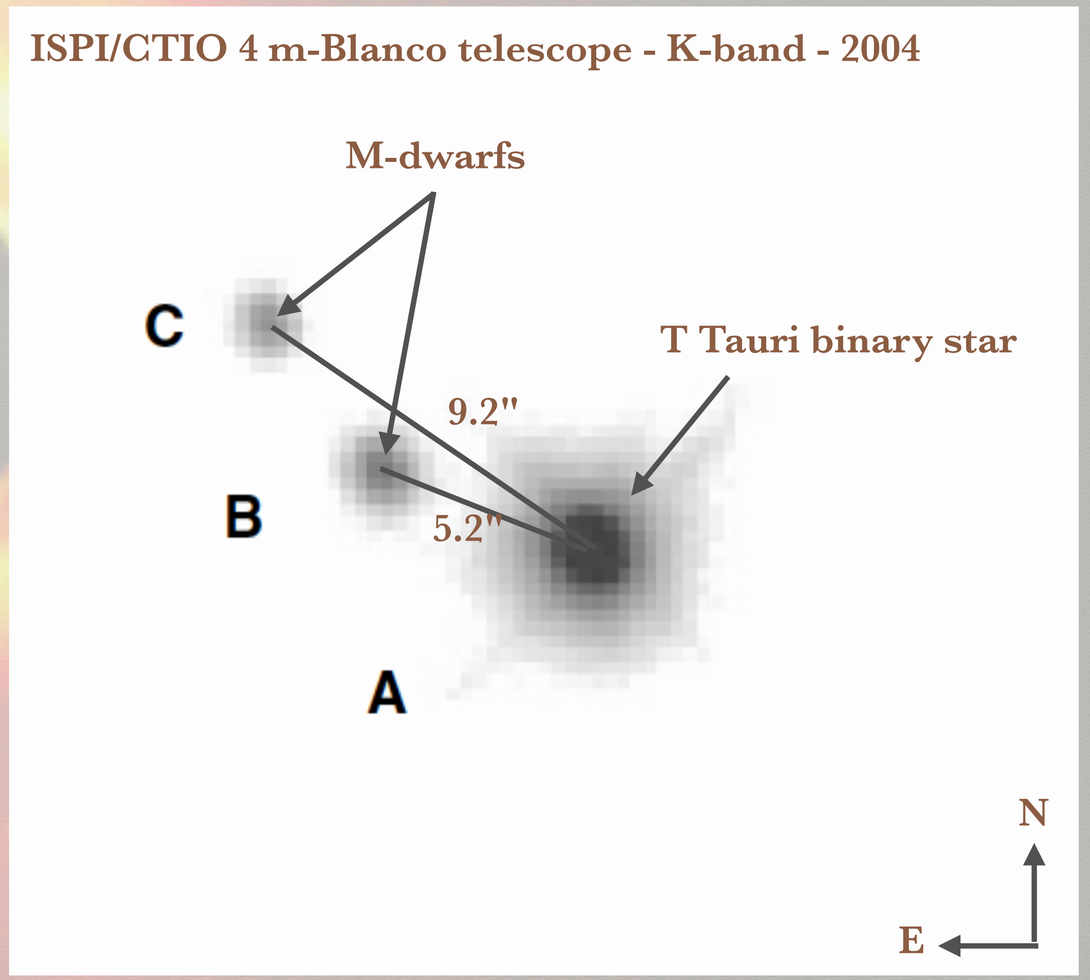

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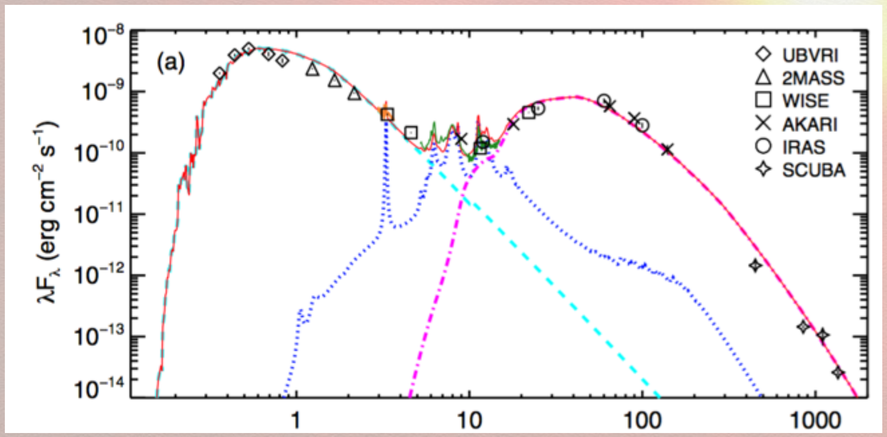

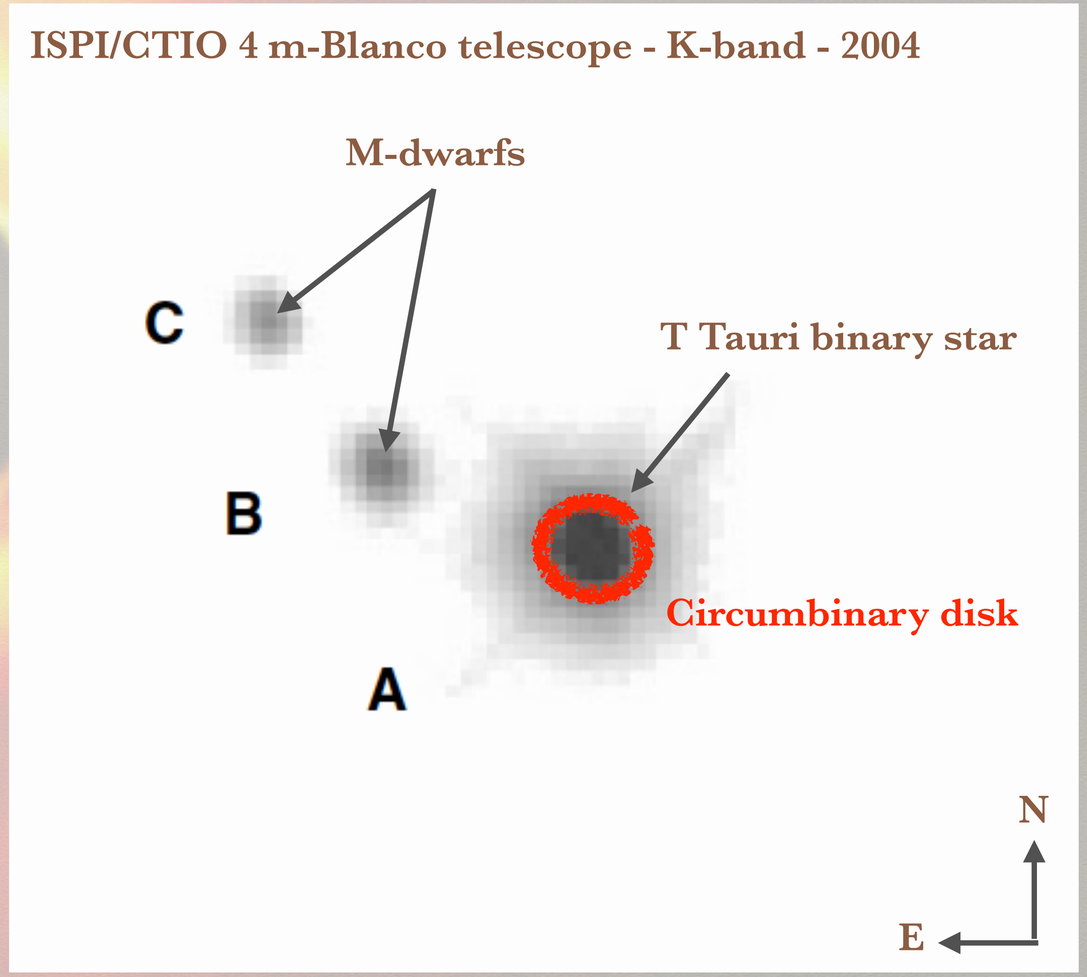

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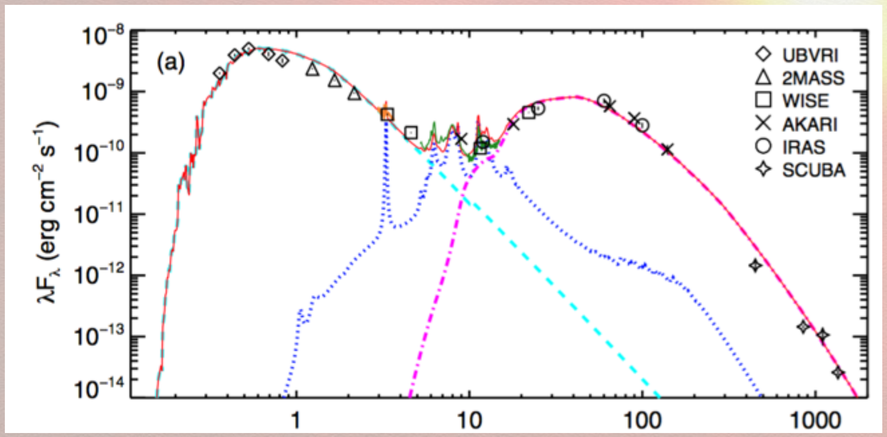

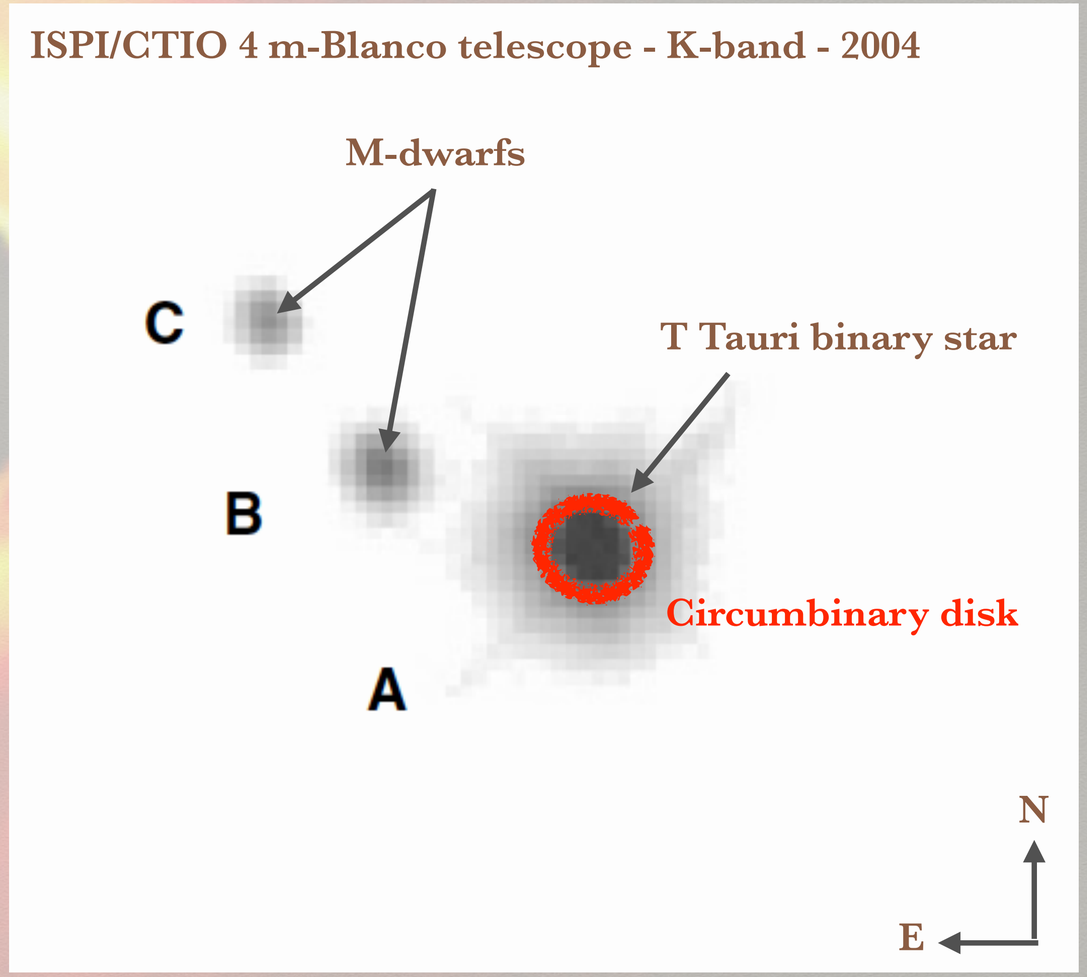

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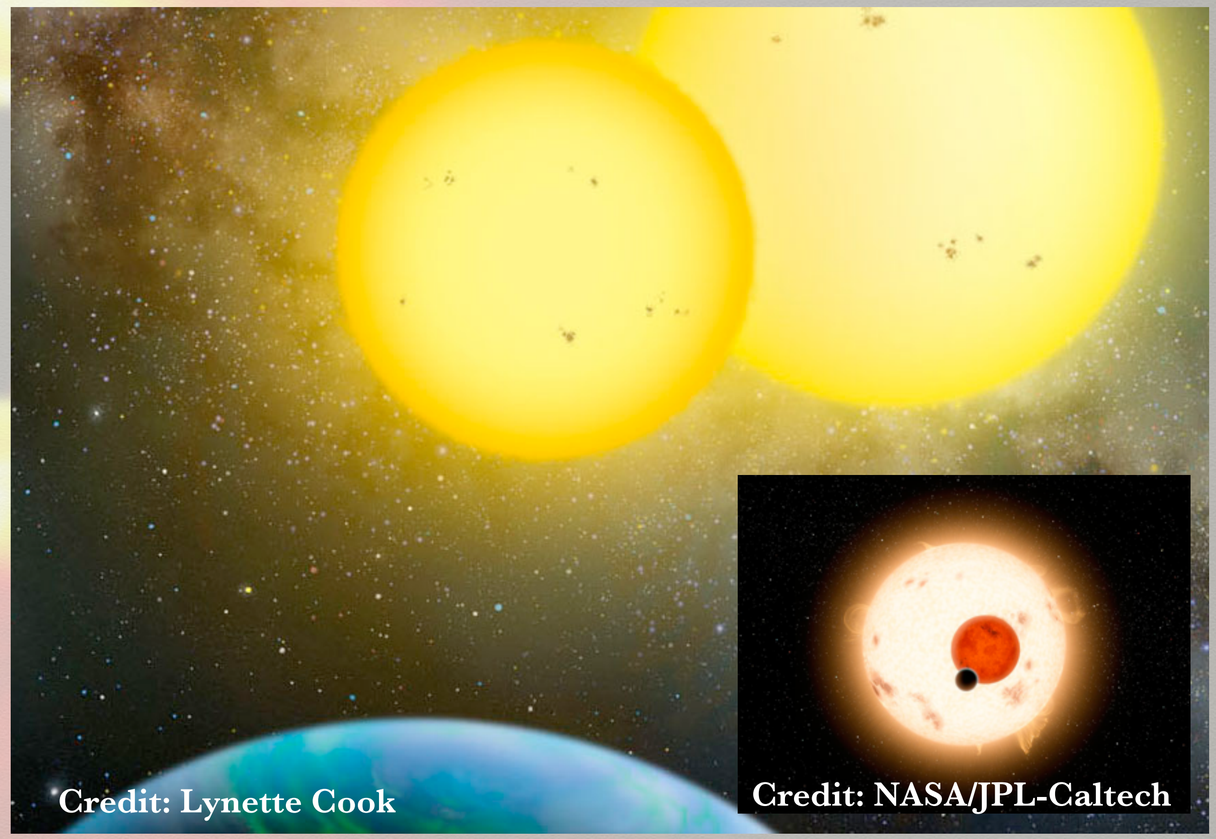
Kepler circumbinary planet systems

(examples: Kepler 16-b [Doyle et al. 2011], Kepler-35b [Welsh et al. 2012])



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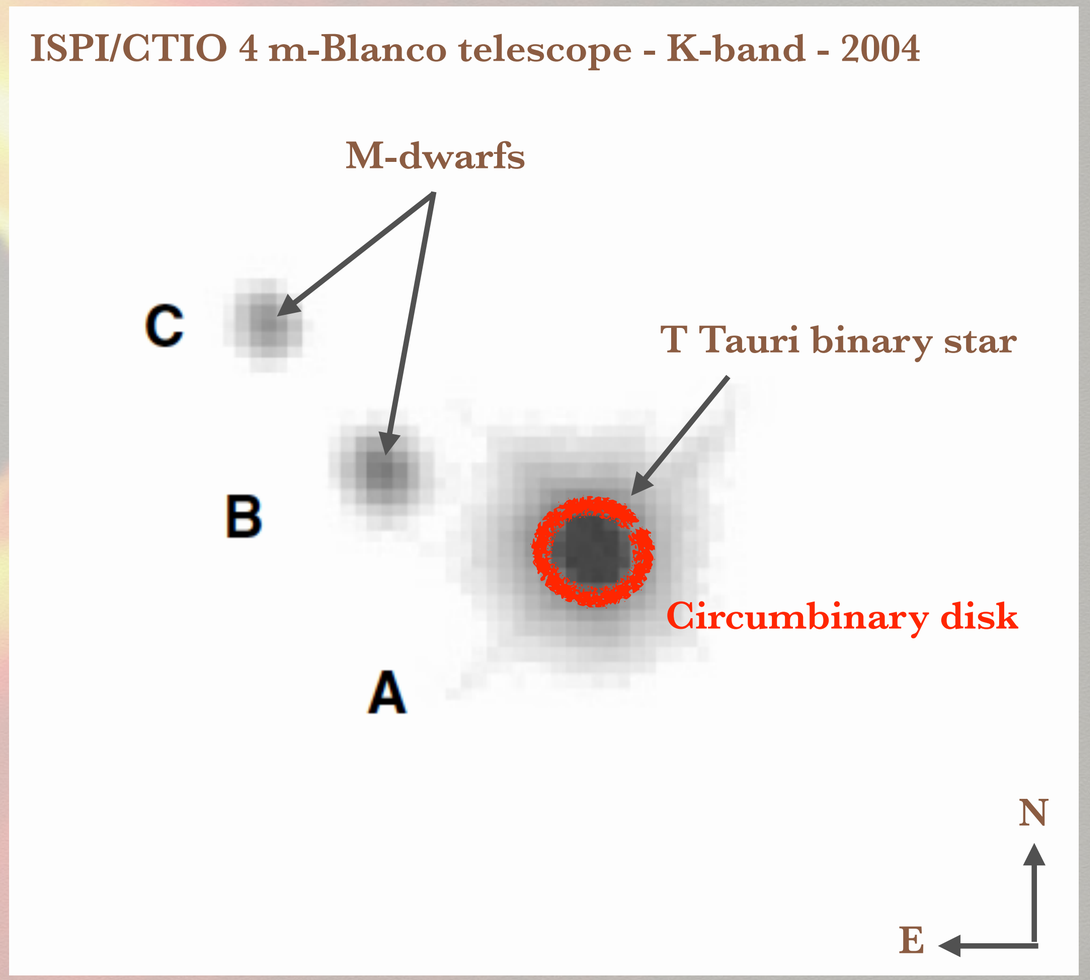

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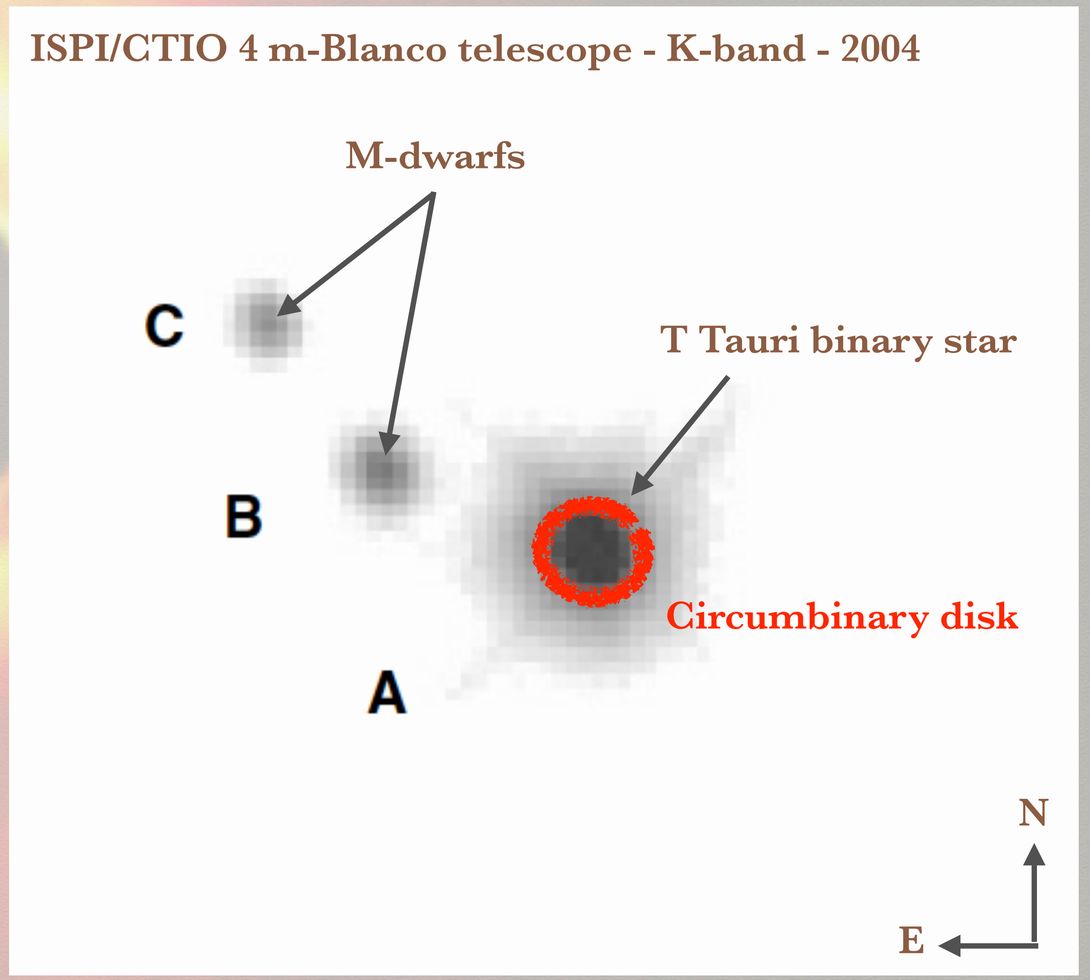
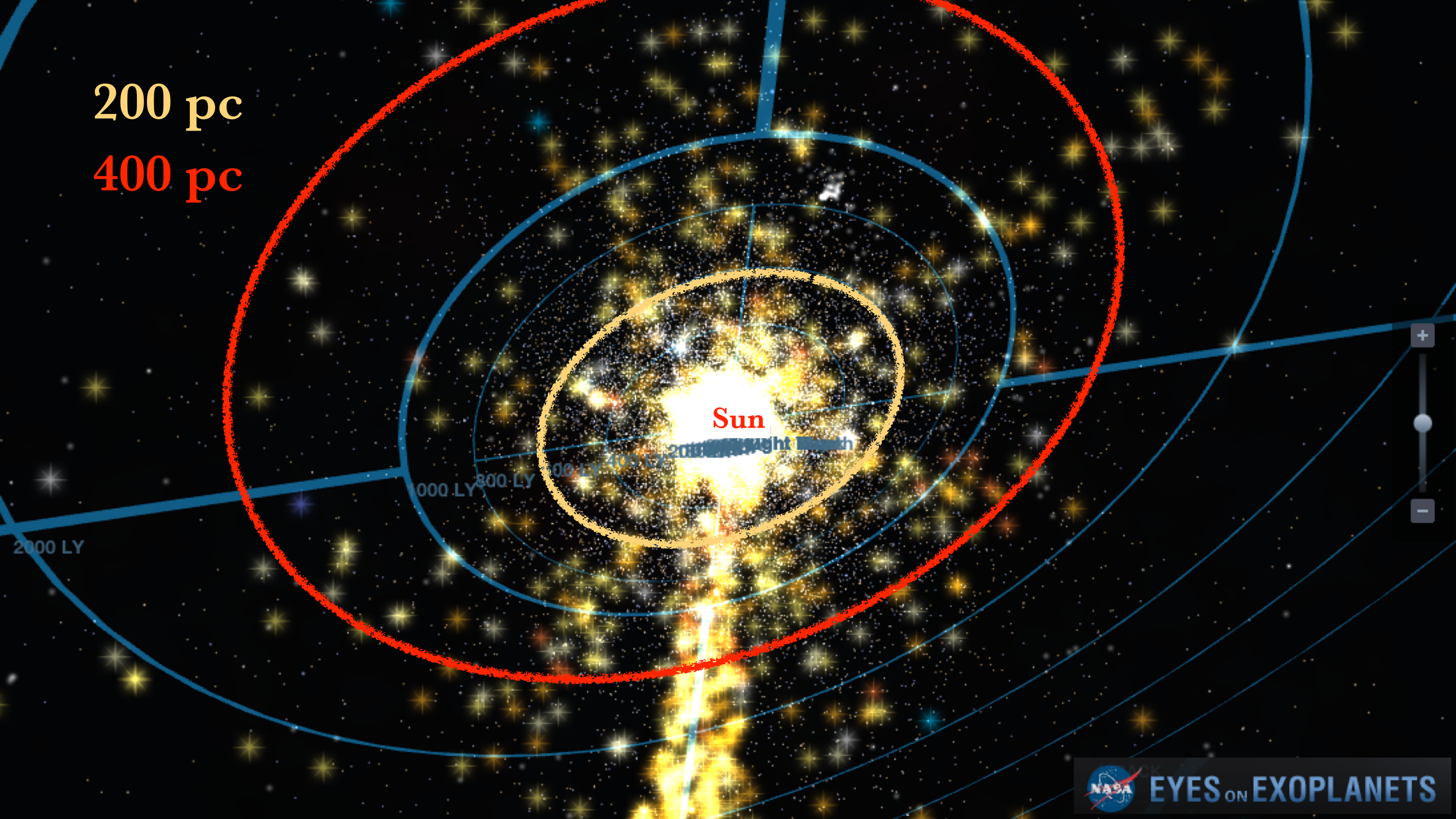
- **Pretty far system** (between 200 and 400 pc: distance was not well constrained until very recently)




200 pc
400 pc
Sun
800 LY
2000 LY
EYES ON EXOPLANETS

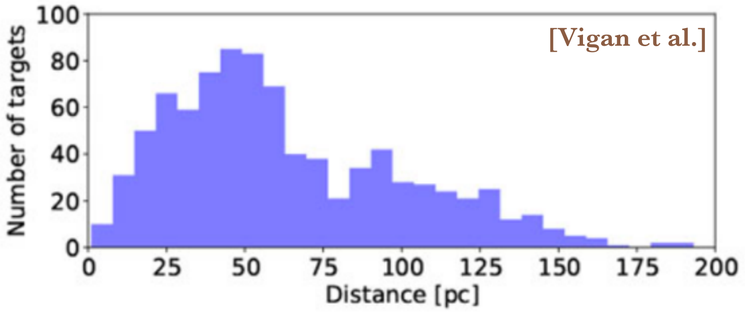
200 pc

Sun

800 LY

2000 LY

SpHere INfrared survey for Exoplanets (SHINE) survey targets
=> highest priority given to the youngest and most nearby stars



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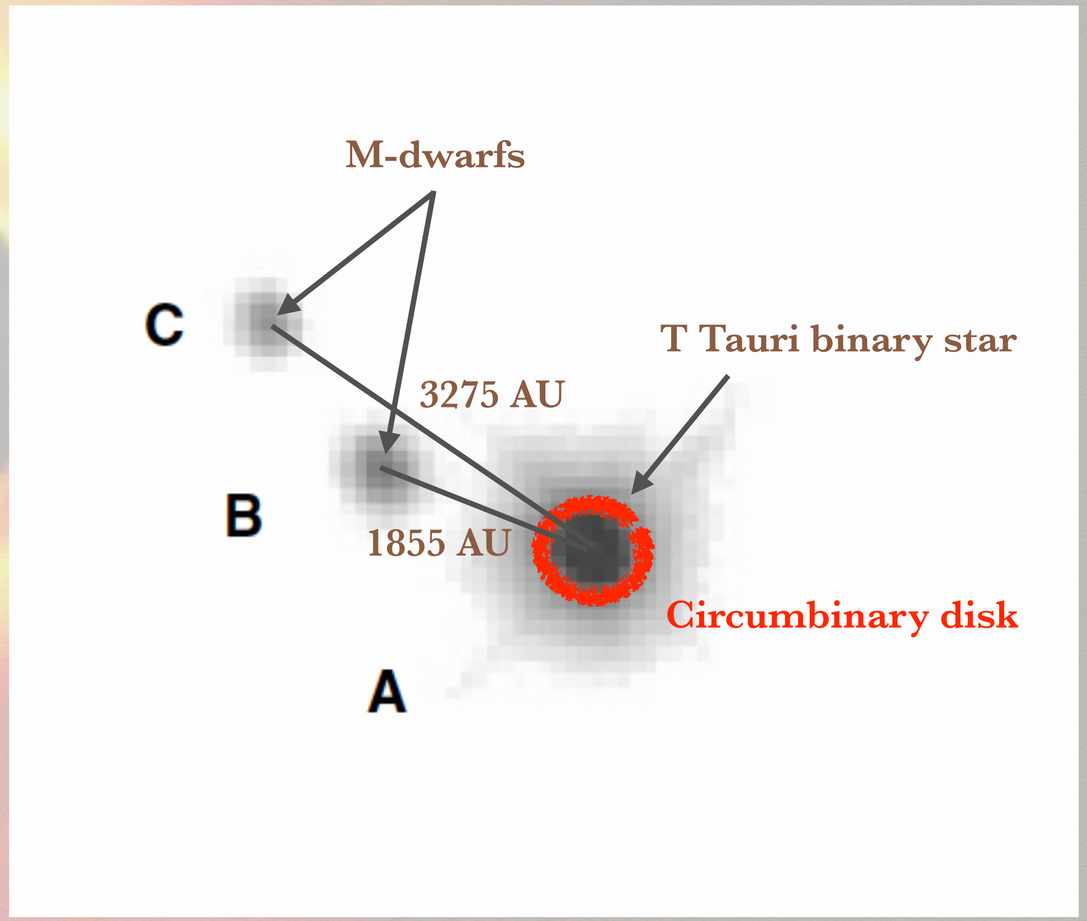
GAIA parallax
356 pc +/- 6pc



First high-contrast images with HST-NICMOS

Observations from 1998!

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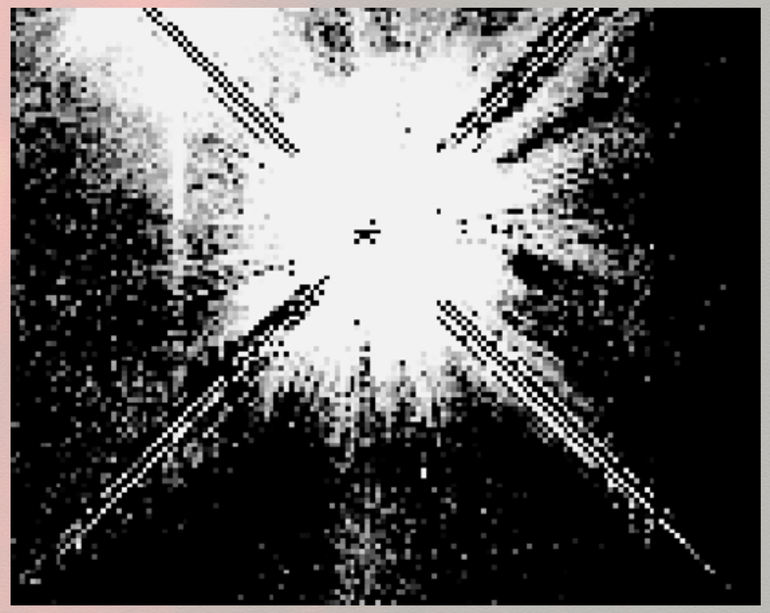

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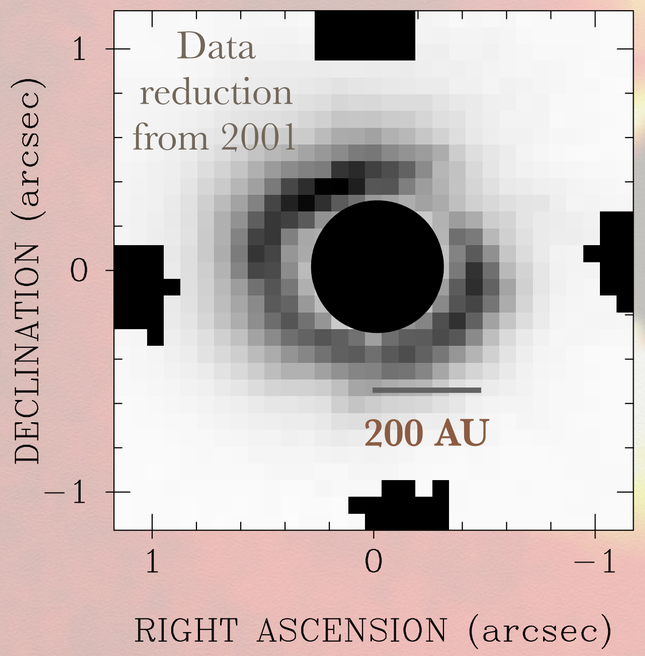
Classical PSF subtraction



Ygouf et al., in prep

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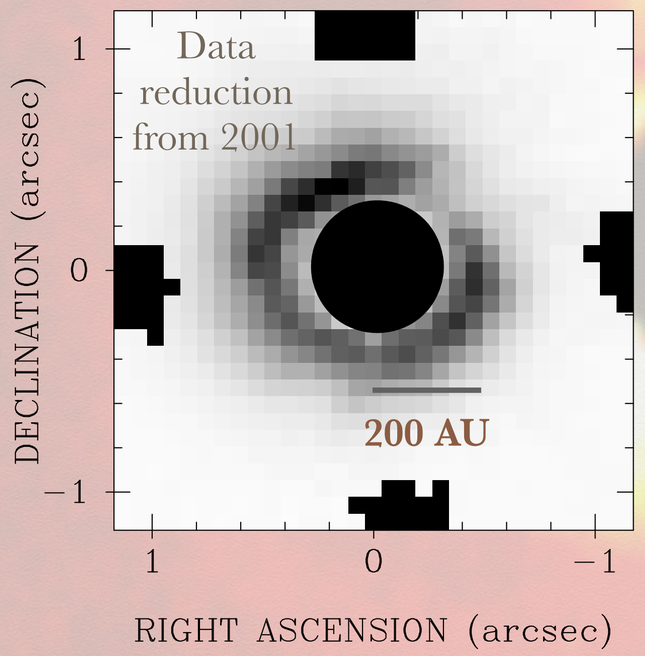

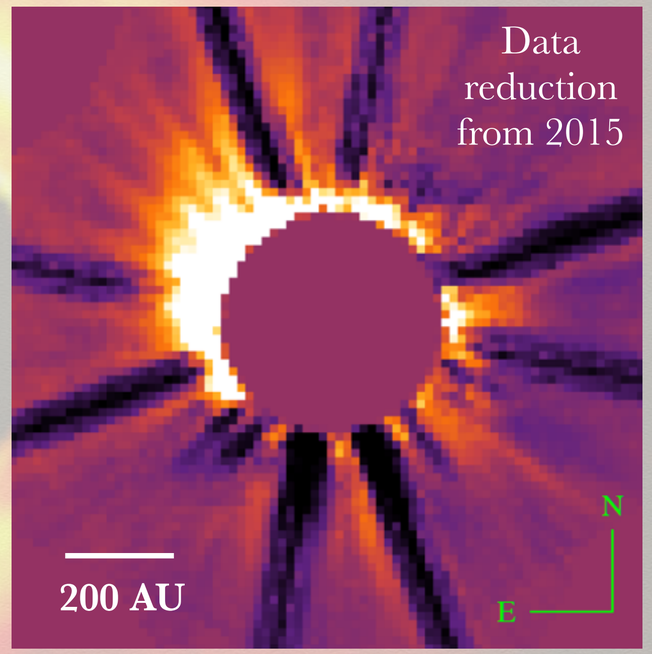

Reduction with KLIP (Soummer et al. 2012) as part of the ALICE project (Choquet et al.)

Ygouf et al., in prep

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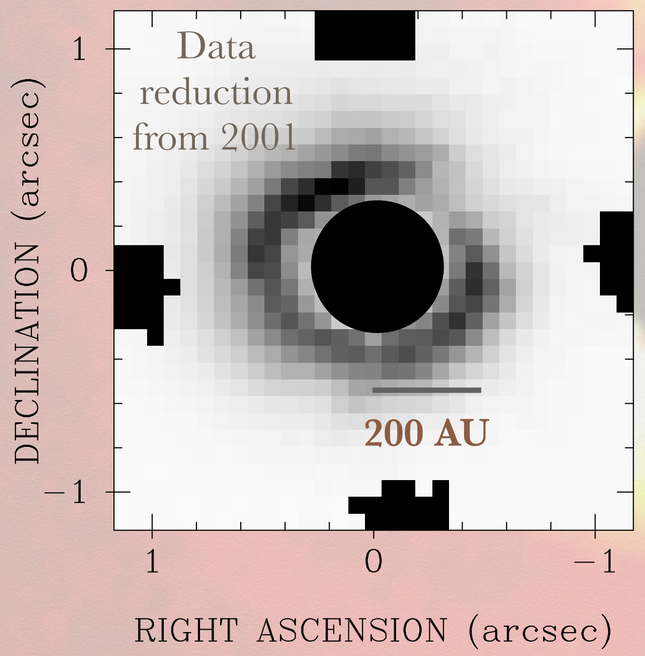

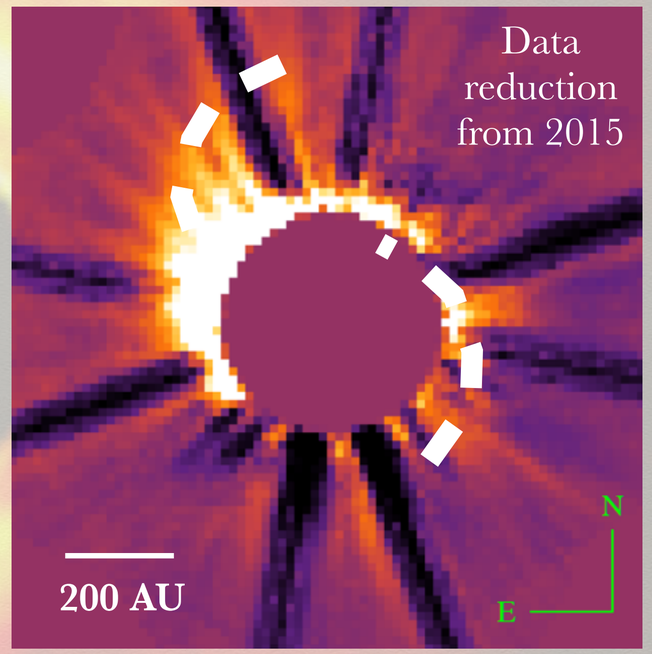

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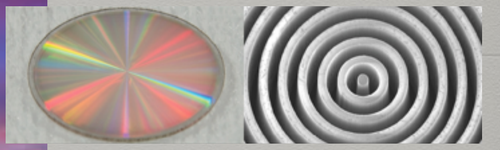
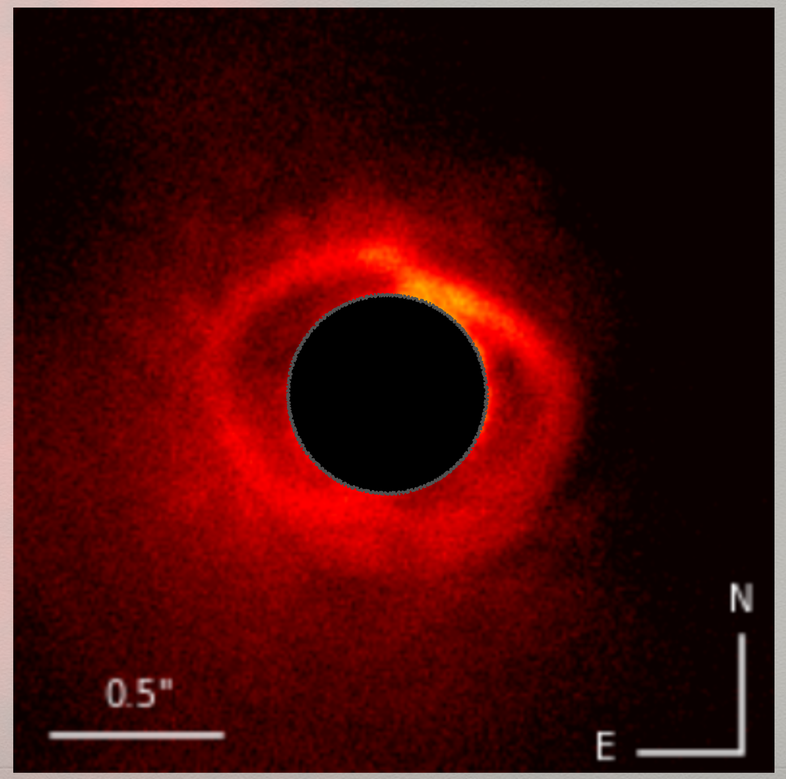
Ygouf et al., in prep

Keck Observations

- L'-band observations with Vortex with Keck-NIRC2
- Clear evidence for cavity clearing and ring-like disk
- Spirals: Non-detection



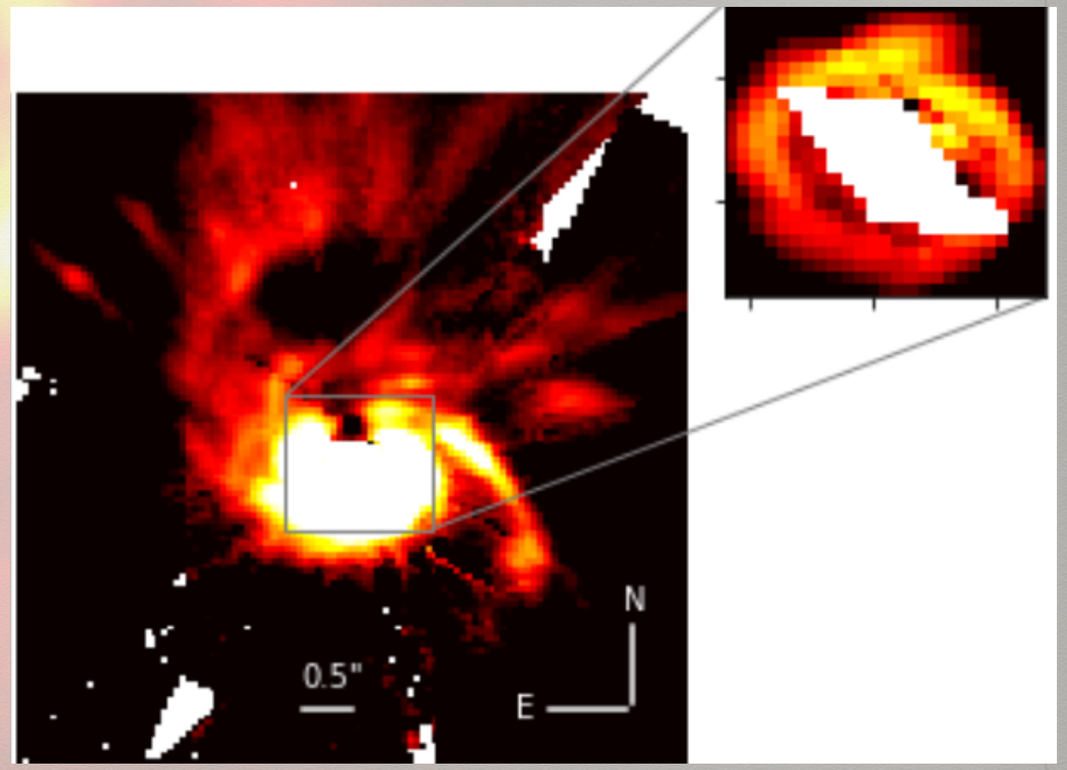
Mawet et al.



Ygouf et al., in prep

Observations with HST-STIS

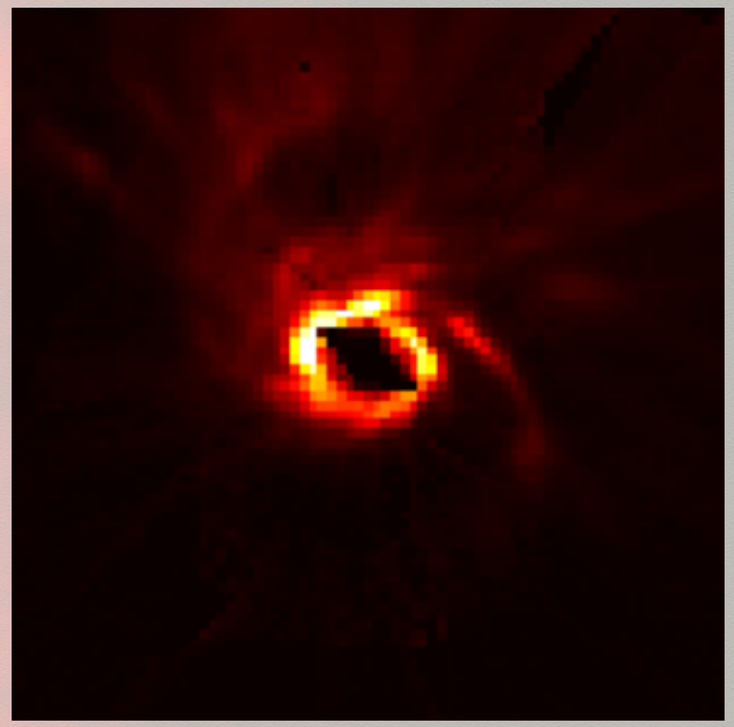
- Observation in the visible with 50CORON BAR5 and Wedge1.0 on HST-STIS 5850 (Å) Central wavelength- 4410 (Å) FWHM
- Clear evidence for at least two spirals, hints for at least one more
- Consistent with ring-like structure
- Hint for structures in the ring
- Hint for dust material inside the cavity



Ygouf et al., in prep

New Questions

- Detection of low SNR additional spiral: is it real?
- What are the physical processes responsible for the spirals?
- What are the physical processes responsible for clearing the cavity?



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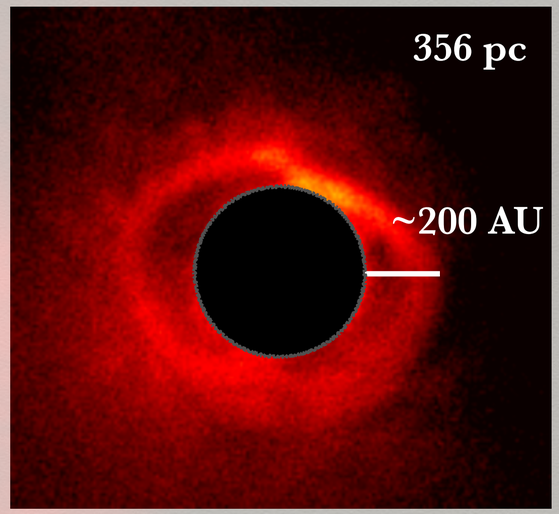
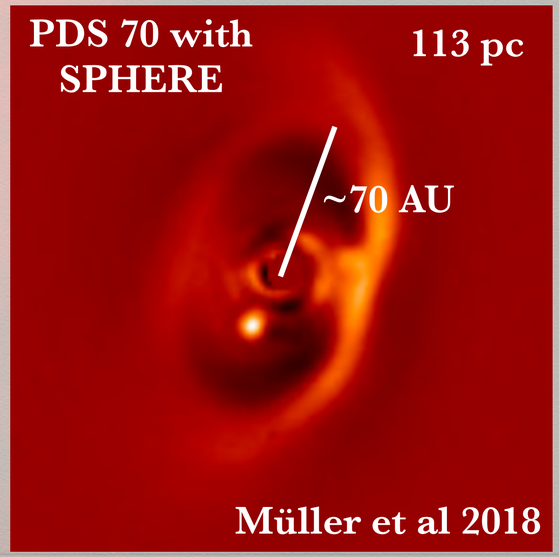
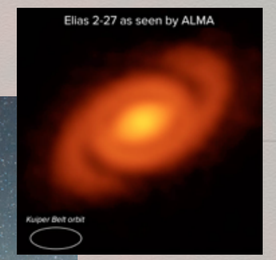
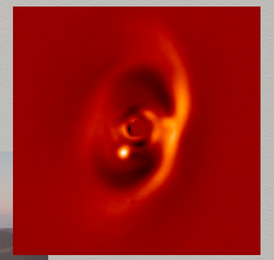


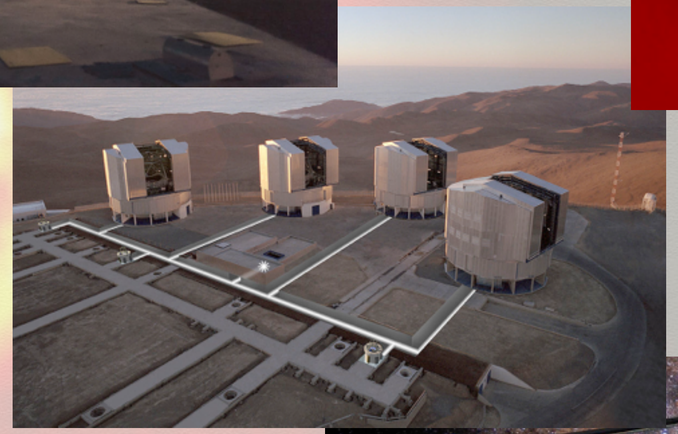


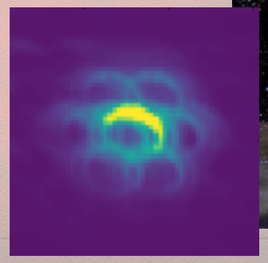
Next Steps

- Observations of the disk with complementary facilities including ALMA, SPHERE and JWST
- Dynamical and composition studies

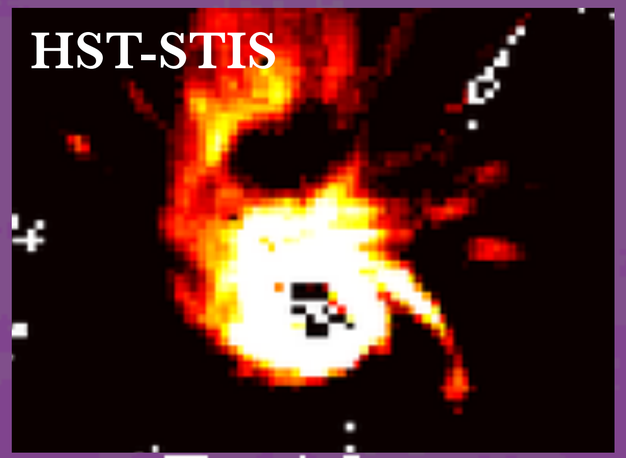




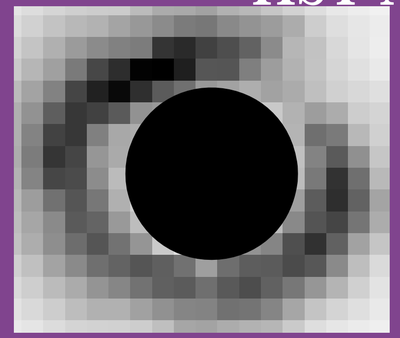




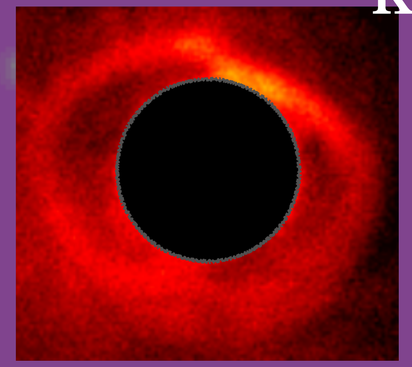
Summary



HST-NICMOS



Keck



HST-STIS

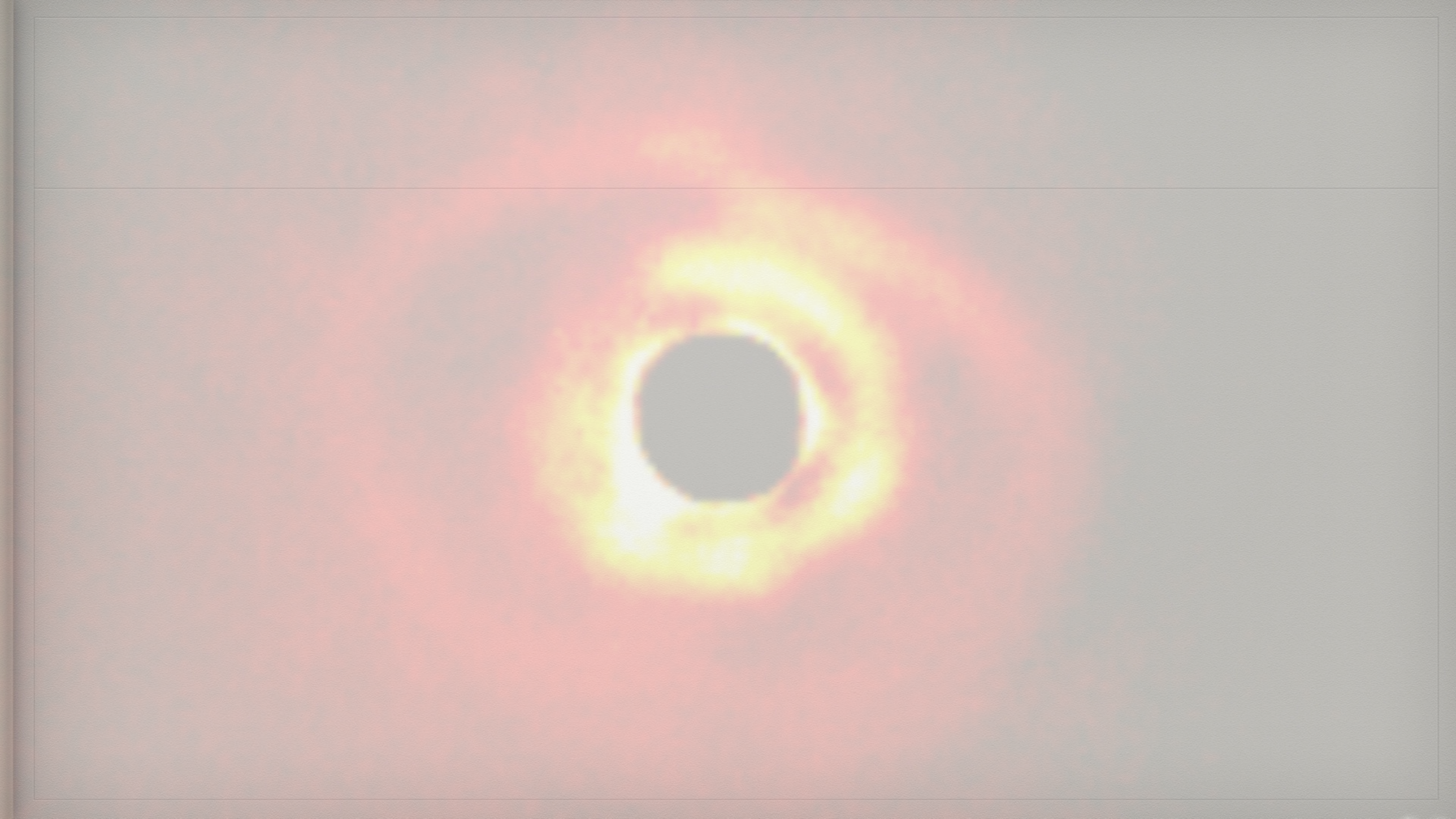
- ✓ Cavity clearing
- ✓ Spirals

1855 AU

Ygouf et al., in prep

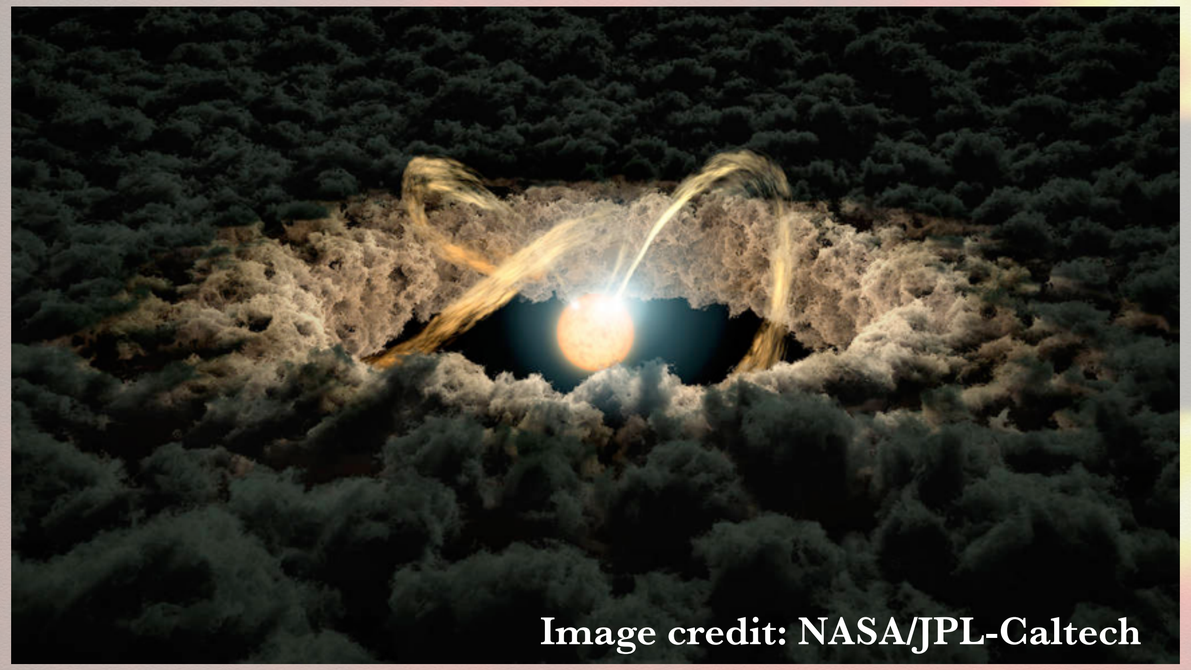
N

E

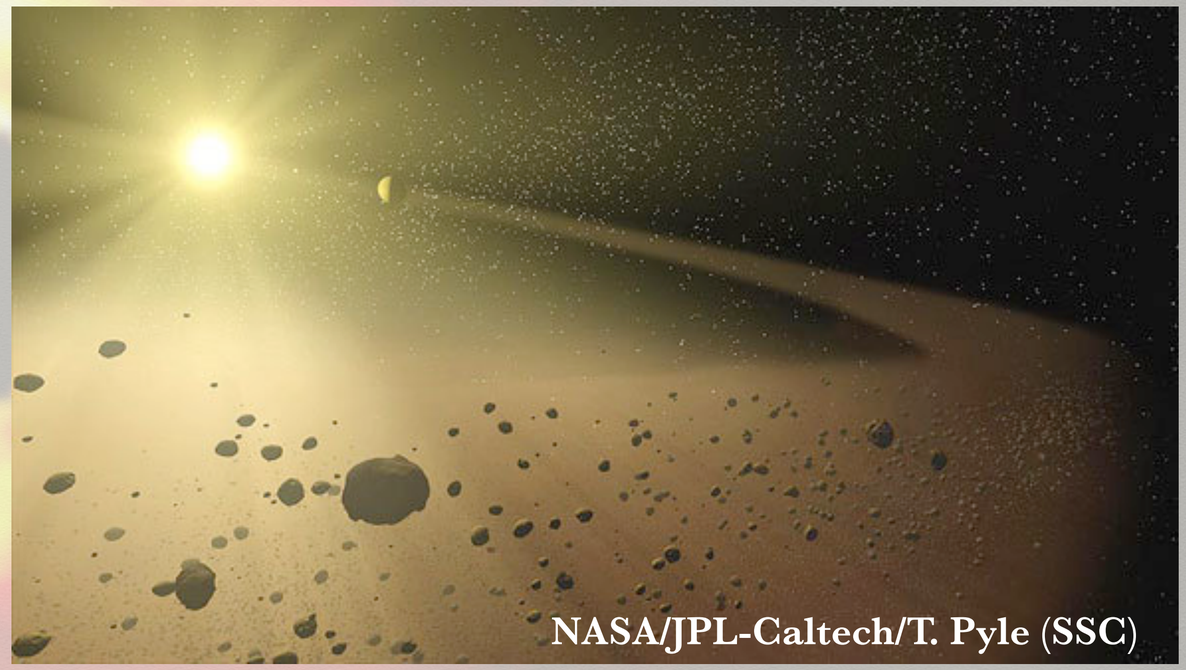


A controversial disk

Protoplanetary disk?



Debris disk?



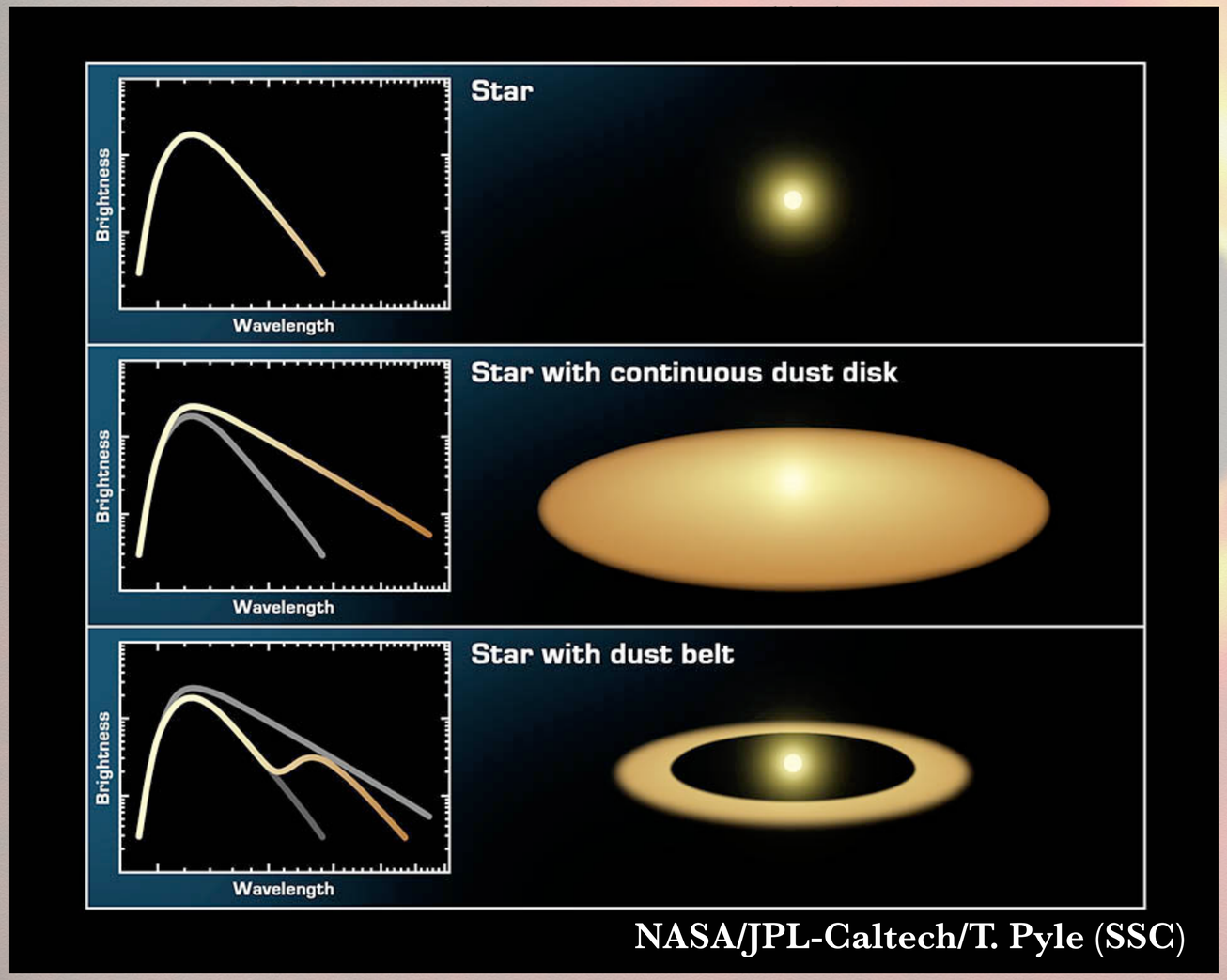
A controversial disk

Protoplanetary disk?

- Binary does not appear to be evolved: Measurements of Hα emission, lithium abundance and X-ray activity together argue for accretion still on-going, pointing to a young system
- Another indication of youth is based on its disk mass of $1.4 \times 10{-}2\ M\odot$, which has been measured using CO detections from SCUBA

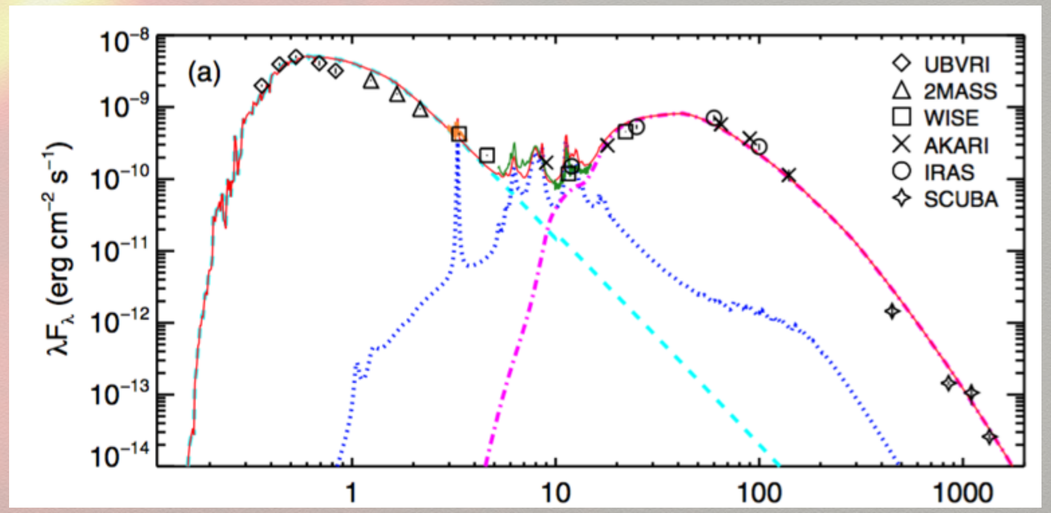
Debris disk?

A controversial disk



Debris disk?

- Both the Hα emission and the Li I λ6798 absorption are relatively weak, indicating that the disk age cannot be a few mega-years but a few tens of mega-years.
- SED indicates the presence of a dust belt



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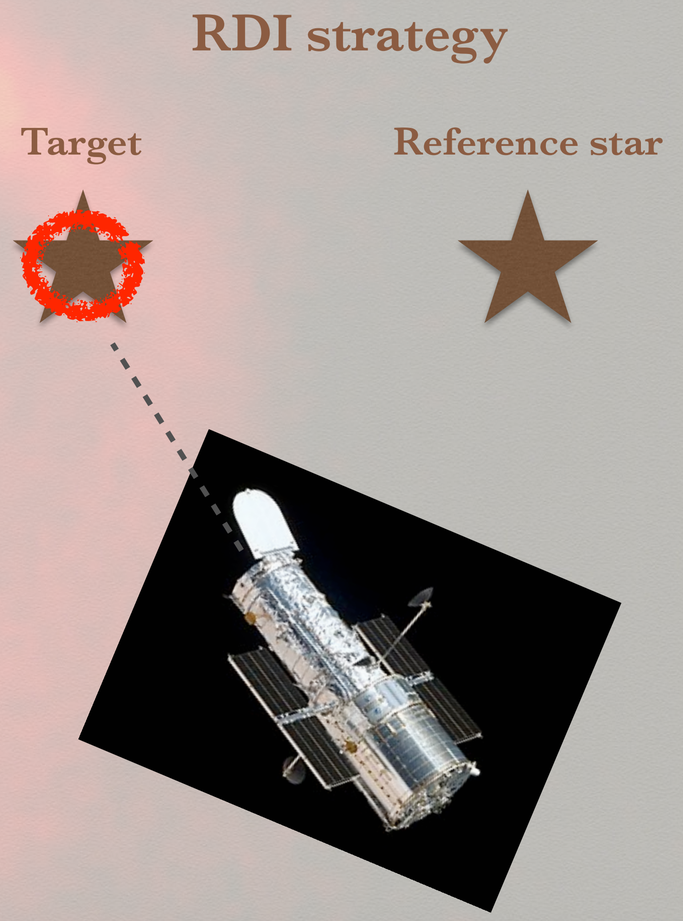
- Coronagraphic observing mode of the NICMOS Camera 2 (NIC2)
- J-band (F110W)
- ~1280 sec on target
- RDI strategy



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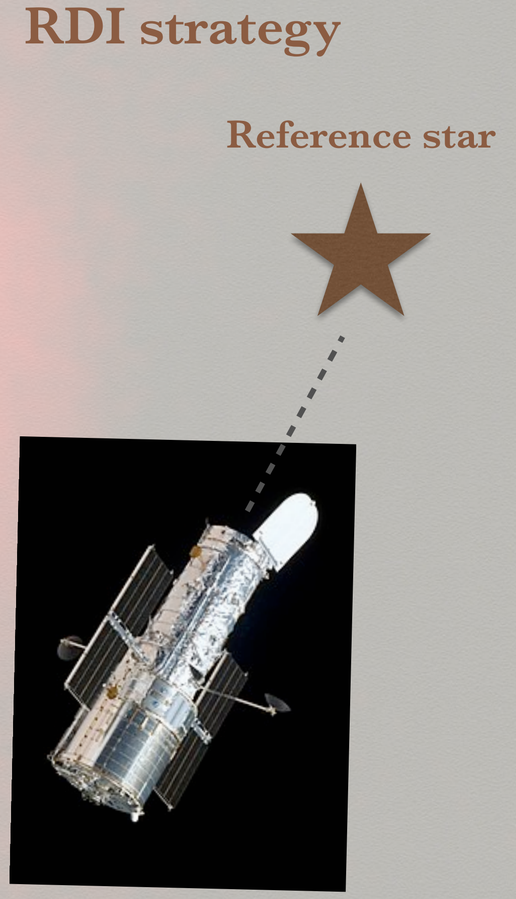

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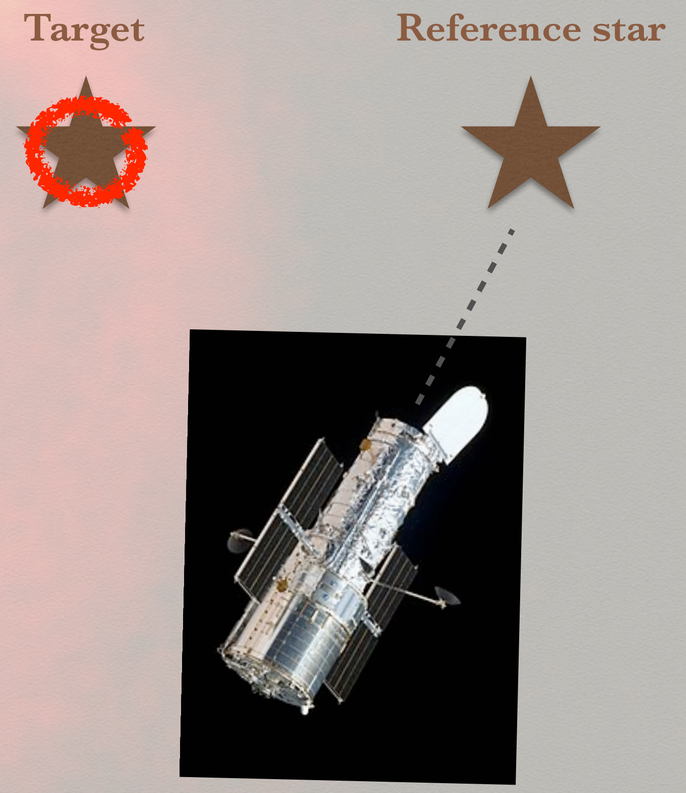
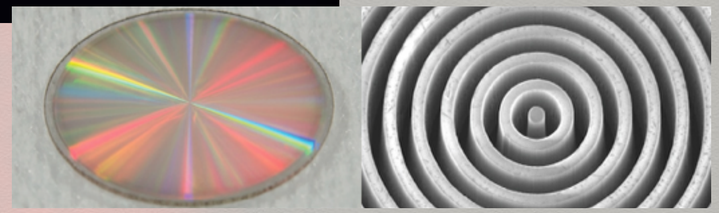
+ 2 different telescope orientations or rolls (ADI strategy)

RDI strategy



Keck Observations

- Observation with Vortex with Keck-NIRC2
- L'-band
- ~1 hour clock-time observation on target
- RDI and ADI strategies



ADI strategy

Ygouf et al., in prep

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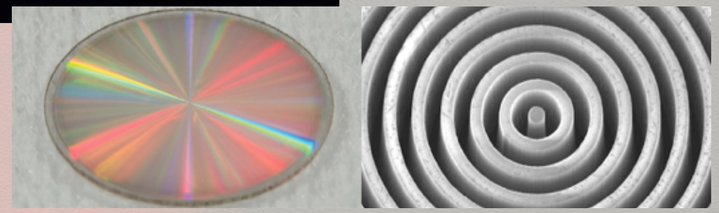

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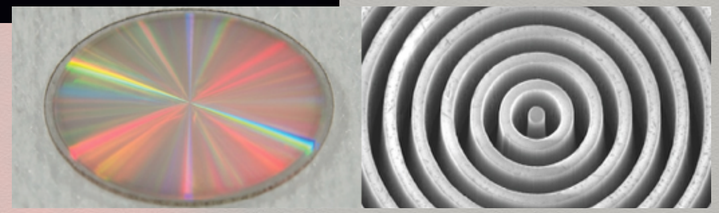
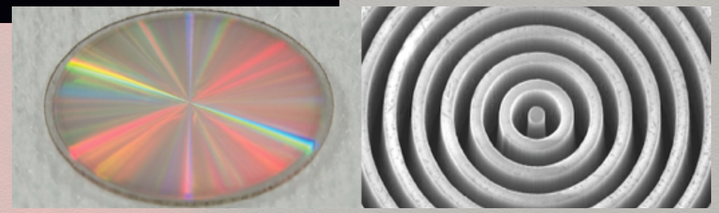


ADI strategy

Ygouf et al., in prep

Keck Observations

- Observation with Vortex with Keck-NIRC2
- L'-band
- ~1 hour clock-time observation on target
- RDI and ADI strategies



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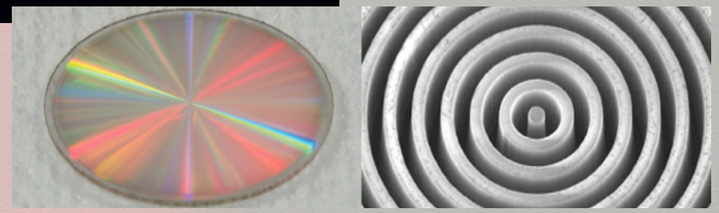
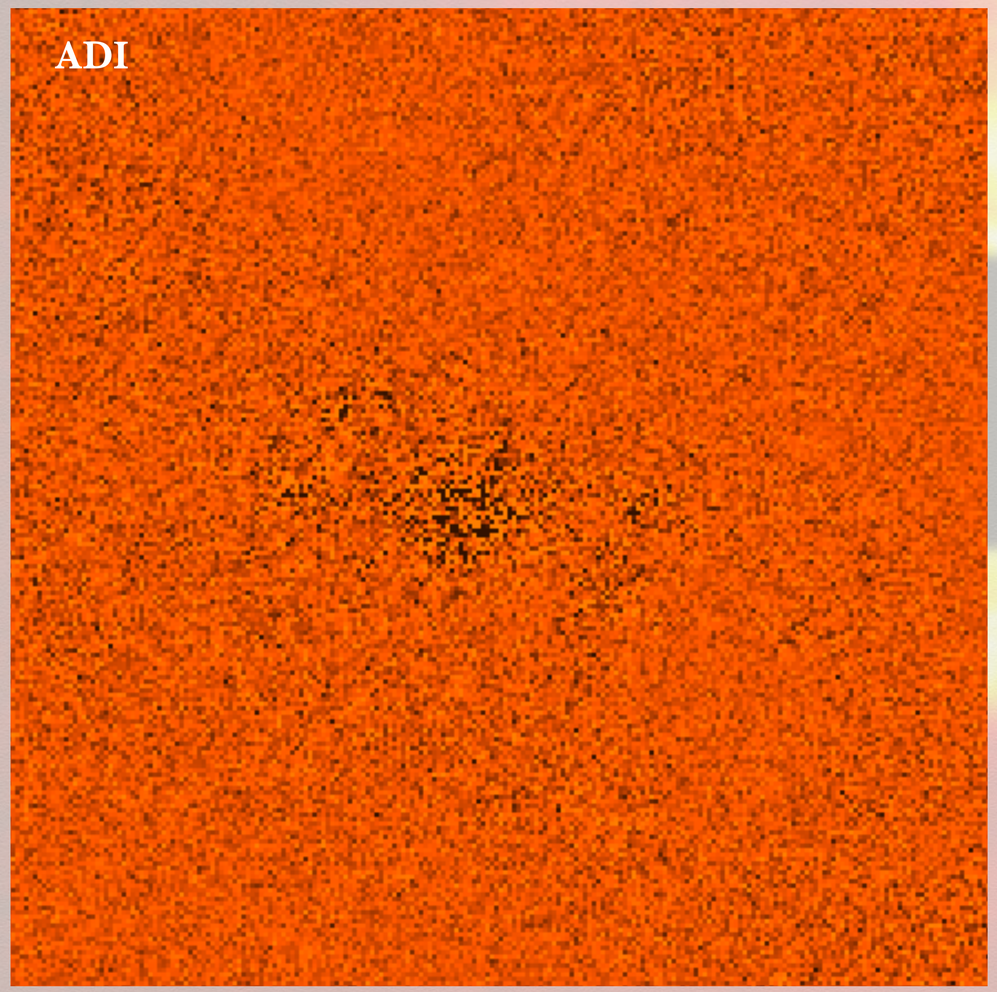


ADI strategy

Ygouf et al., in prep

Keck Observations

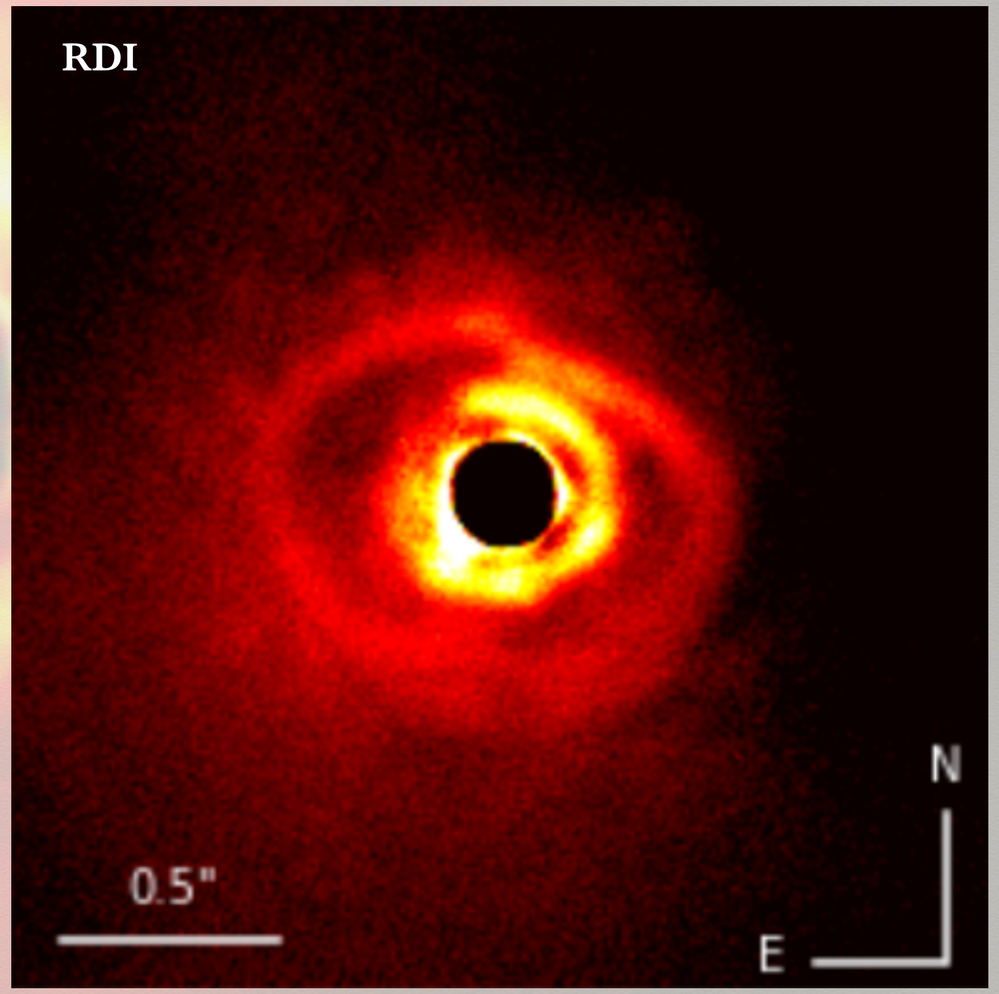


- ADI strategy from the ground
  - Very efficient as subtracting residual starlight
  - Suffer from self-subtraction => no ideal for face-on disks

Ygouf et al., in prep

Keck Observations

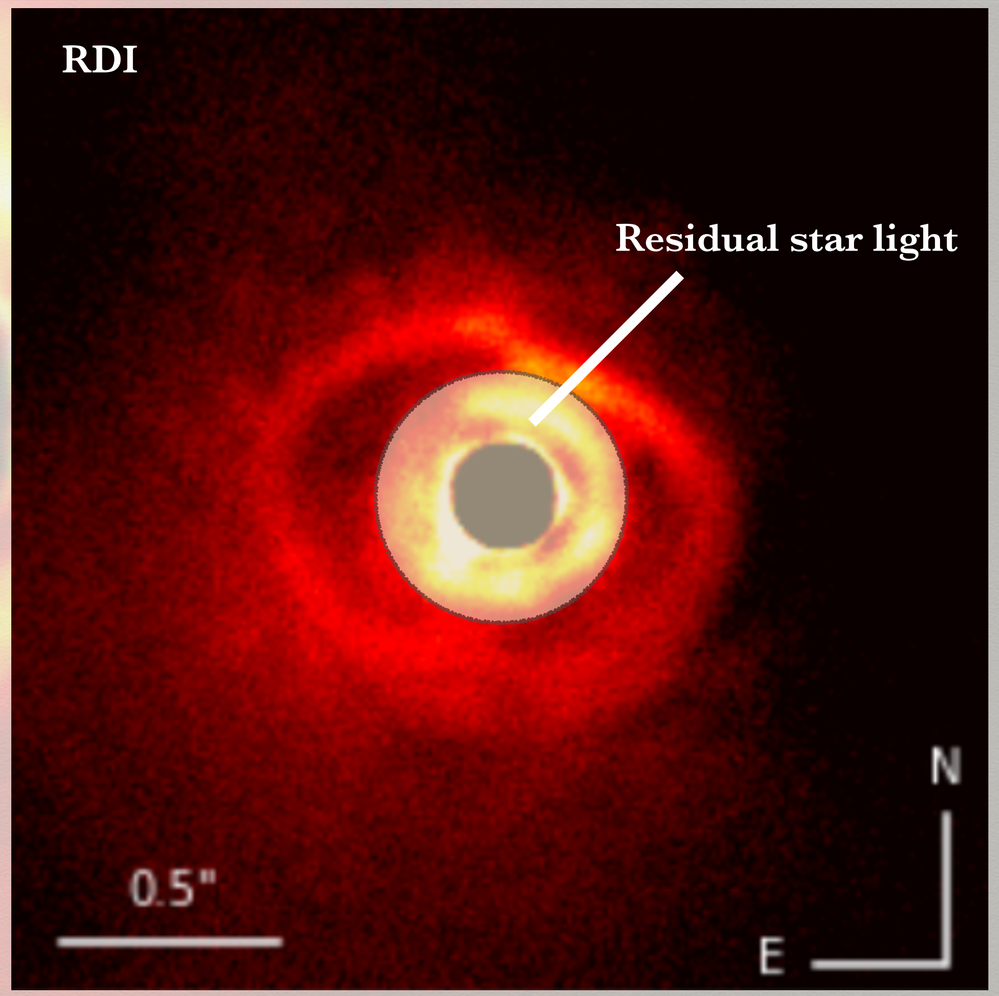
- RDI strategy from the ground
  - Less efficient as subtracting residual starlight
  - No self-subtraction
  - Needs iterations between target and reference star observations to better compensate for quasi-static aberrations evolution



Ygouf et al., in prep

Keck Observations

- Clear evidence for cavity clearing and ring-like disk
- Spirals: Non-detection



Ygouf et al., in prep

Hints for temporal variations (19 years timescale)

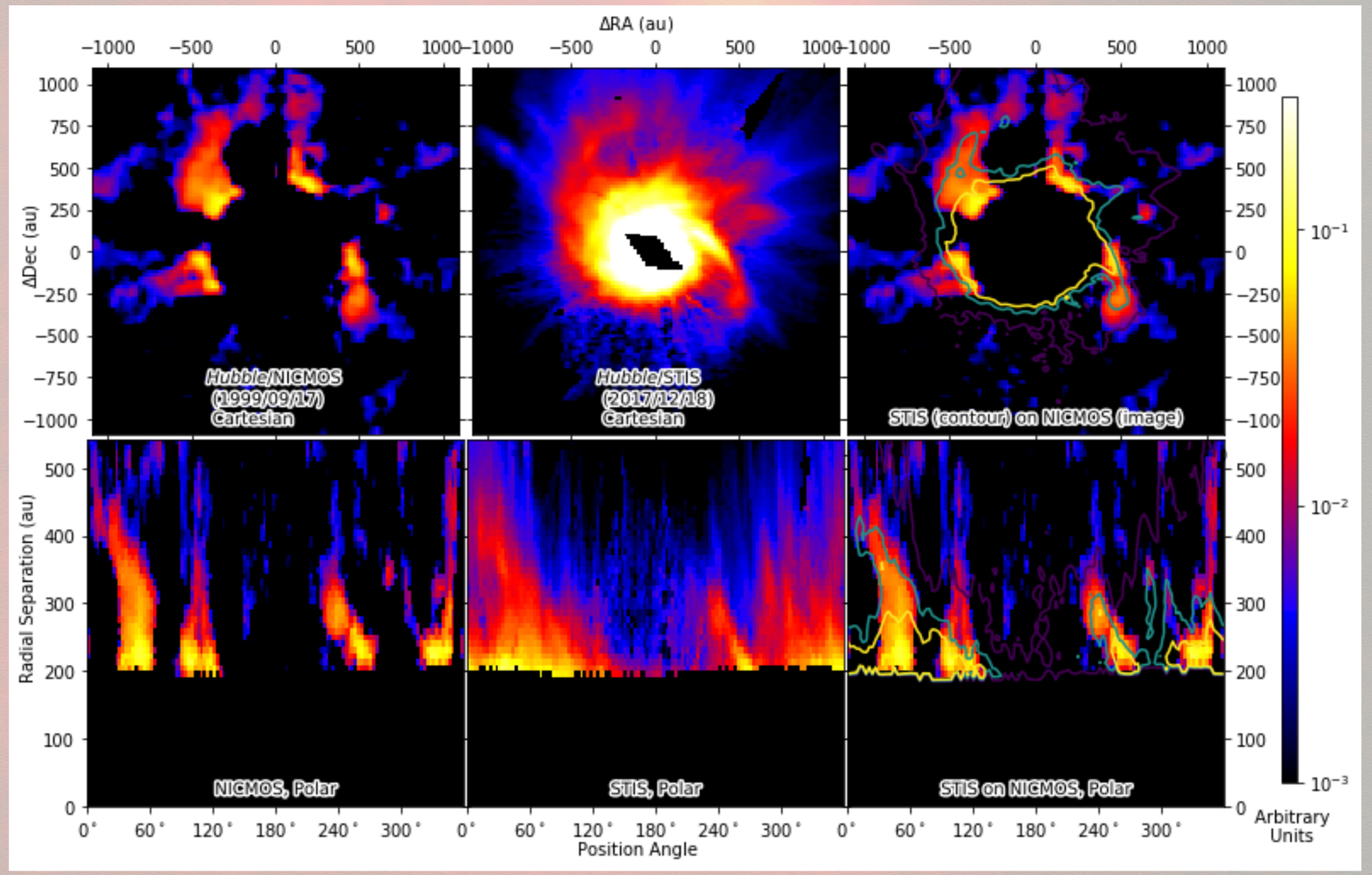


Figure by Bin Ren

Updated fits for B and C companion stars