The VORTEX team

Université de Liège

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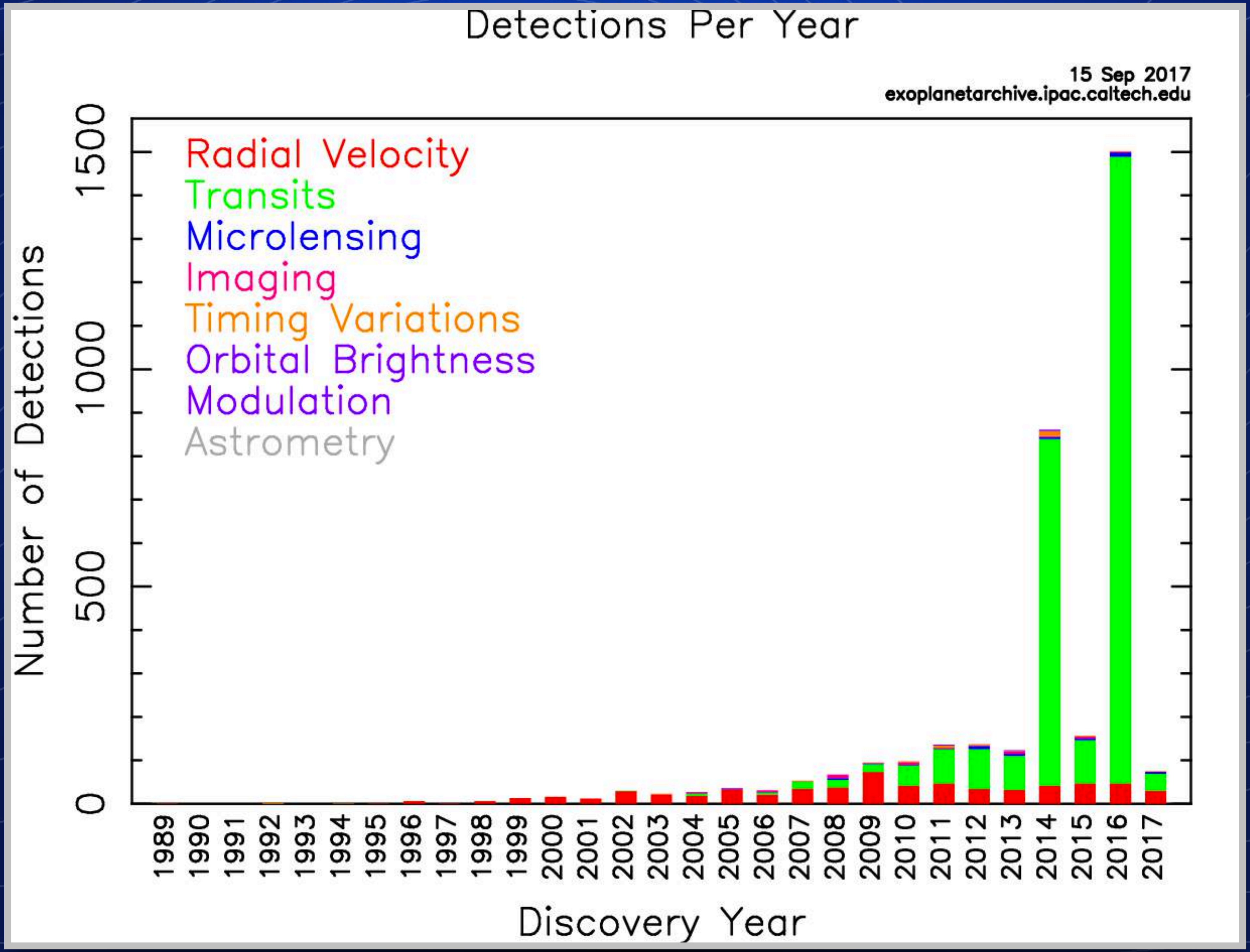
MADDALENA REGGIANI & VORTEX TEAM

A CANDIDATE ACCRETING PROTOPLANET IN THE TRANSITION DISK AROUND MWC 758

DIRECT IMAGING OF EXOPLANETS: WHY?



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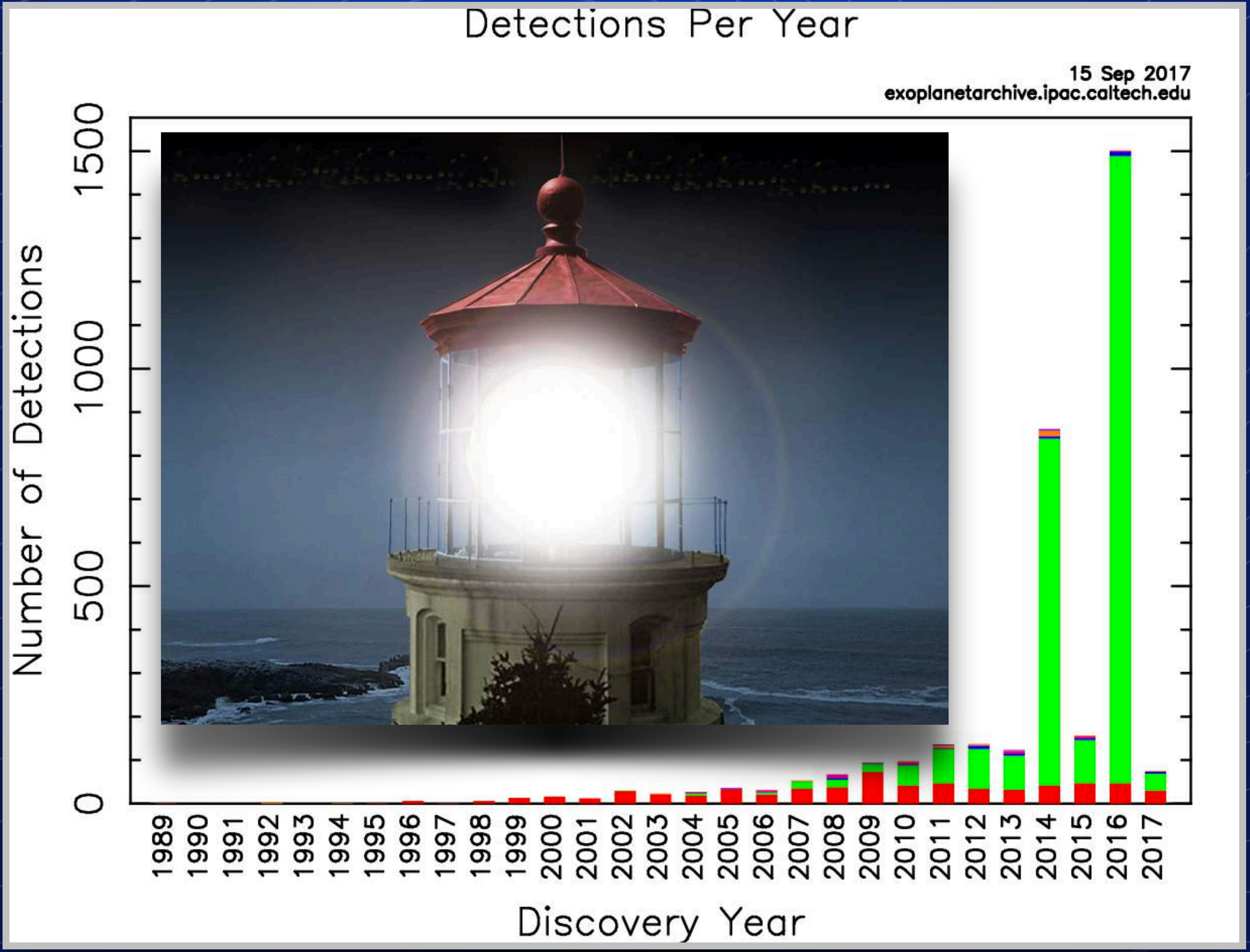

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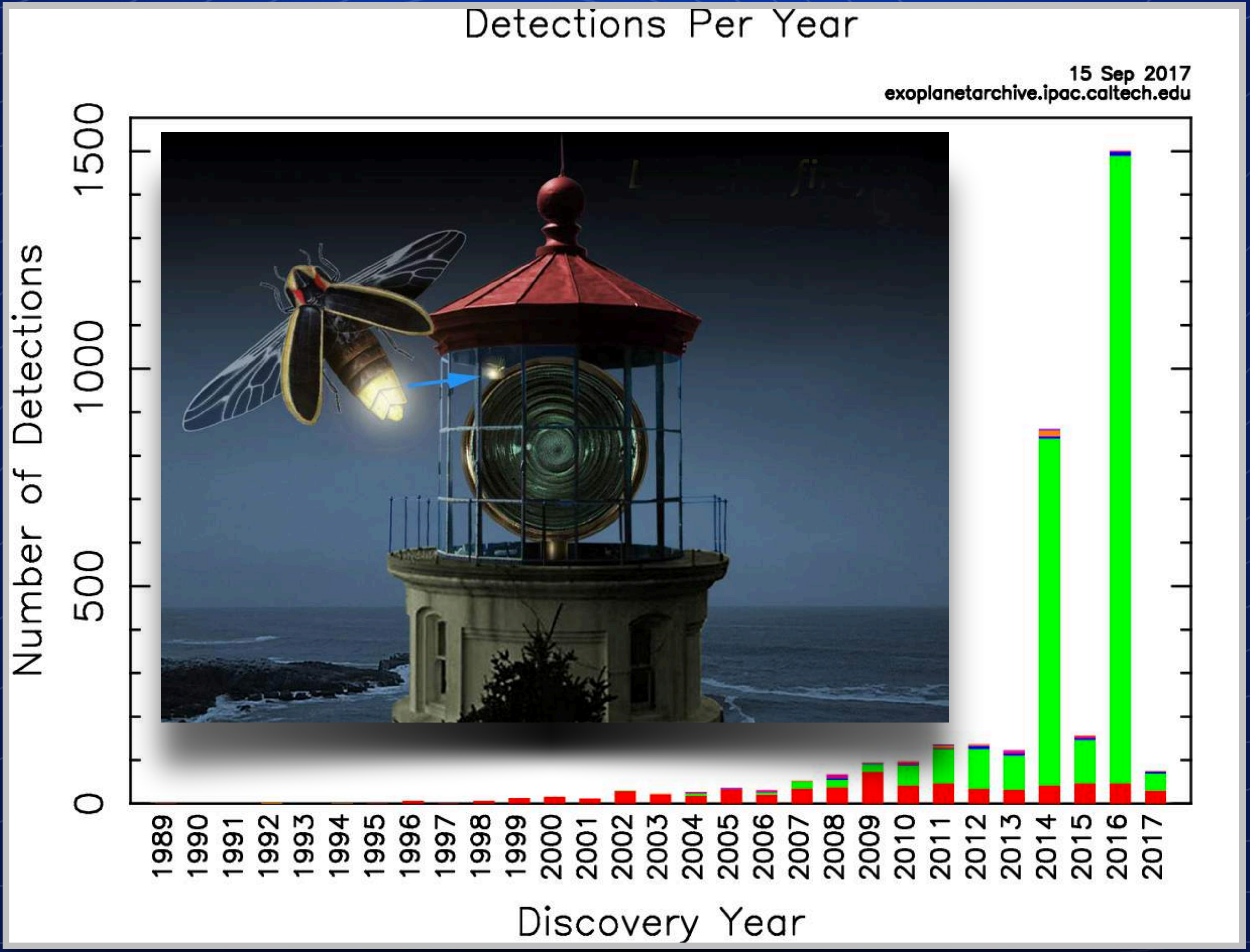

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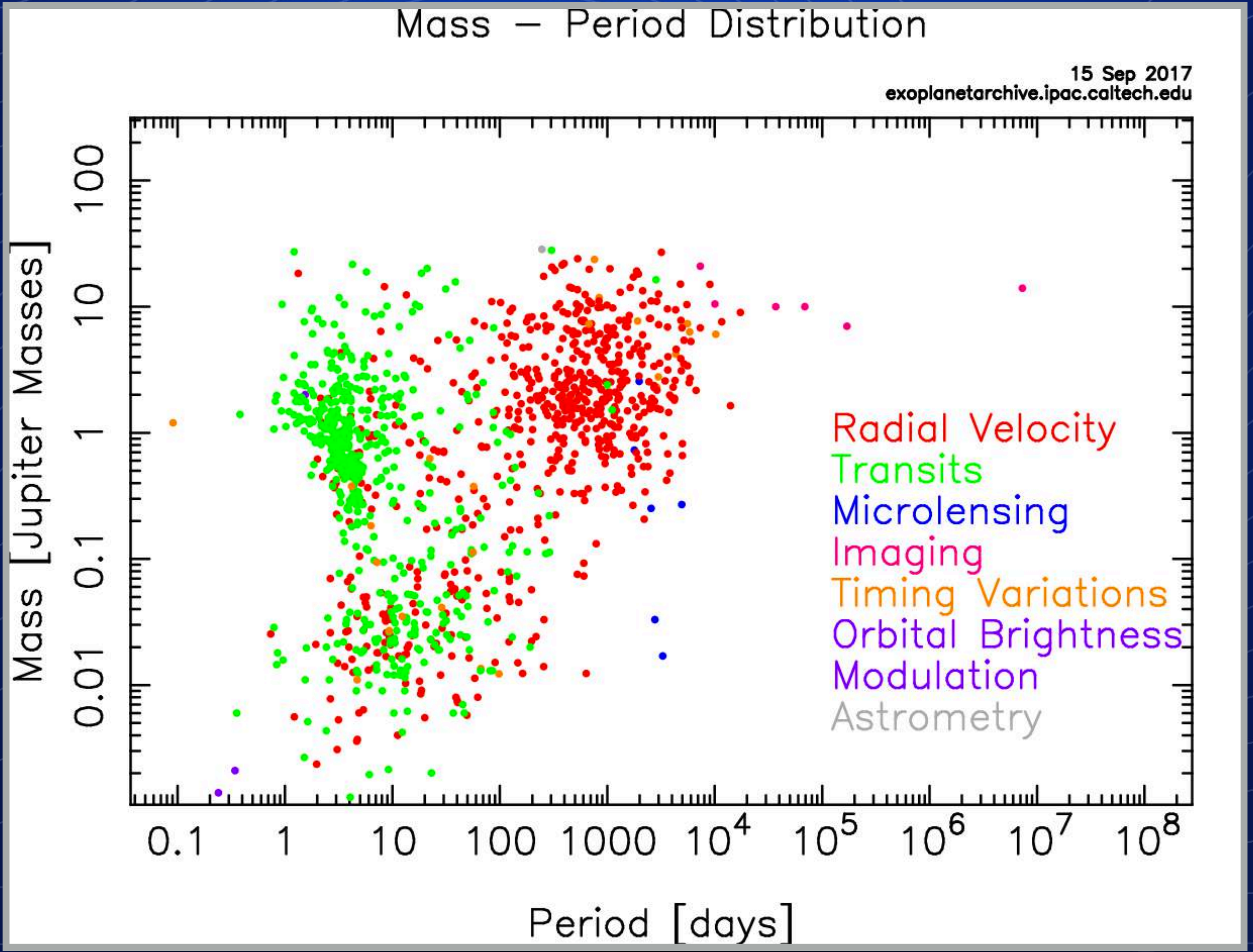

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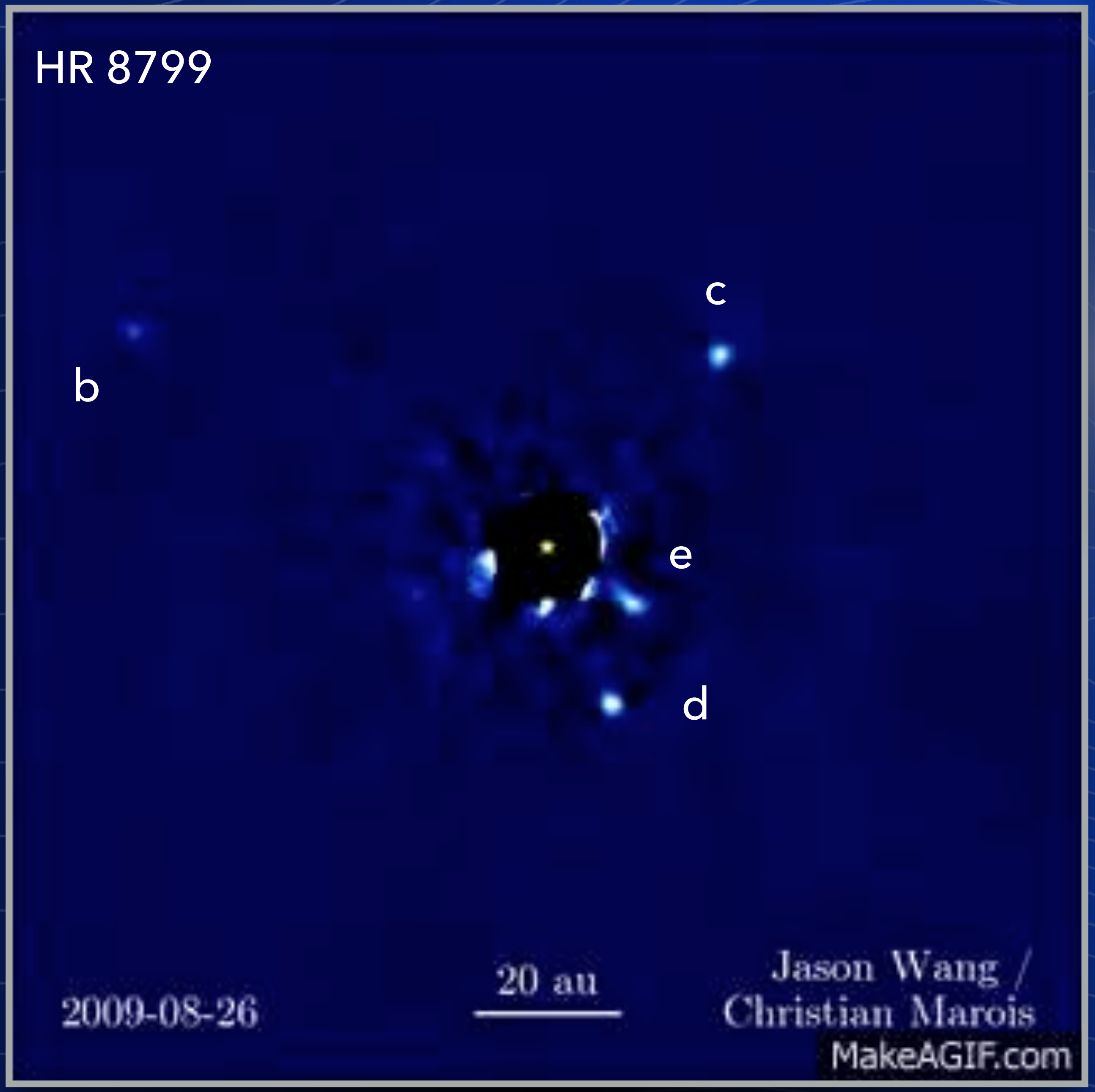
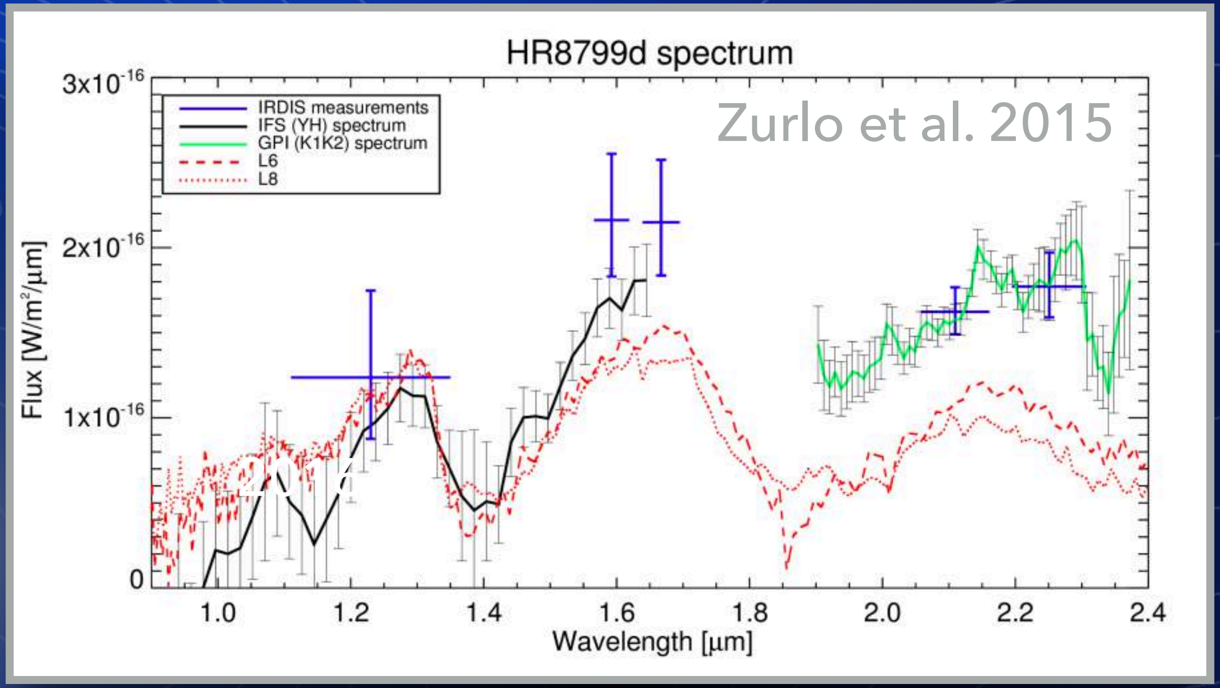
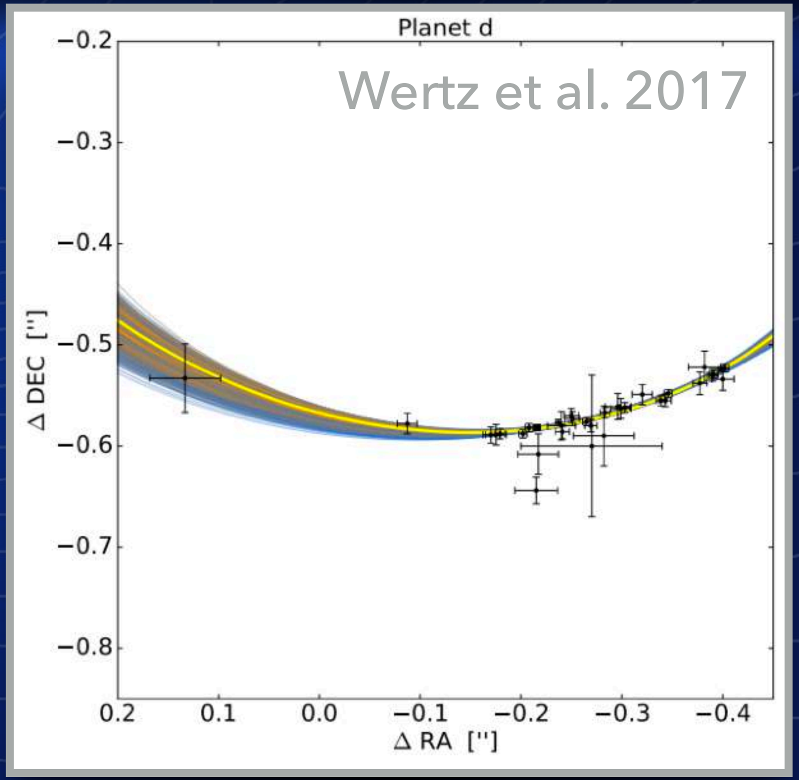
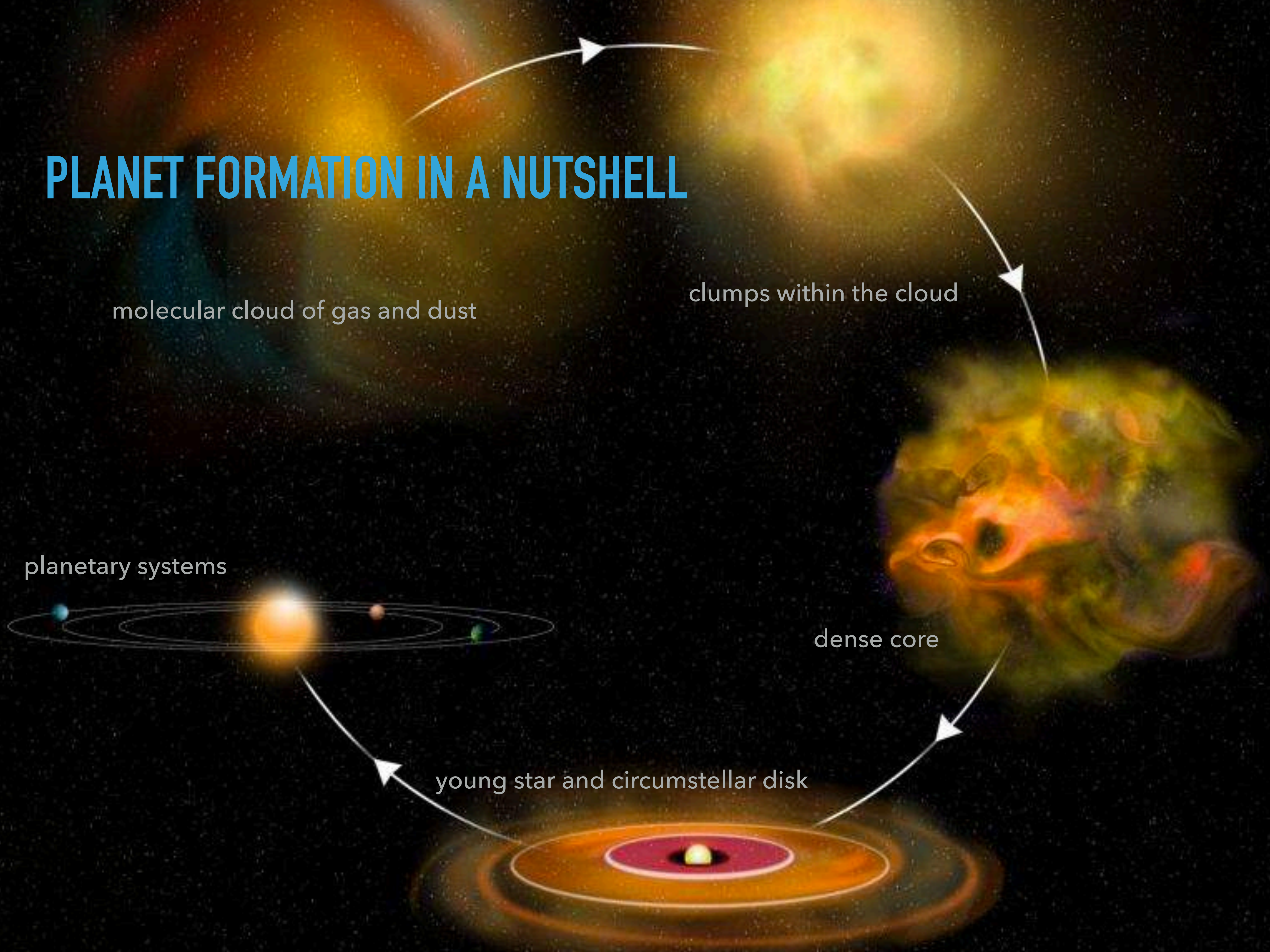
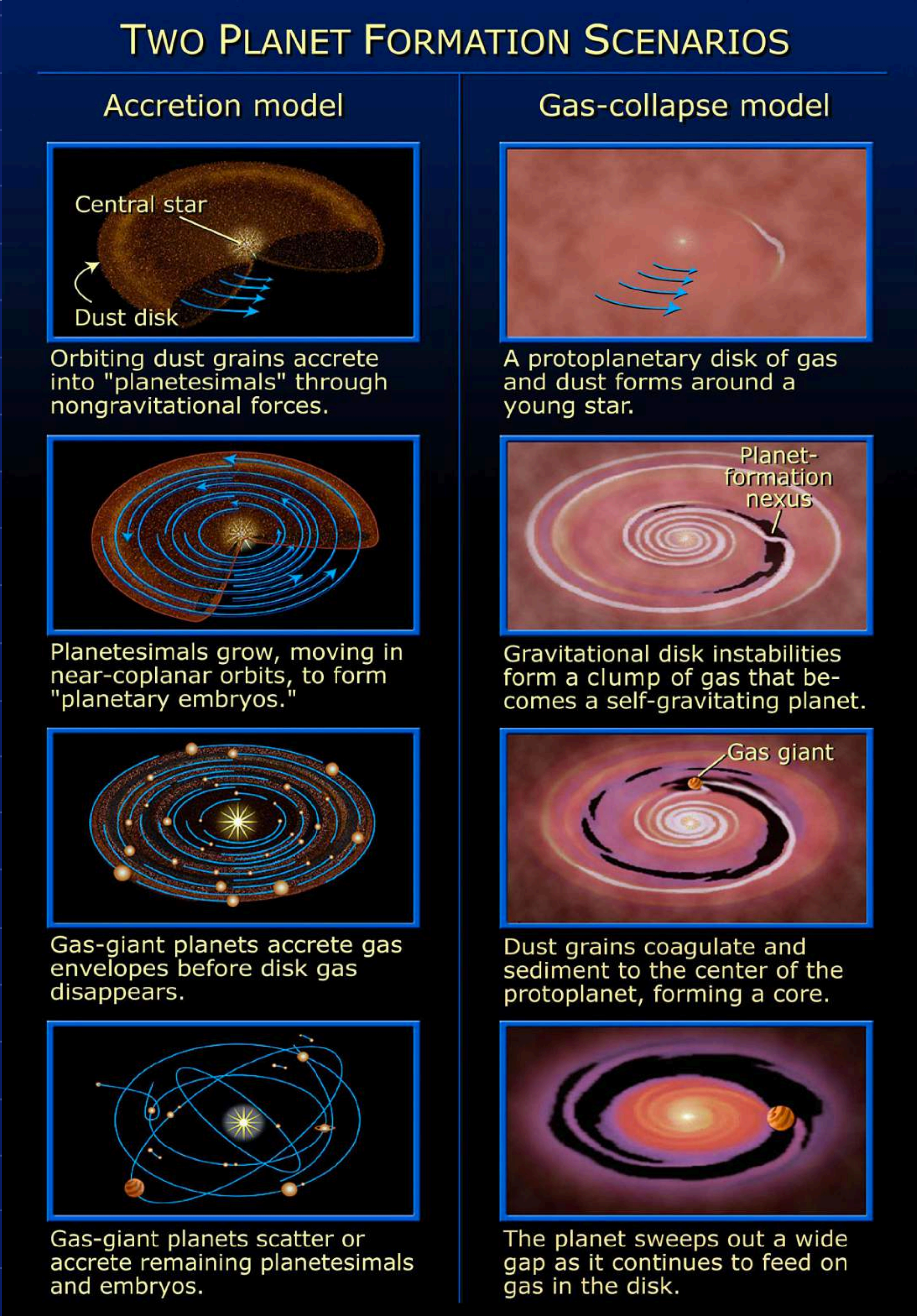


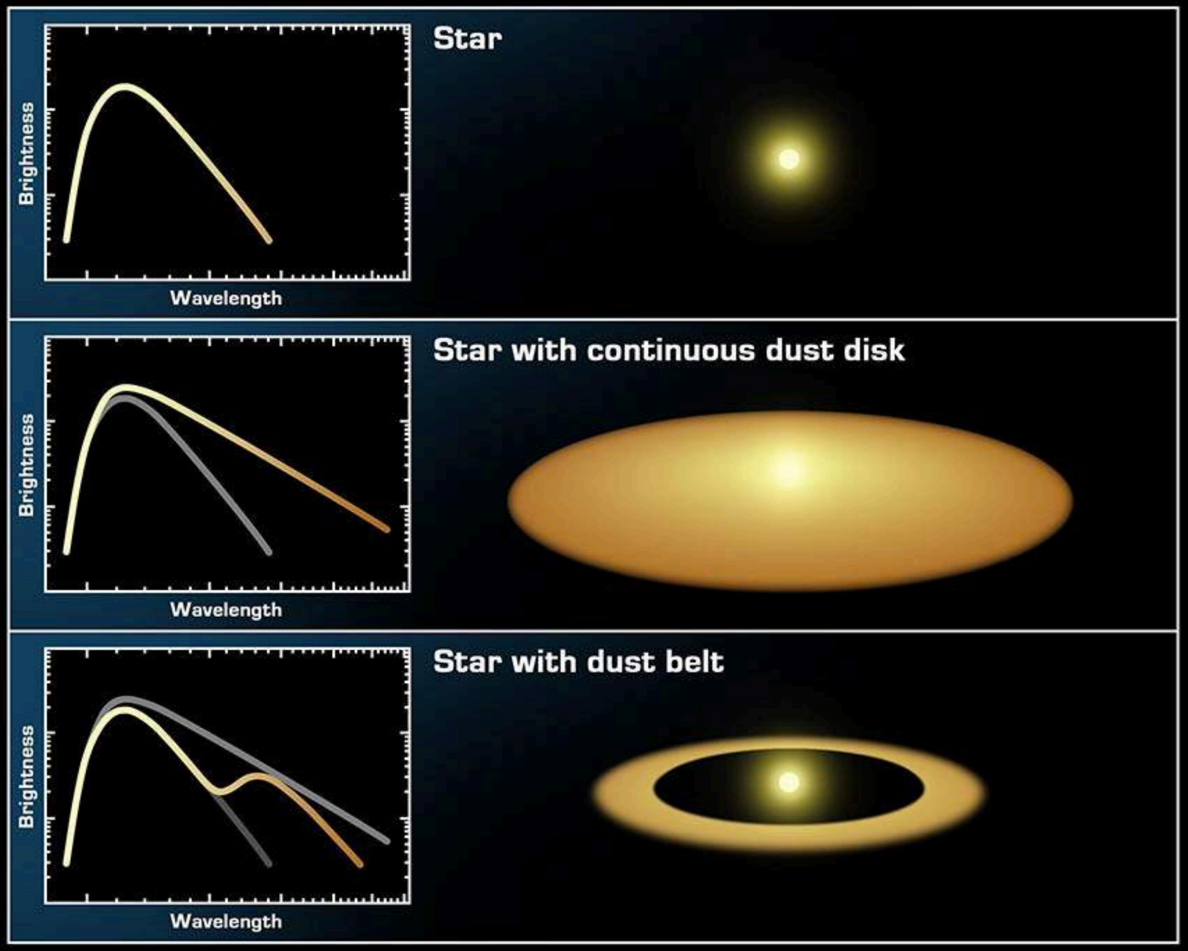




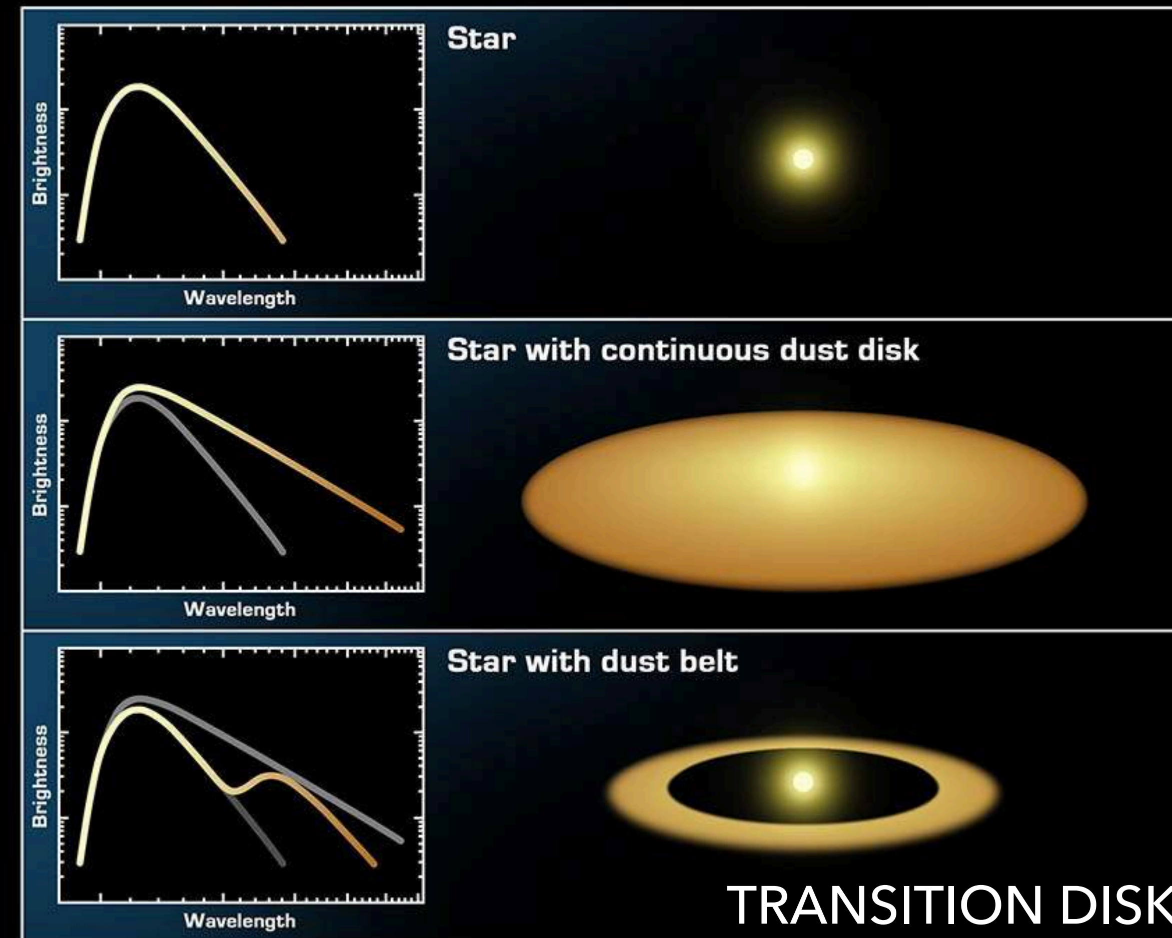
PLANET FORMATION IN A NUTSHELL







Giant planet formation must occur before the gas in the disk gets dissipated (max. ~10 Myr)



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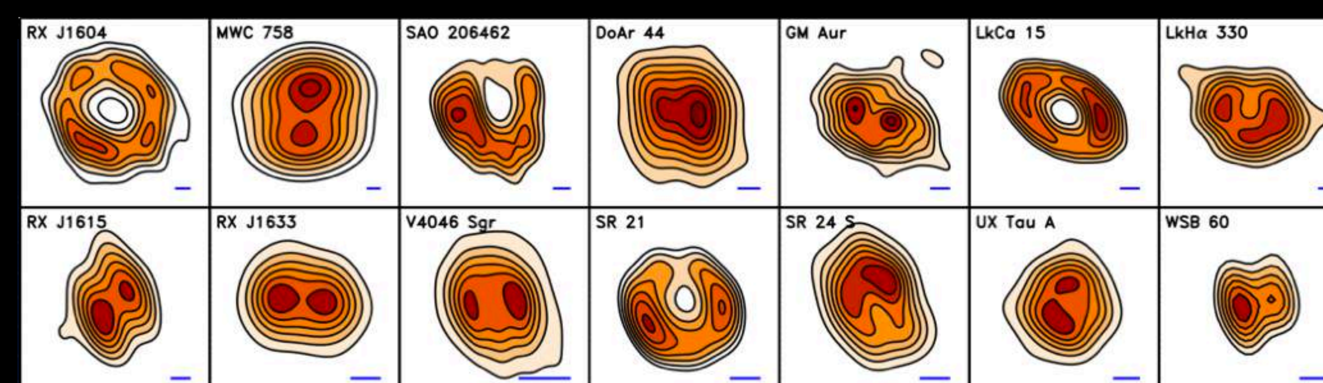
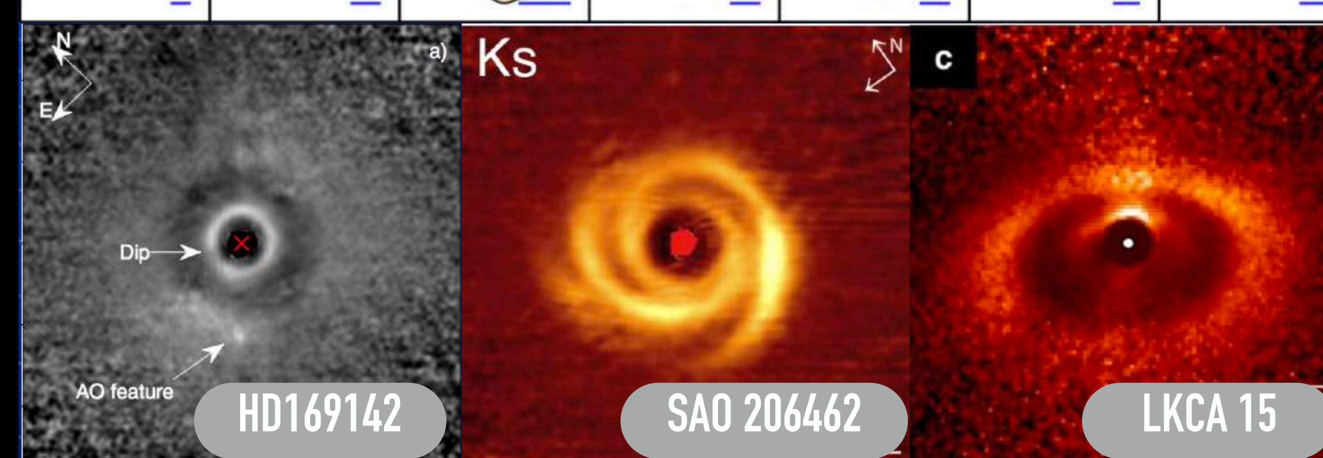


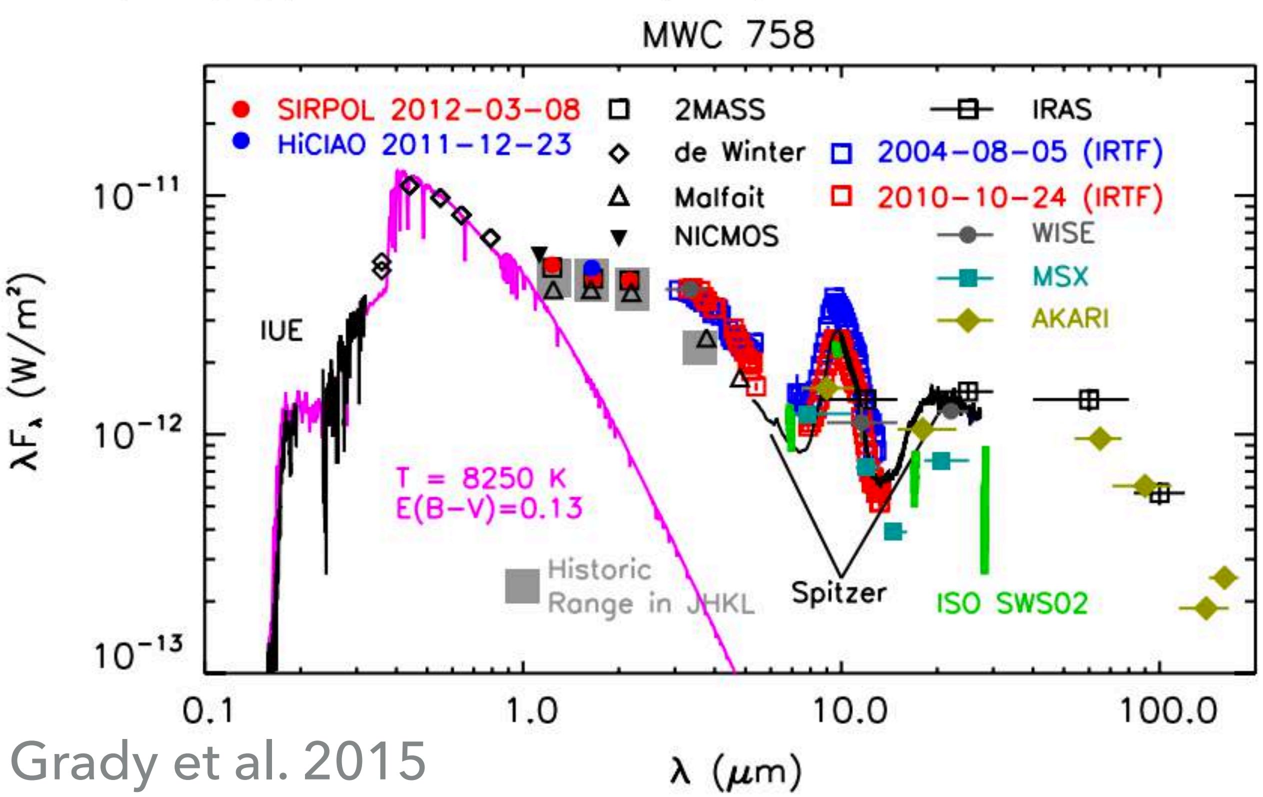


TRANSITION DISK AROUND MWC 758

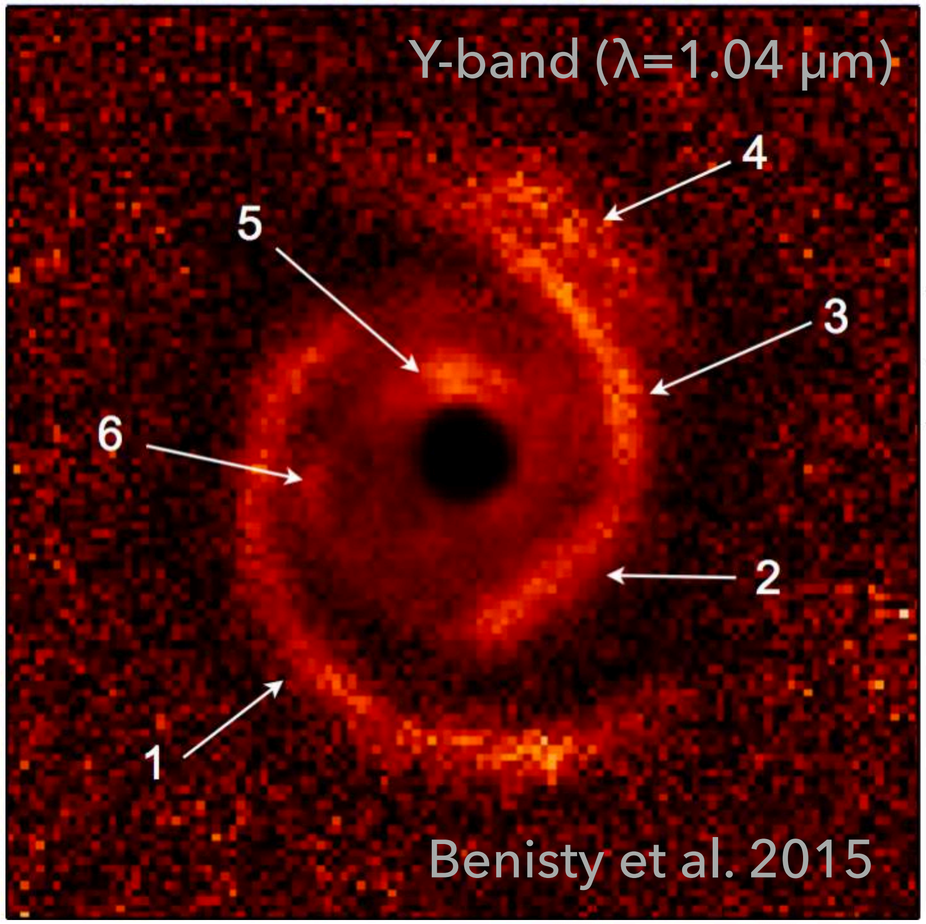
inclination: 21 degrees
PA semi-major axis: 65 degrees

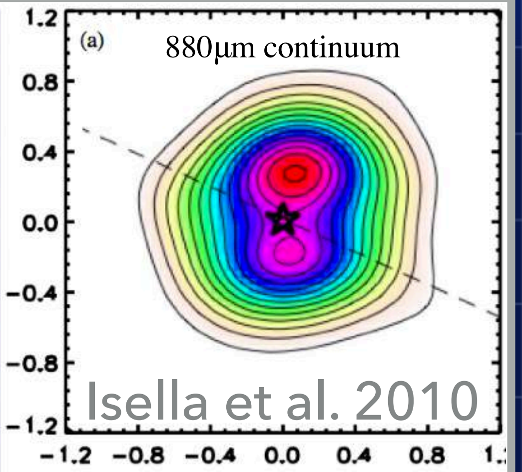
Properties	Values
RA (J2000)	$05^{h}30^{m}27^{s}.530$
DEC (J2000)	$+25°19''57''.082$
Age (Myr)	3.5 ± 2.0 (1)
Mass ($M_{\odot}$)	2.0 ± 0.2 (2)
L' (mag)	4.75 (3)
Distance (pc)	151^{+8}_{-9} (4)

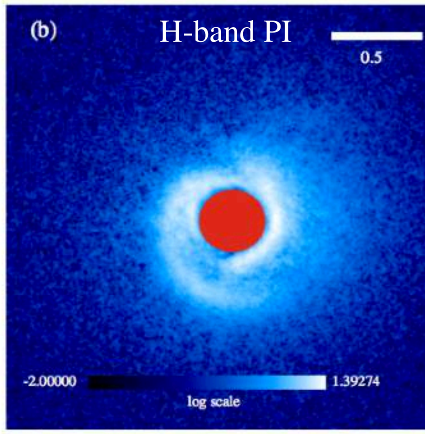
References. (1) Meeus et al. (2012); (2) Isella et al. (2010); (3) Malfait et al. (1998); (4) Gaia Collaboration (2016).

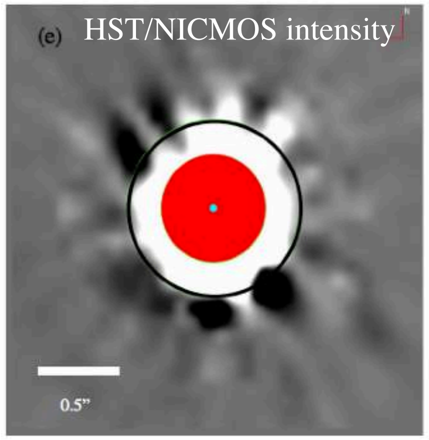


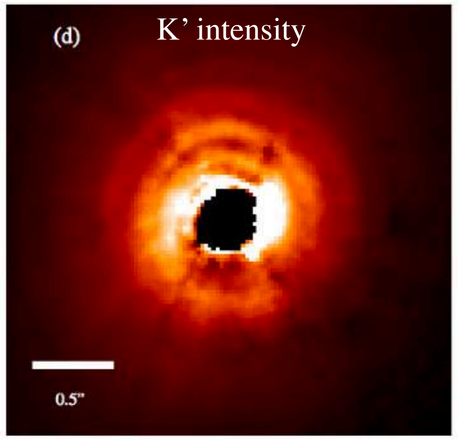
Grady et al. 2015

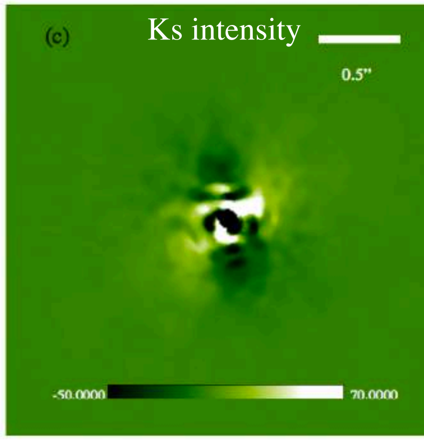












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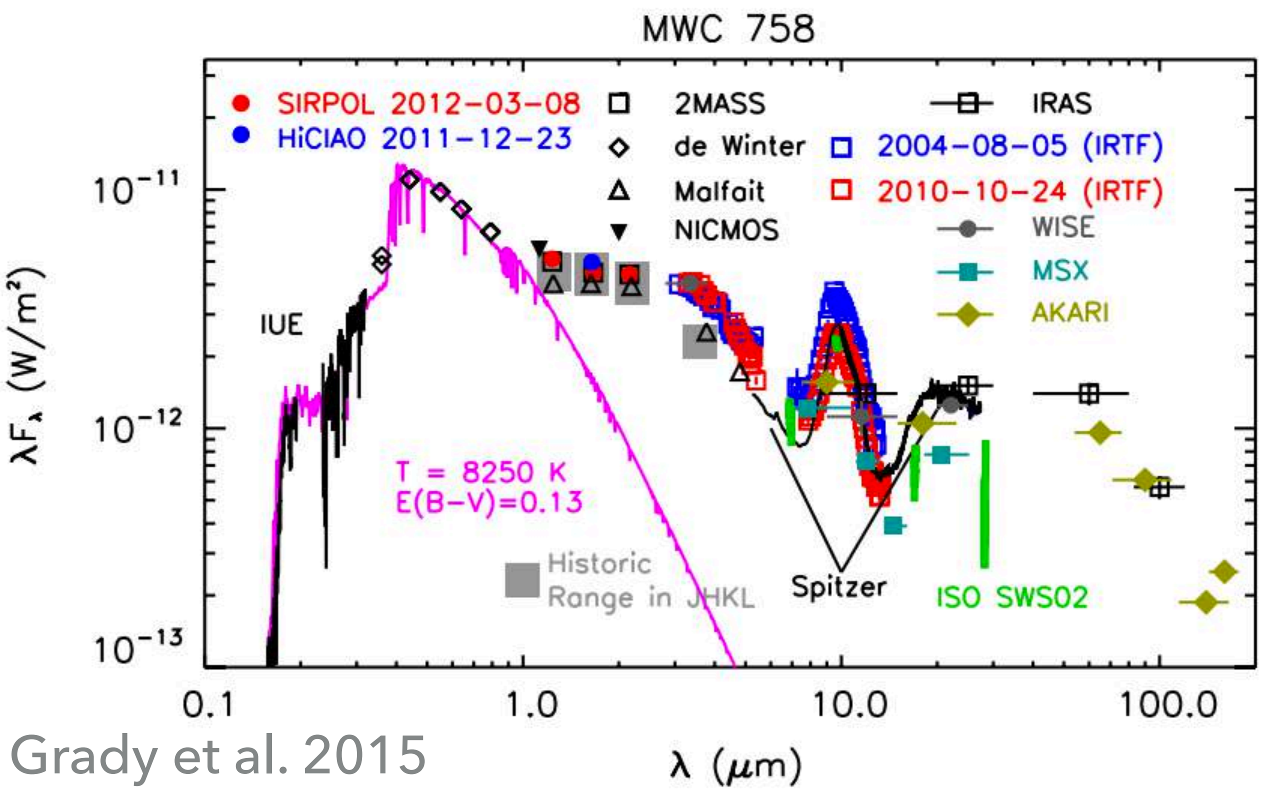

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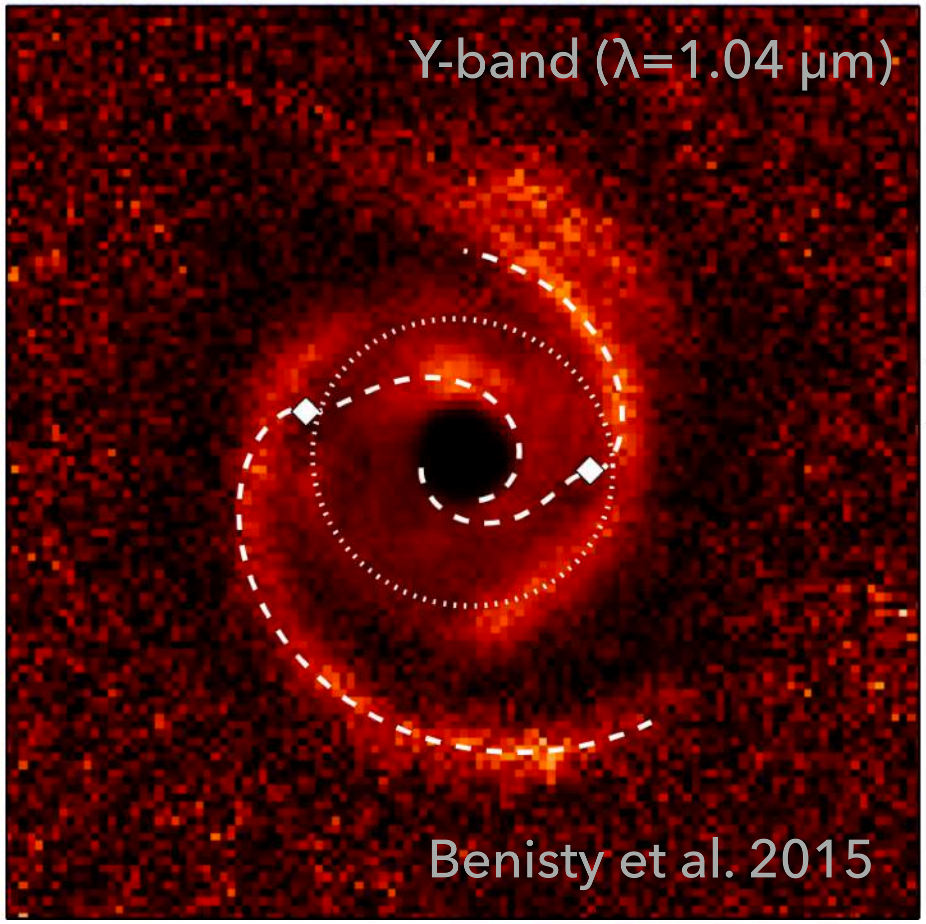
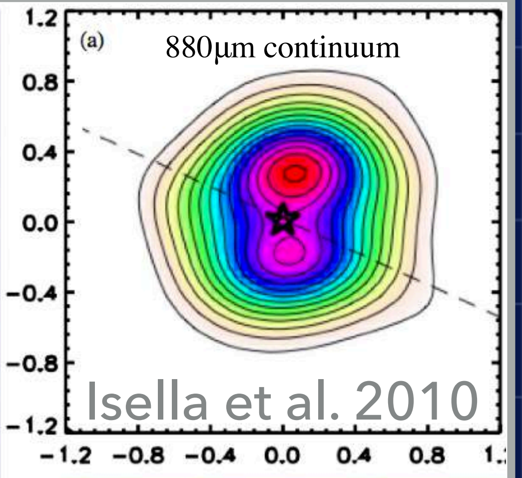


Benisty et al. 2015



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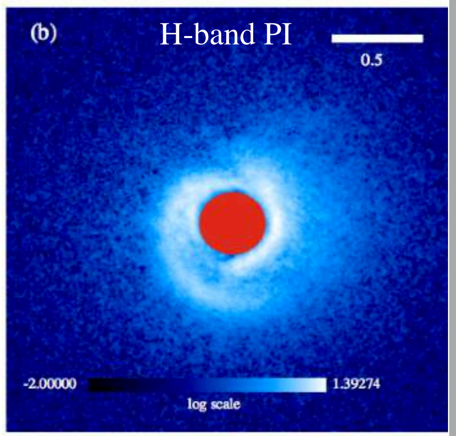

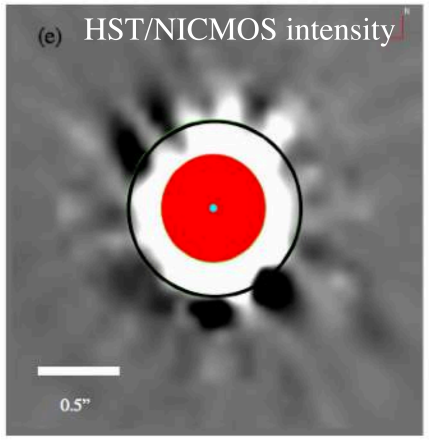

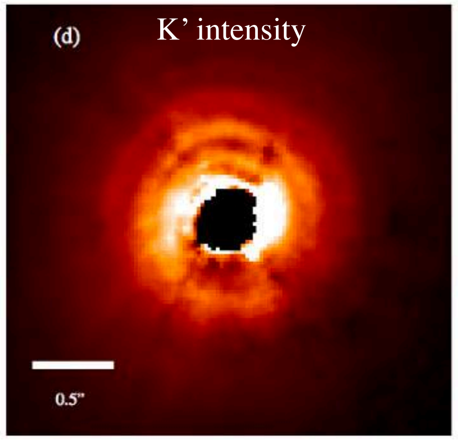

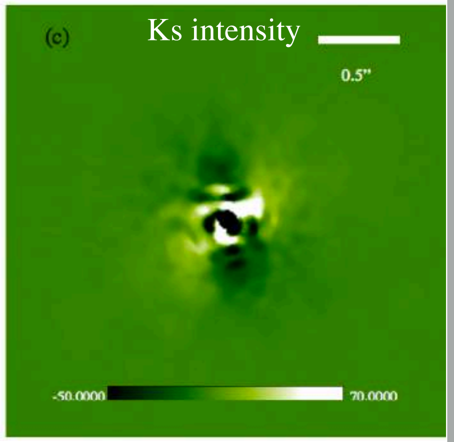

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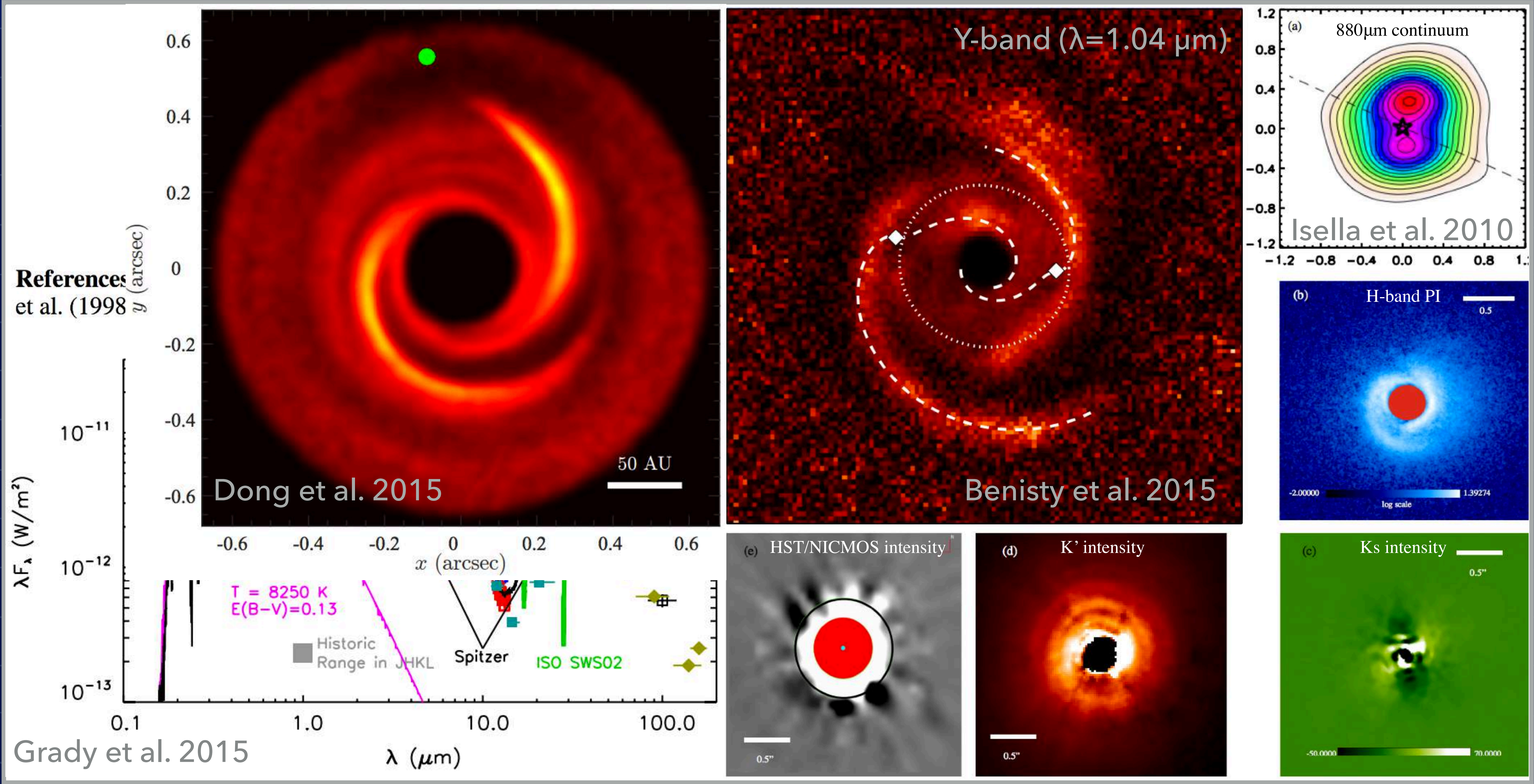

KECK/NIRC2 OBSERVATIONS

- Keck/NIRC2 in ADI mode
- L′ band (λ=3.8 μm)
- AGPM vortex coronagraph
  (Serabyn et al. 2017)
- operations fully automated with QUACITS: ensures consistent centering and data quality
  (Huby et al. 2015/2017)
- flat fielding, re-centering, bad pixel correction and bad frame removal, PCA-based background subtraction with VIP
  (Gomez Gonzalez et al. 2017)

	First epoch	Second epoch
UT date (yyyy/mm/dd))	2015/10/24	2016/10/24
DIT (s)	0.5	0.25
Coadds	50	160
Number of frames	80	80
Total Int. Time (s)	2000	3200
Plate scale (mas/pix)	9.942	9.942
Filter Coronagraph	L'	L'
Par. angle start/end (°)	-128/+103	-90/+97
Mean airmass	1.012	1.074
Seeing	0.64	0.75

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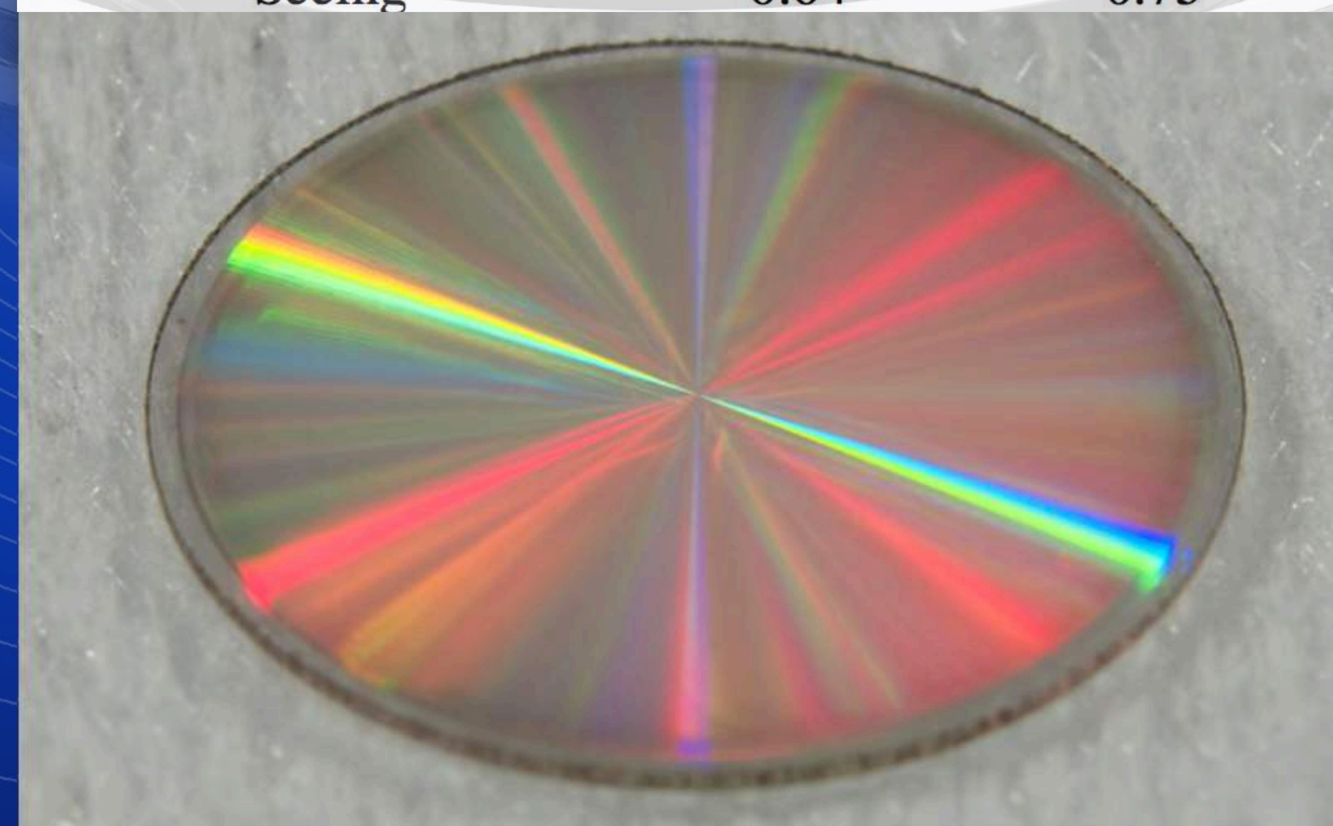
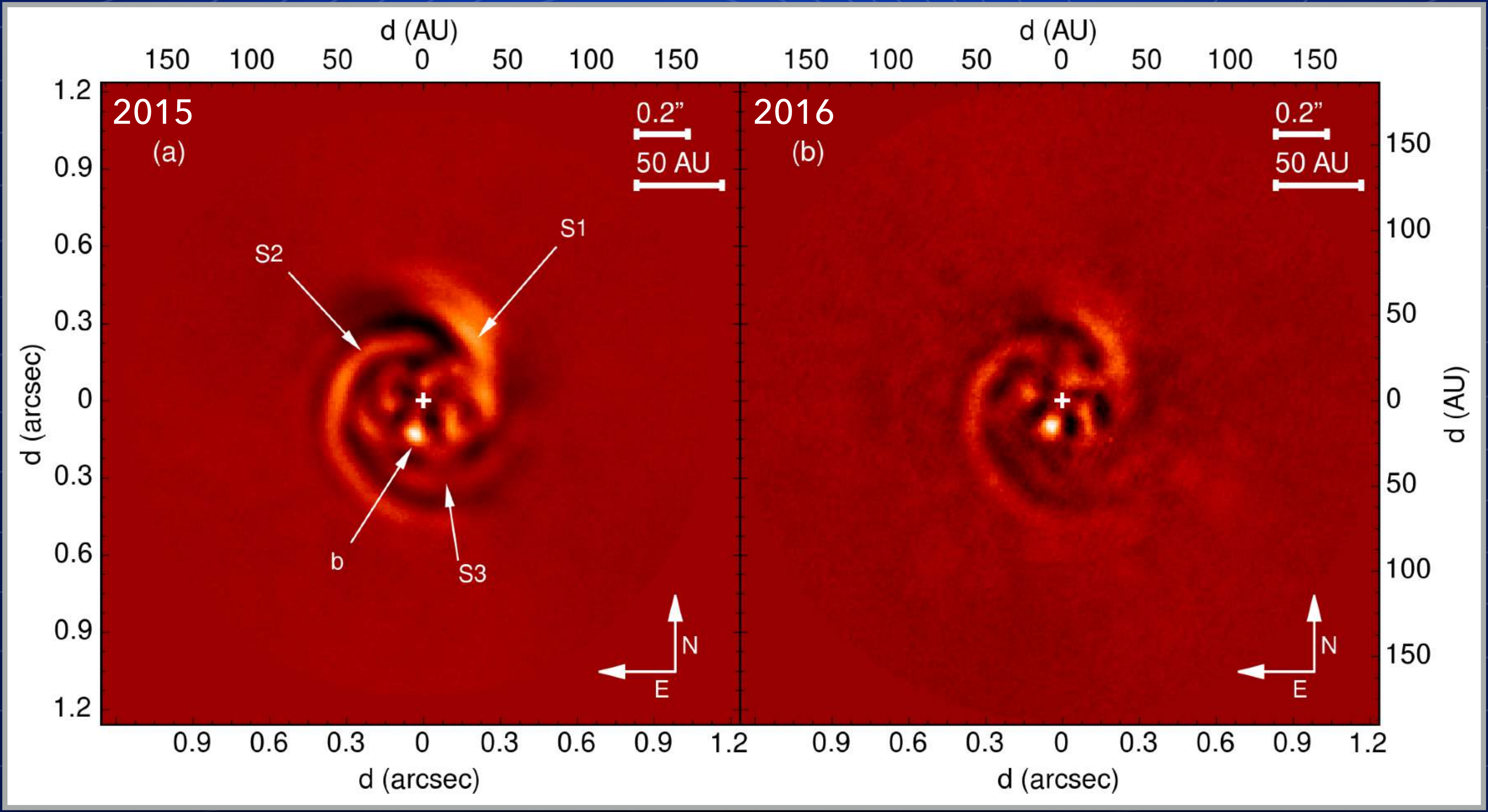


FINAL PCA/ADI IMAGES



Reggiani et al. (submitted)

POINT-LIKE SOURCE: PROPERTIES AND EXPLANATIONS

UT date (yyyy/mm/dd)	r* (″)	PA‡ (°)	ΔL′§ (mag)	$M_{L'}^{\#}$ (mag)
2015/10/24	0.112 ± 0.006	169 ± 4	7.1 ± 0.3	11.85
2016/10/24	0.110 ± 0.006	162 ± 5	6.9 ± 0.5	11.65

R = 0.111 ± 0.004 , ΔL′ = 7.0±0.3 @ DEPROJECTED SEPARATION OF 20±1 AU

- background source:
  - probability ≃ 10^{-6} (TRILEGAL galactic model, Girardi et al. 2012)
- asymmetric disk feature:
  - no maximum in polarized emission
- low-mass companion of 41-64 M_J (BT-SETTL models, Allard et al. 2012):
  - no fully depleted cavity in um-size dust ––> <5.5 M_J (Benisty et al. 2015, Pinilla et al. 2015)

POINT-LIKE SOURCE: AN ACCRETING PROTOPLANET, MWC 758 B

UT date (yyyy/mm/dd)	r* (″)	PA‡ (°)	ΔL′§ (mag)	$M_{L'}^{\#}$ (mag)
2015/10/24	0.112 ± 0.006	169 ± 4	7.1 ± 0.3	11.85
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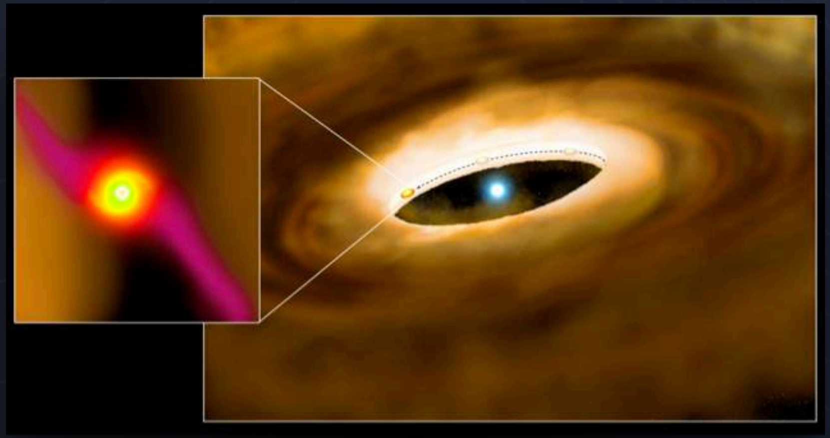
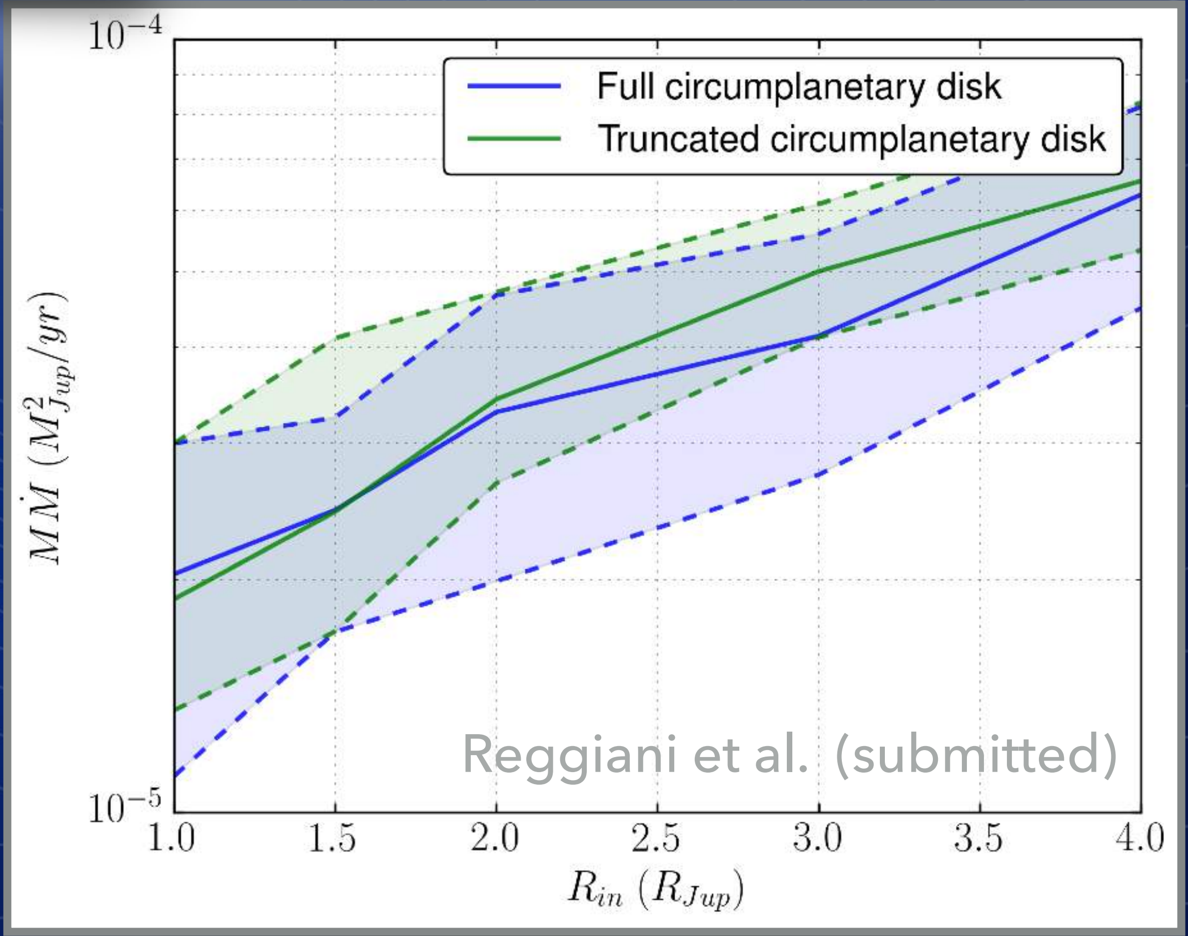
- An accreting protoplanet, MWC 758b



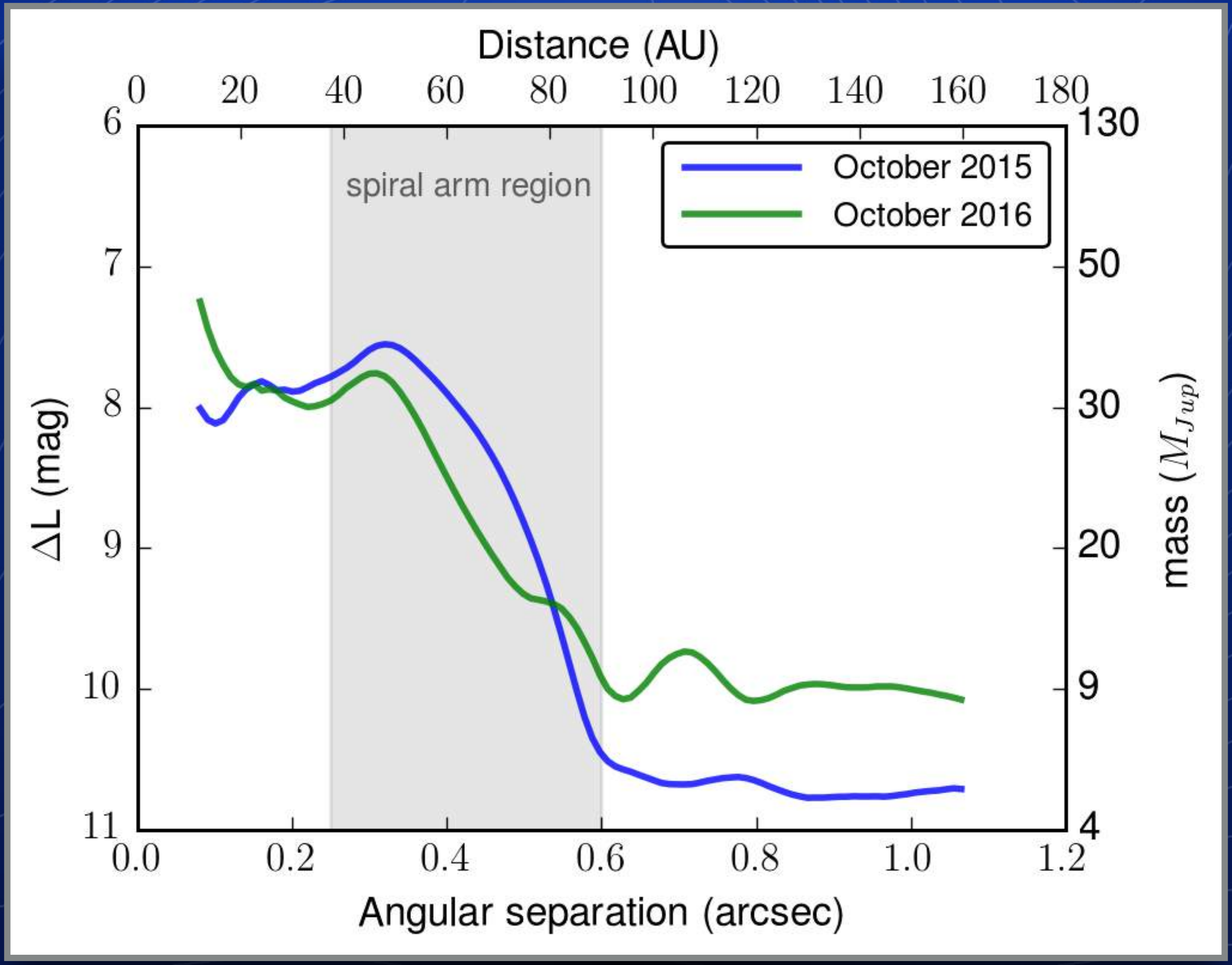
- 0.5-5 M_J @ 10^{-7}-10^{-9} $M_\odot$/yr

(from Zhu et al. 2015 accretion models)



CONSTRAINTS ON OTHER COMPANIONS

Detection limits at 95% completeness, following Ruane et al. 2017 :



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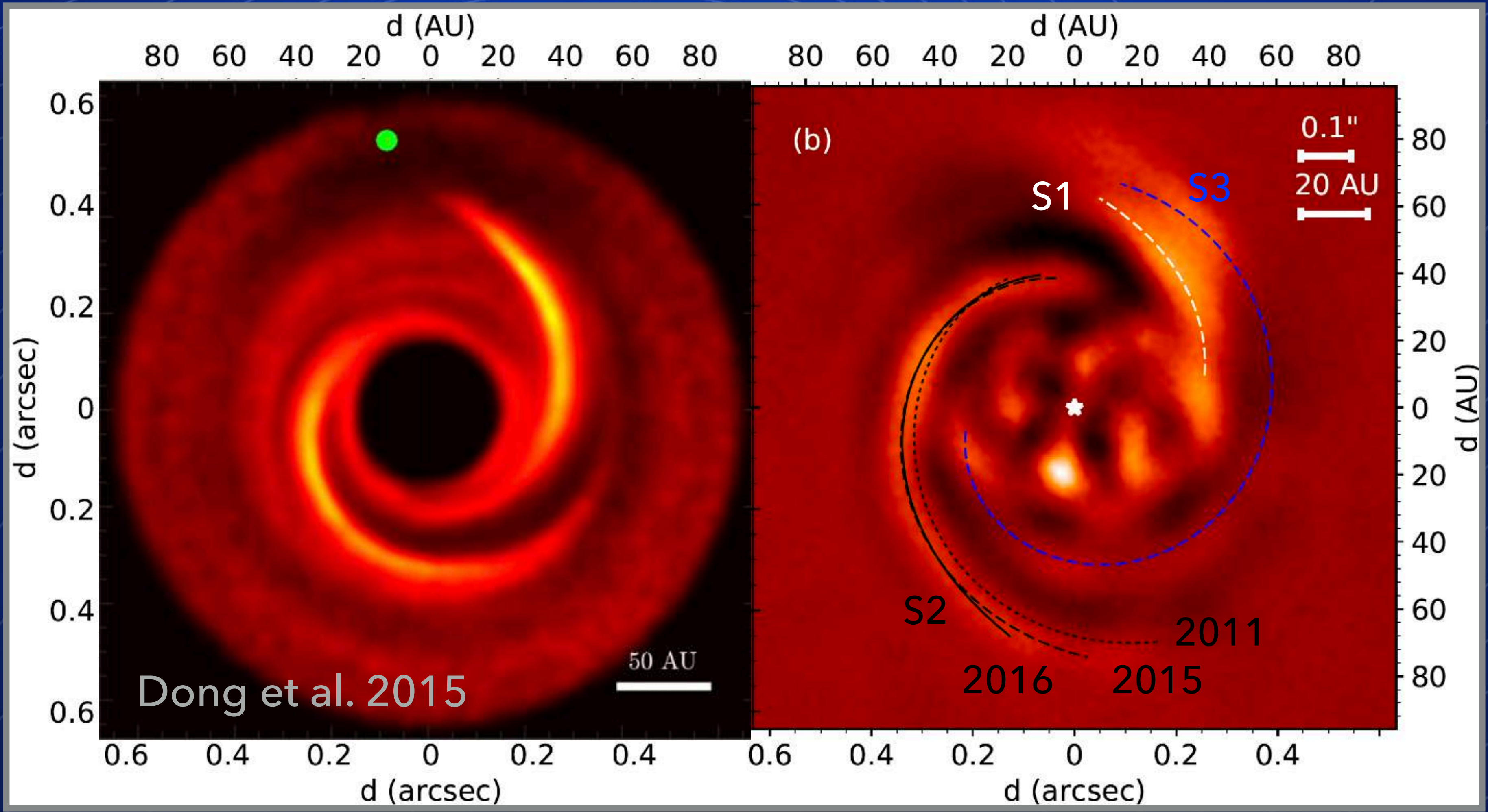
SPIRAL ARMS: PURE GEOMETRICAL FITTING



S1 and S3 (Zhu et al. 2015, Dong et al. 2017, Fung et al. 2015) :

- not related to MWC 758 b
- consistent with primary and secondary arm from external companion
- given the separation between them: $M_p = 7 \pm 1\ M_{Jup}$ located at <100 au

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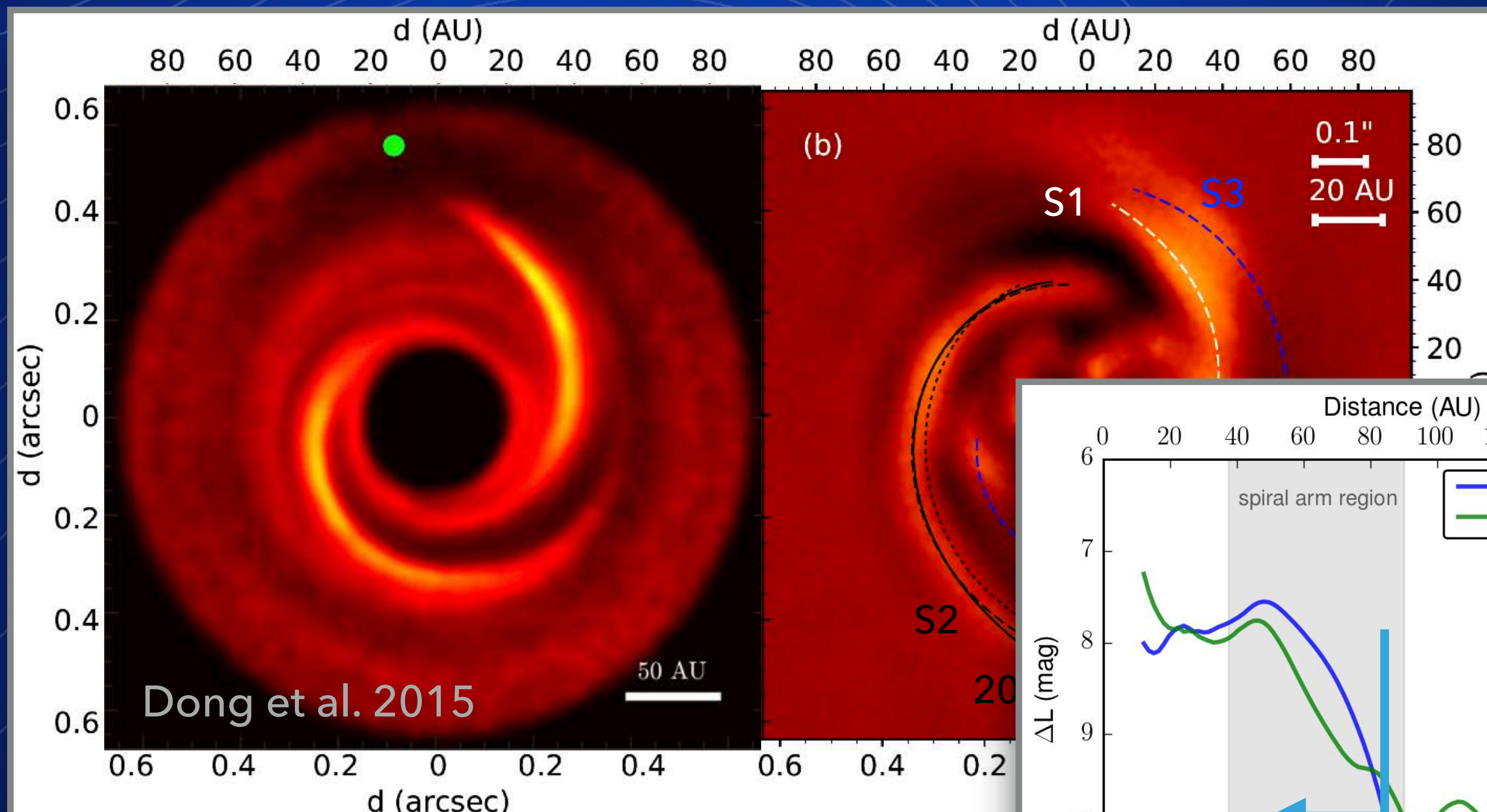

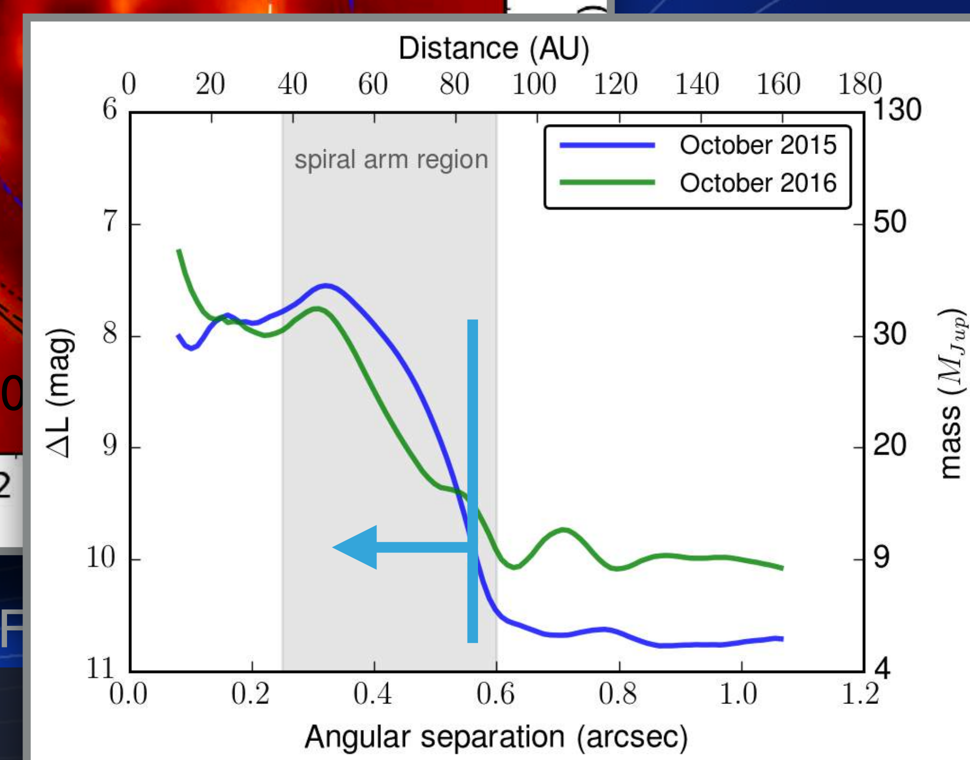

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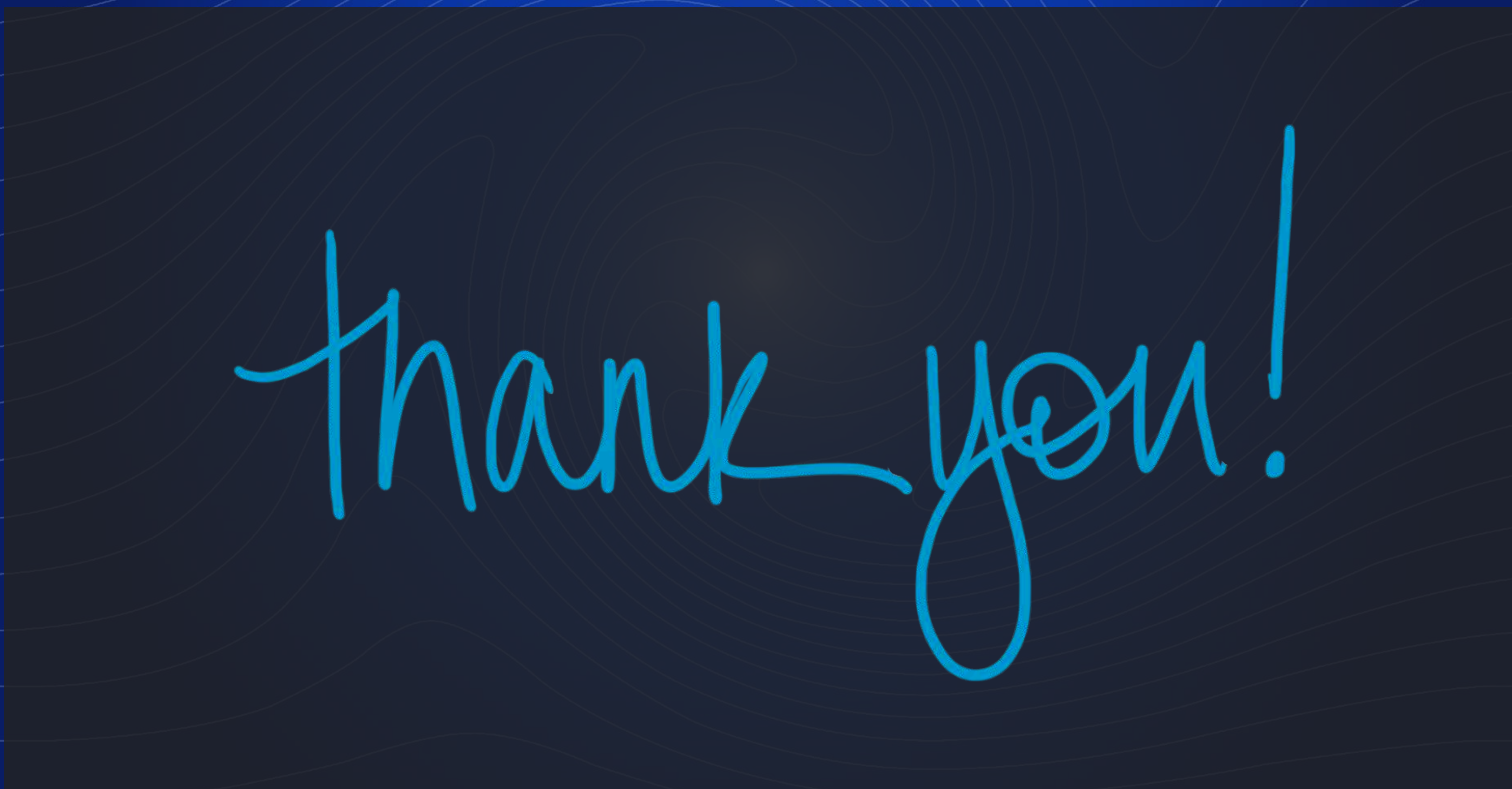
SUMMARY / CONCLUSIONS

- new L′ band images of MWC 758 reveal the presence of a third spiral arm and a bright point-like source south of the star
- the bright emission:
  - is most likely an embedded protoplanet at 20 AU
  - with mass $m_p < 6\ M_J$
  - accreting at a rate of 10^{-7}-$10^{-9}\ M_\odot/yr$
- the spirals are most likely not related to MWC 758b
- S1 and S3
  - could be generated by a yet undetected companion of $m_p = 7 \pm 1\ M_J$ at <80 au

FOLLOW-UP OBSERVATIONS WITH ALMA AND IN THE H ALPHA LINE, TOGETHER WITH NEW DEDICATED SIMULATIONS, WILL PROVIDE FURTHER INSIGHTS ON THE NATURE OF THE PROTOPLANET AND ITS CONNECTION WITH THE SPIRAL ARMS


thank you!