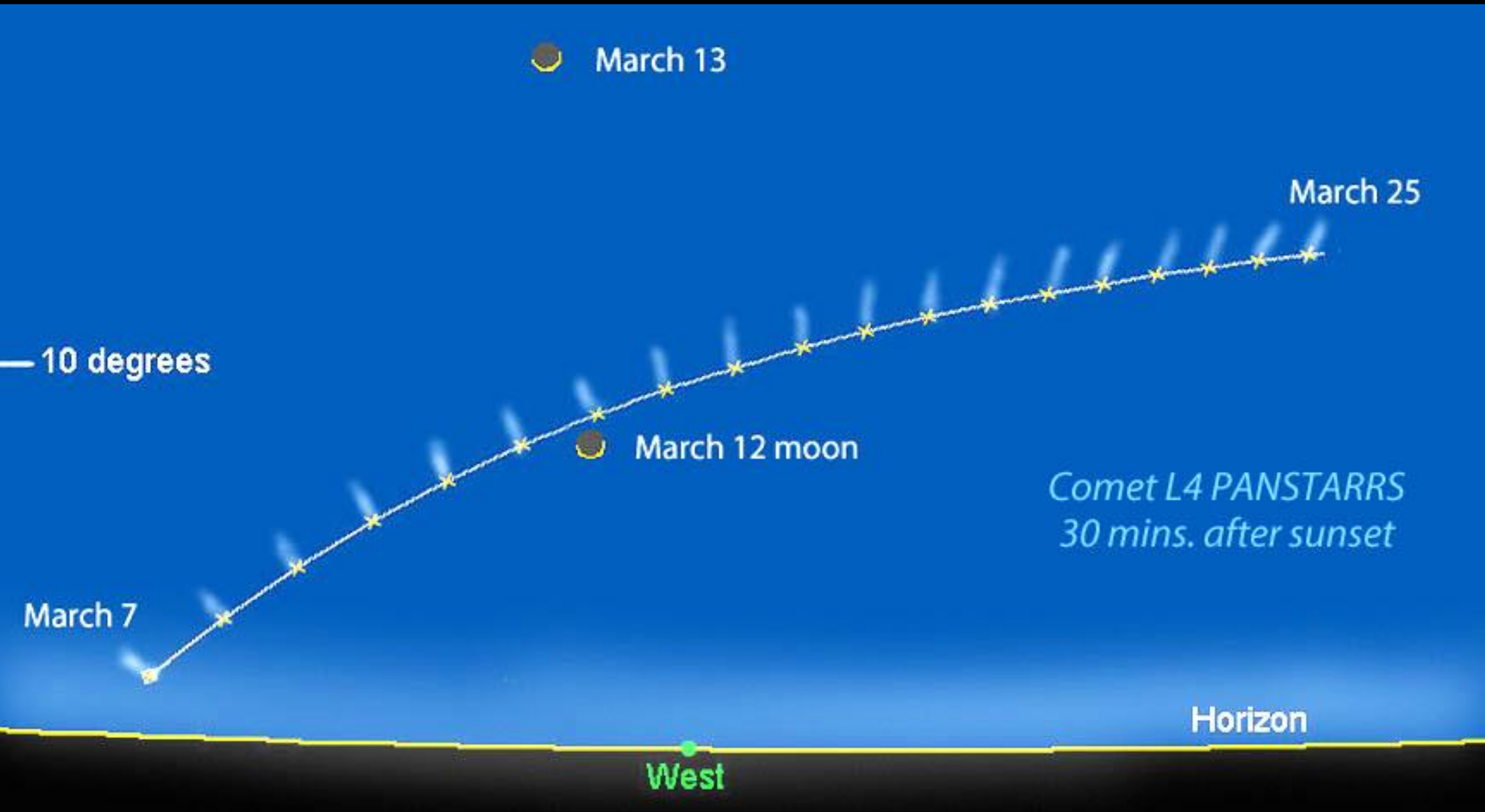
Exoplanets...

...and how to find them

Carolin Crawford

Gresham Professor of Astronomy

ESO/L Calcada



Chris Marriott

Exoplanets...

...and how to find them

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ESO/L Calcada


Carboni & Parker, New Forest Observatory

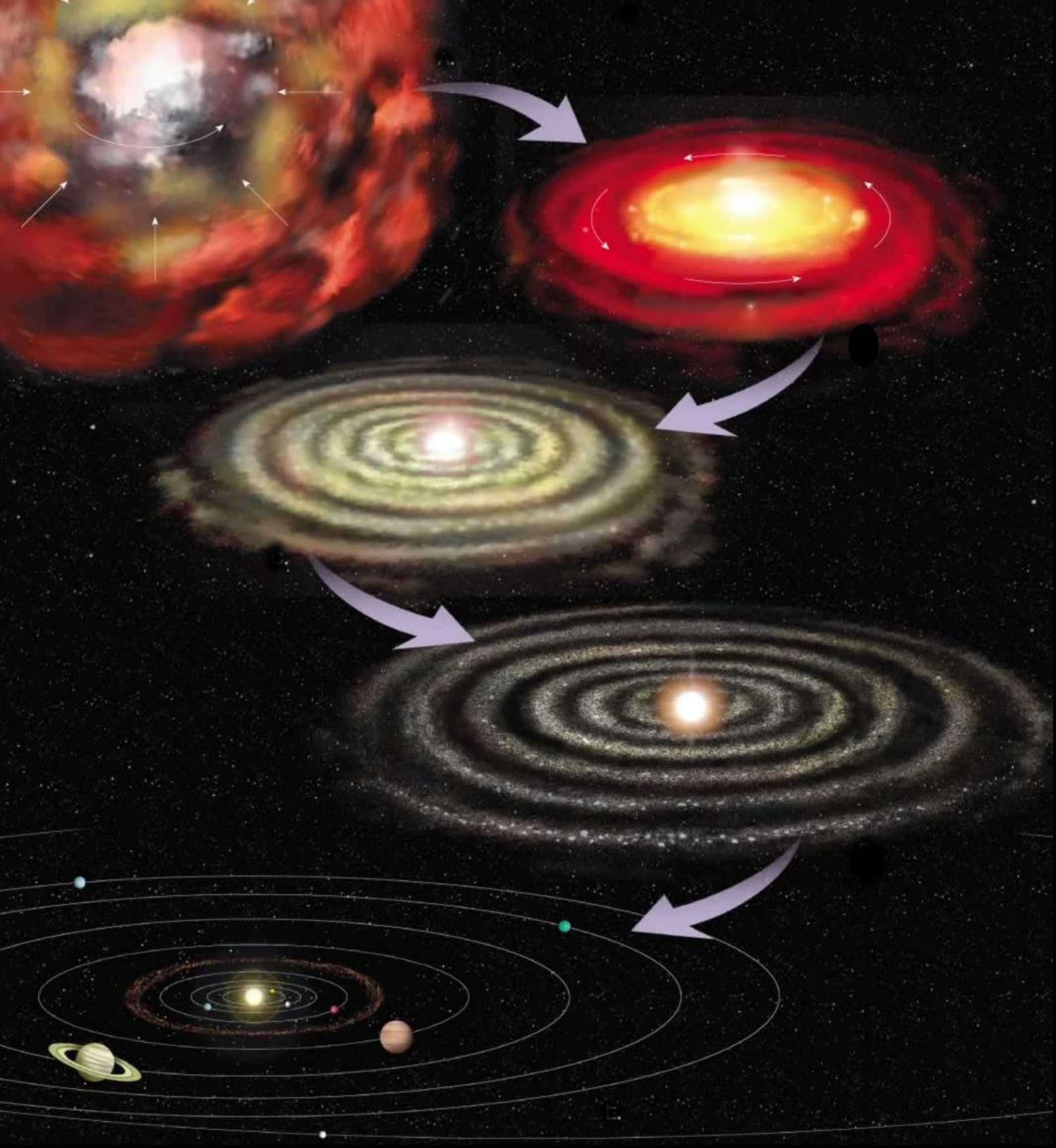
Hubble Legacy Archive/ESA/NASA/Robert Gendler

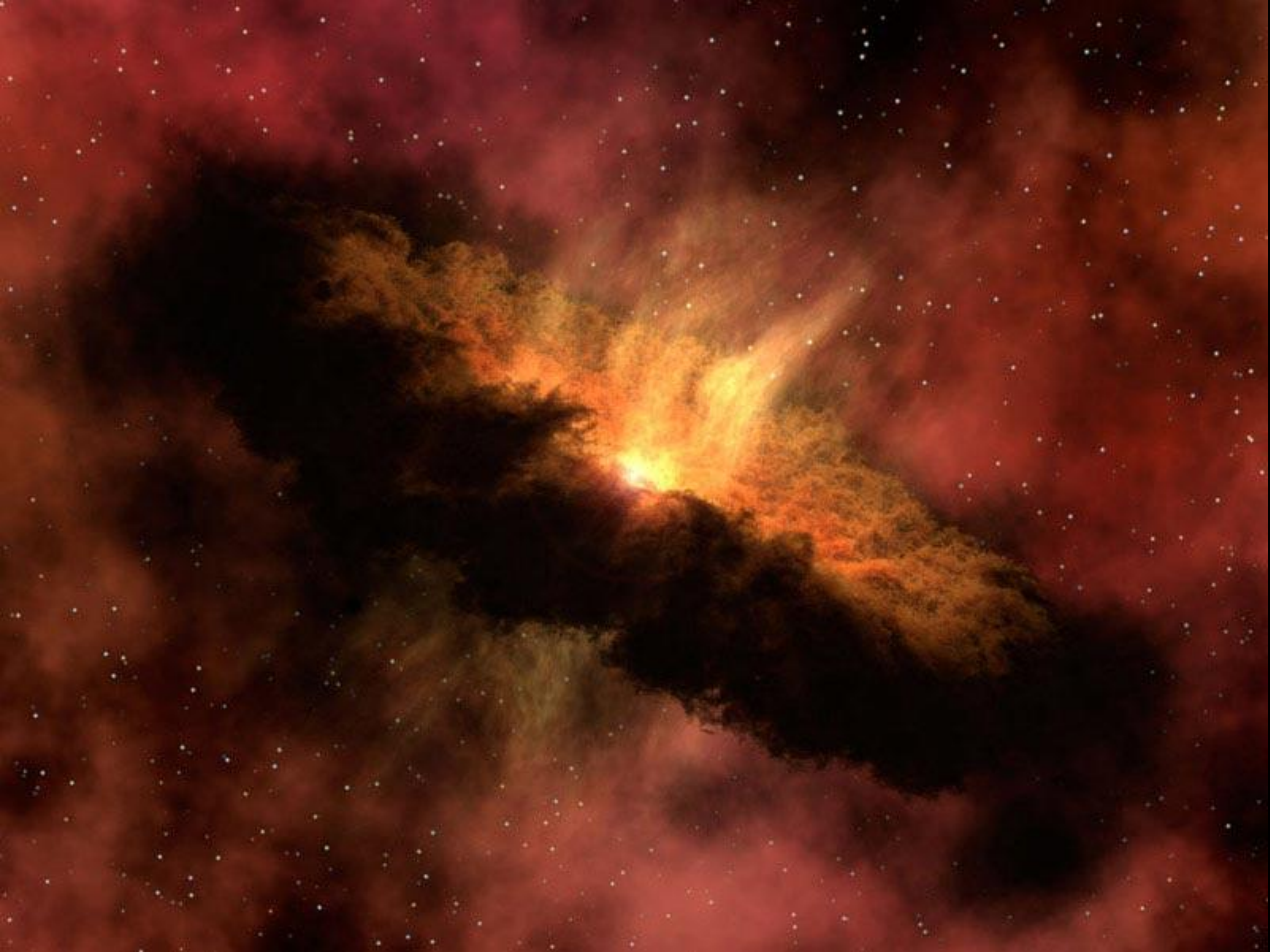

Adam Block (Caelum Observatory) & Tim Puckett

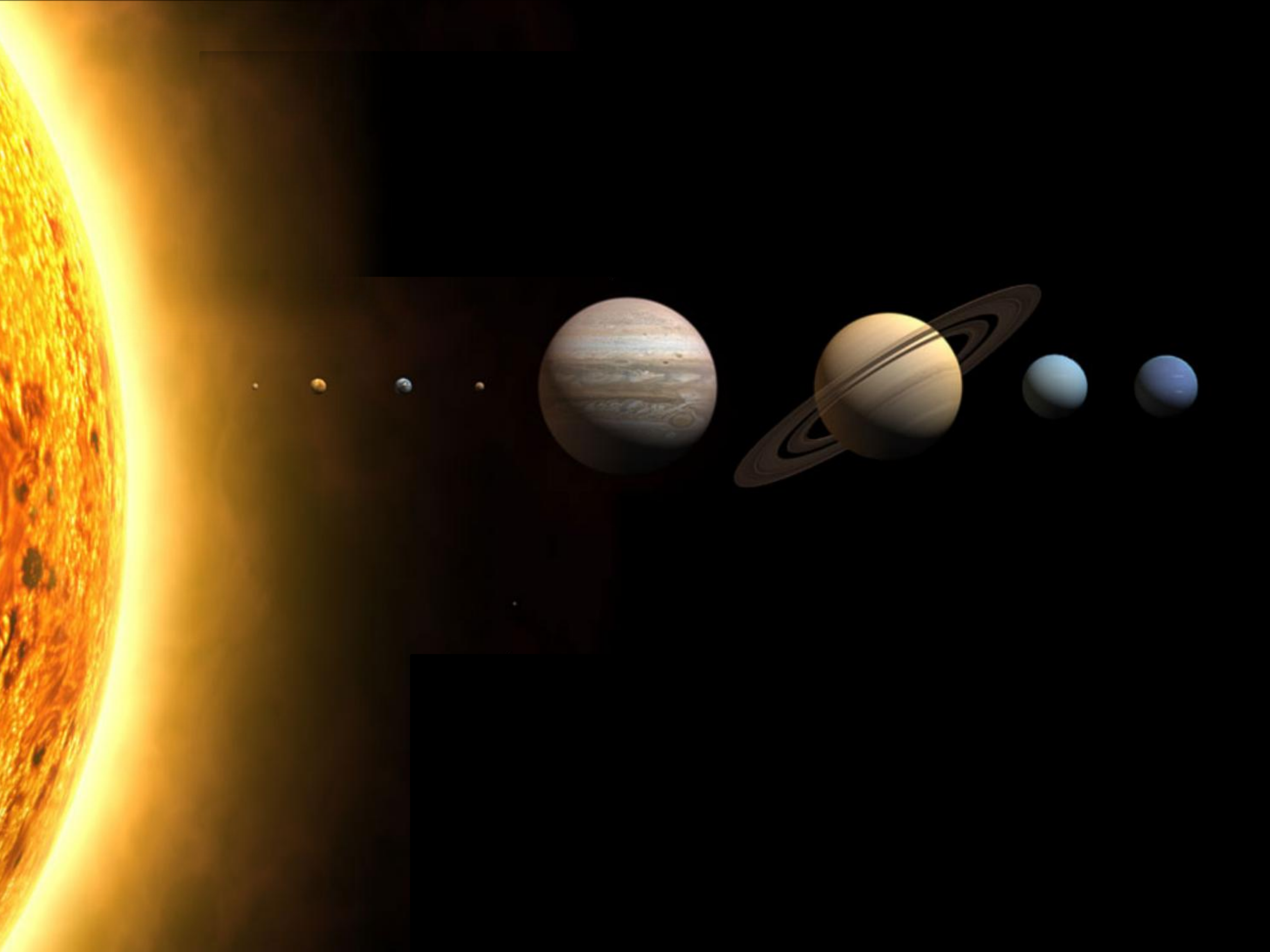

NASA/ESA/M Robberto (STScI/ESA) et al

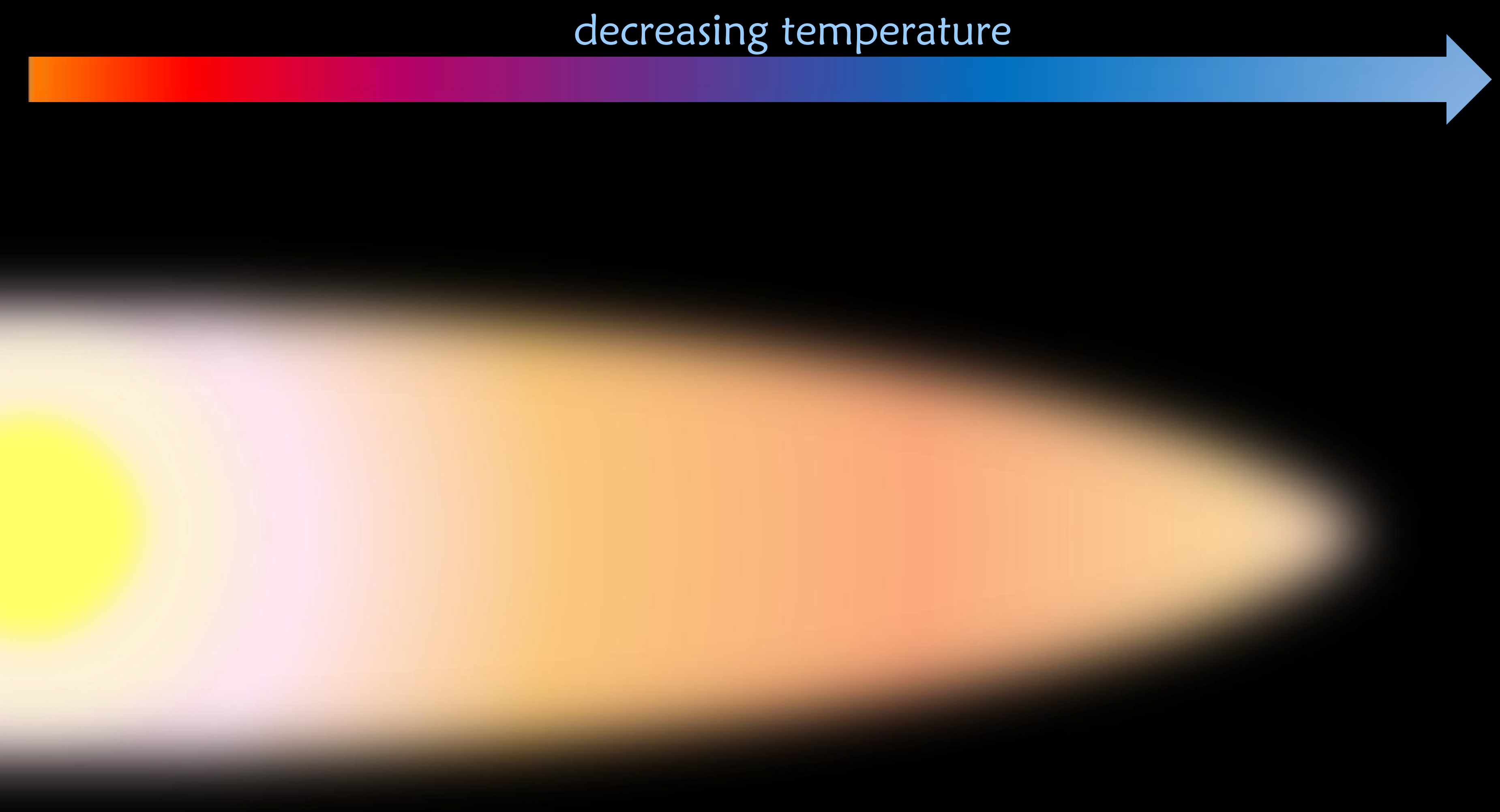
NASA/ESA/ESO (Ricci)

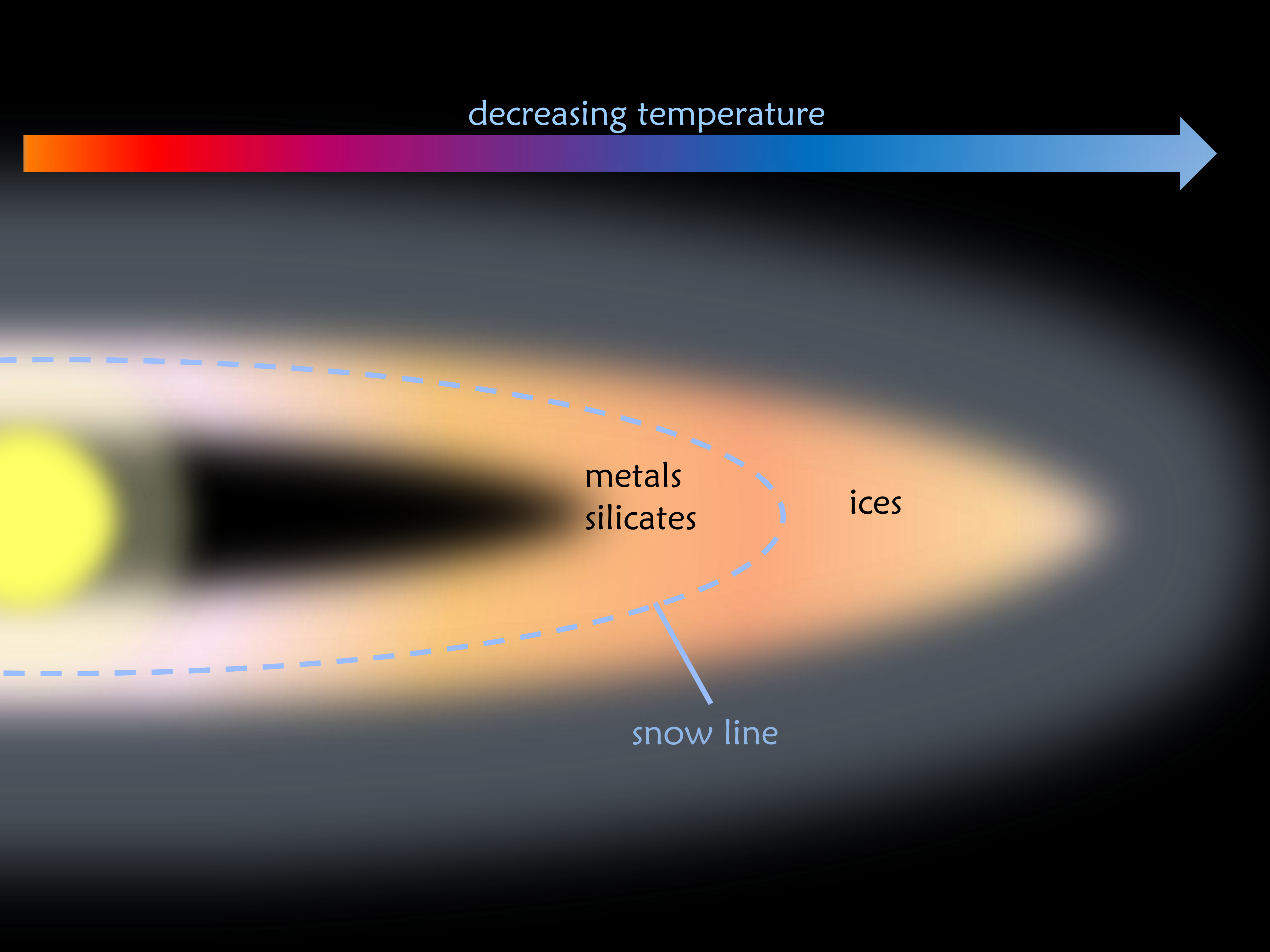
NASA/ESA/L Ricci (ESO)





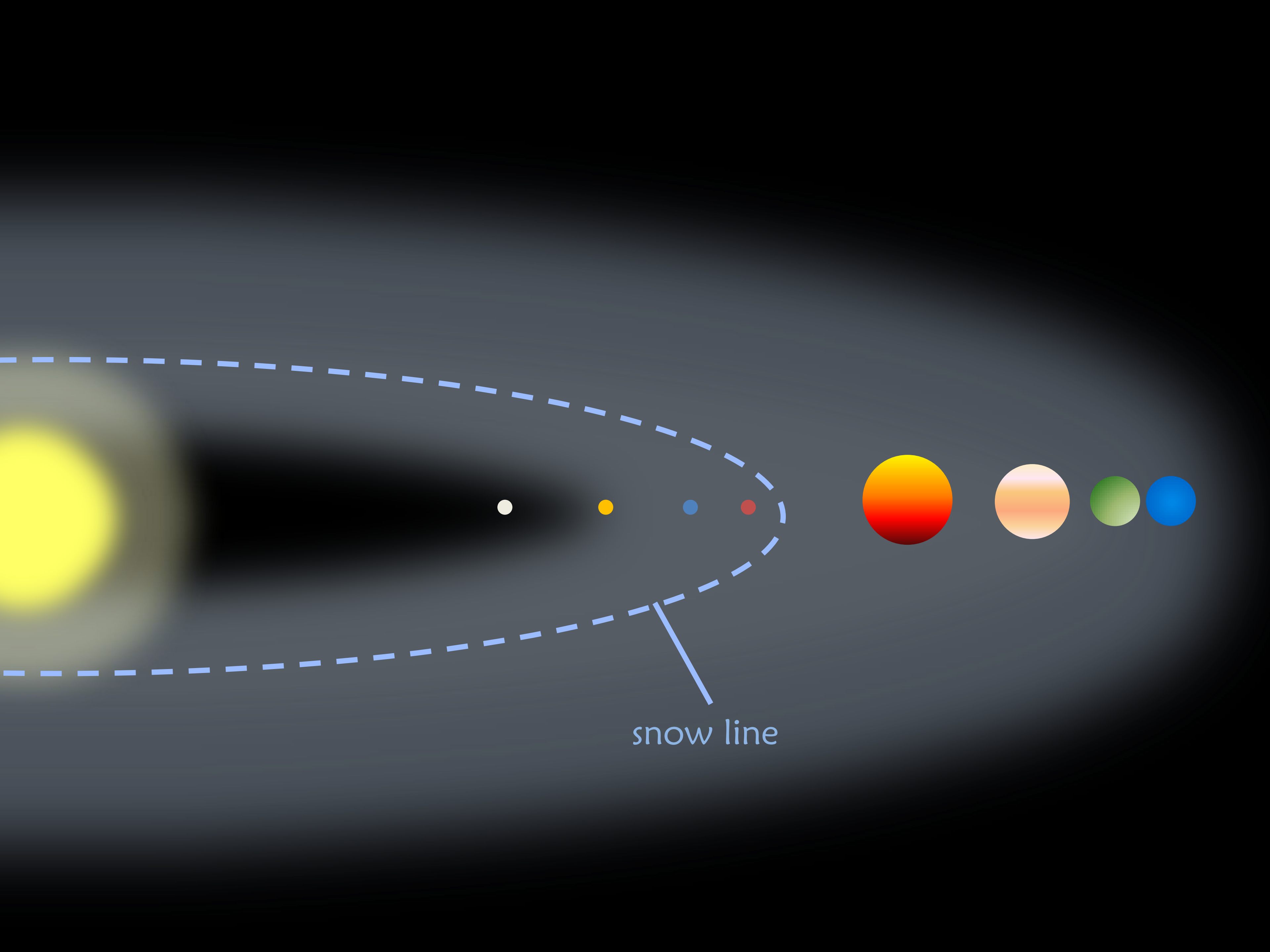



decreasing temperature



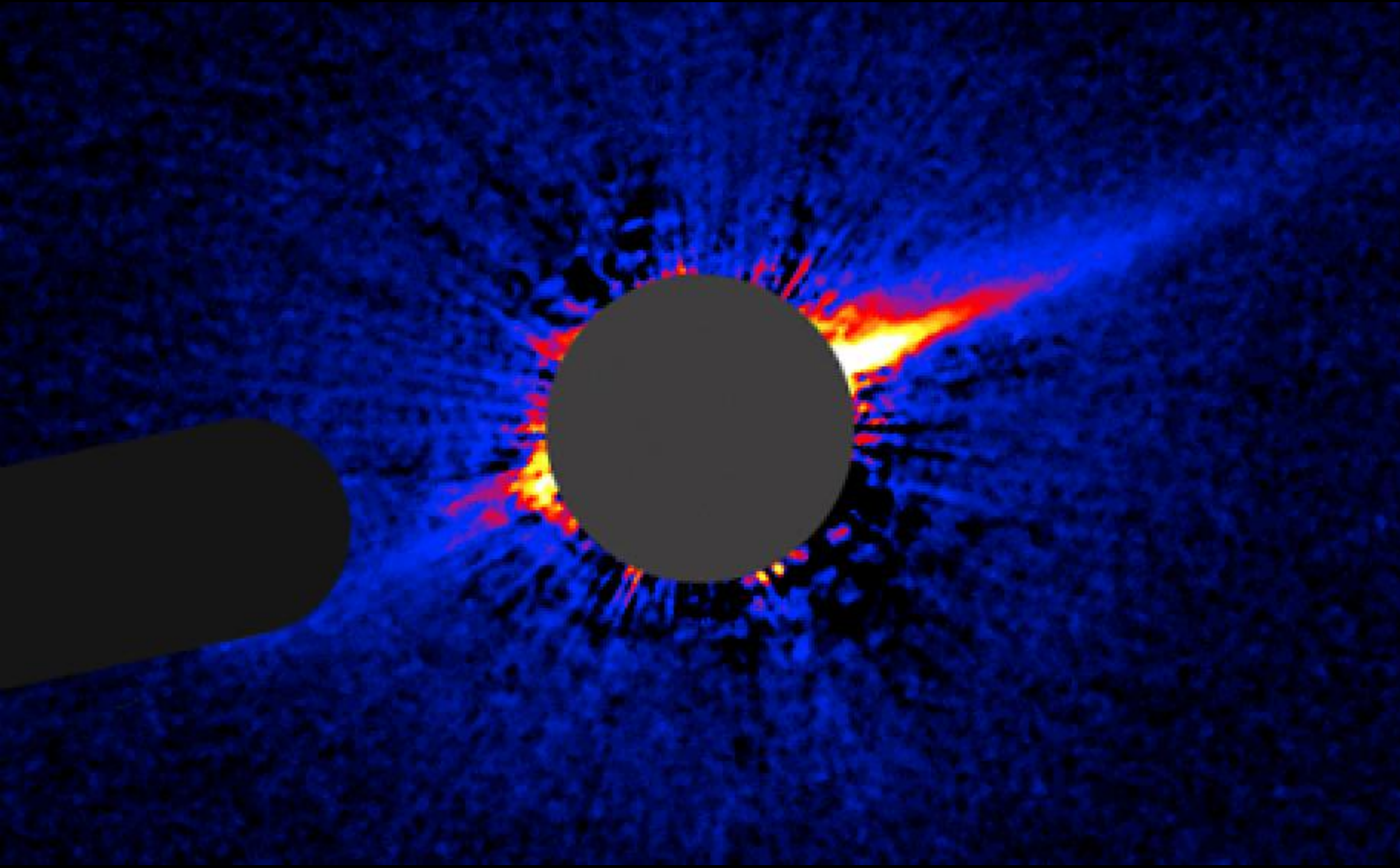
decreasing temperature
metals
silicates
ices
snow line


NASA/JPL- Caltech


snow line

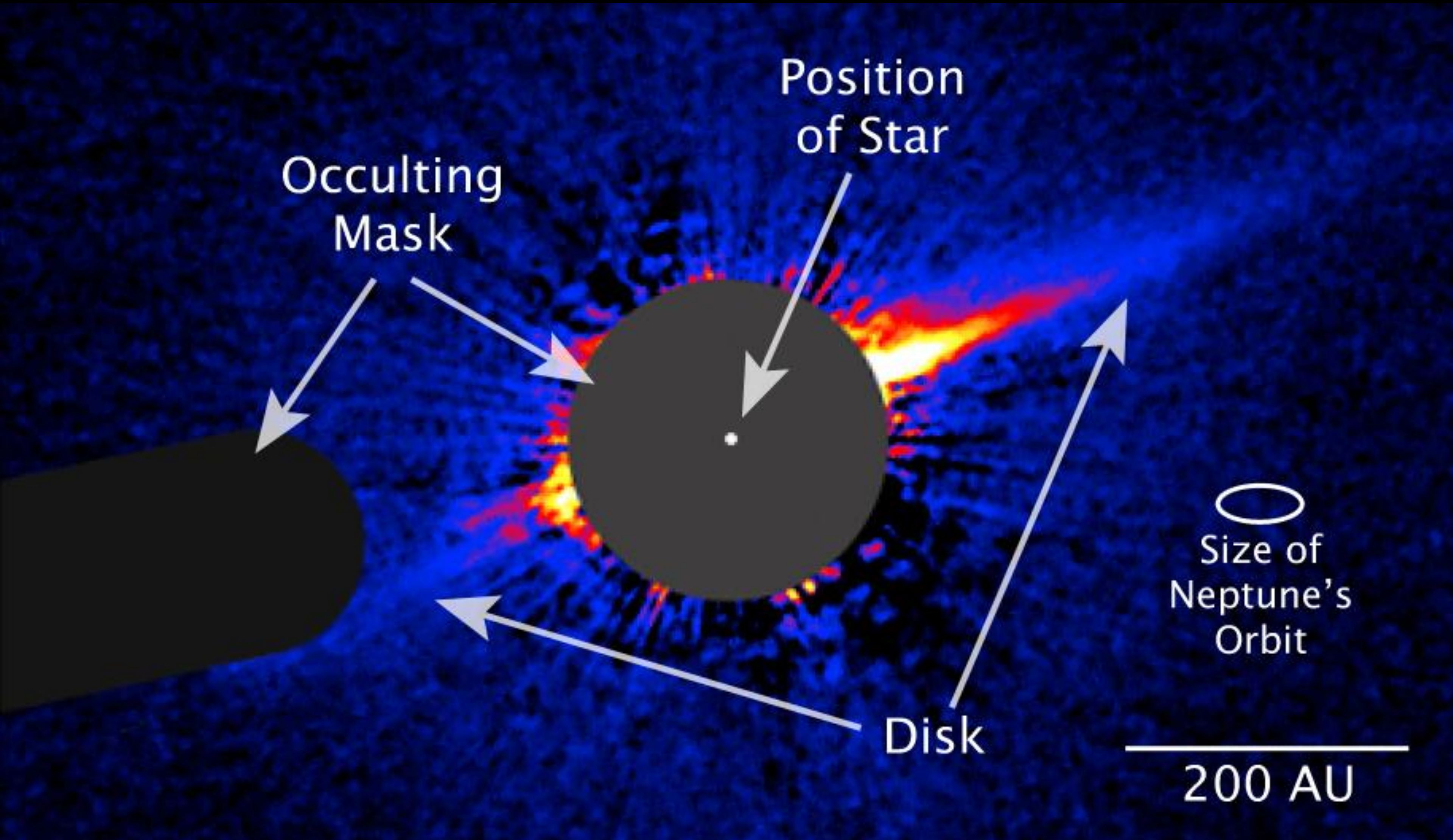

T Pyle (SSC), JPL-Caltech

HD15115



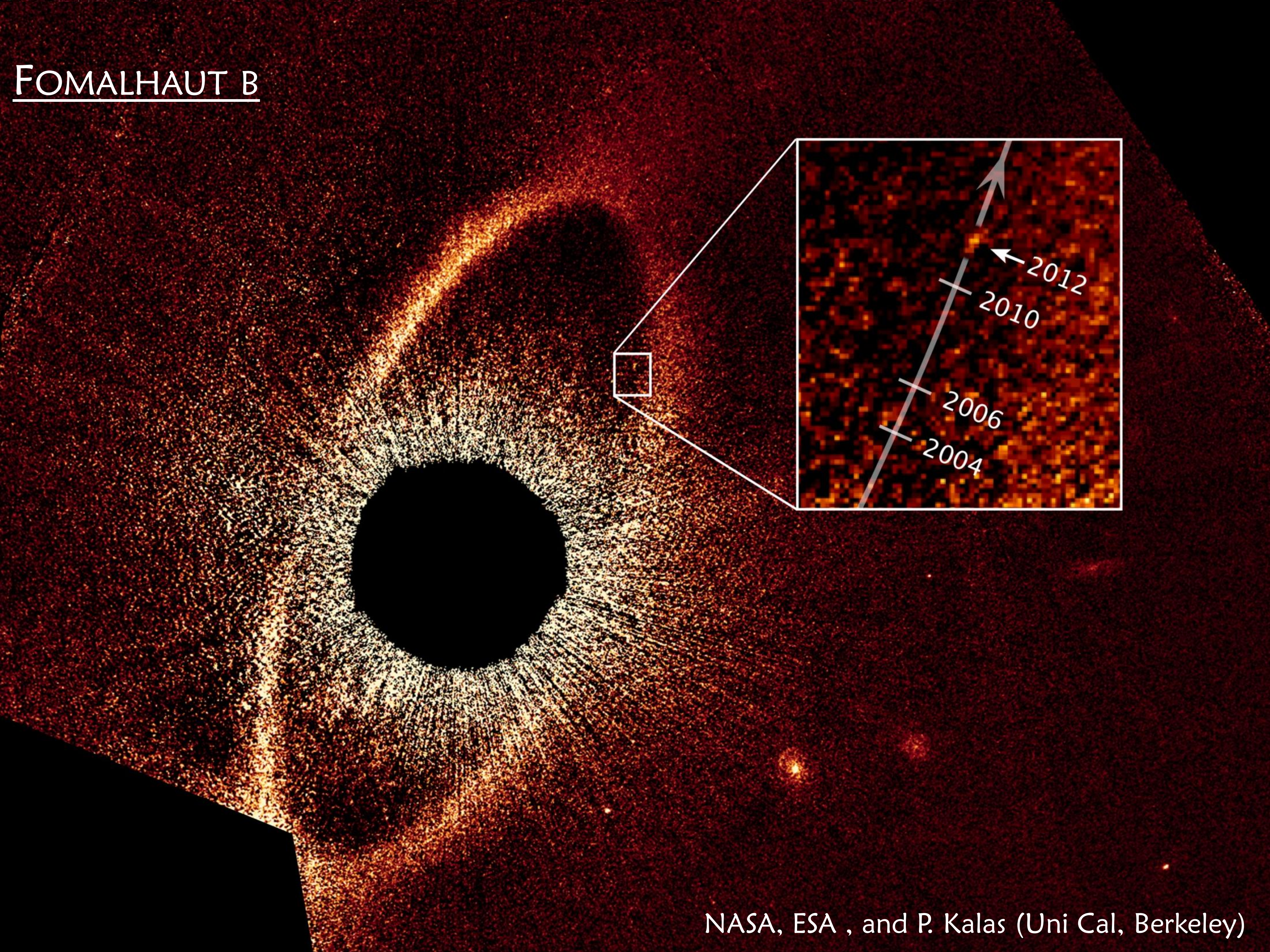
NASA, ESA , and P. Kalas (Uni Cal, Berkeley)

HD15115



NASA, ESA , and P. Kalas (Uni Cal, Berkeley)

Fomalhaut b

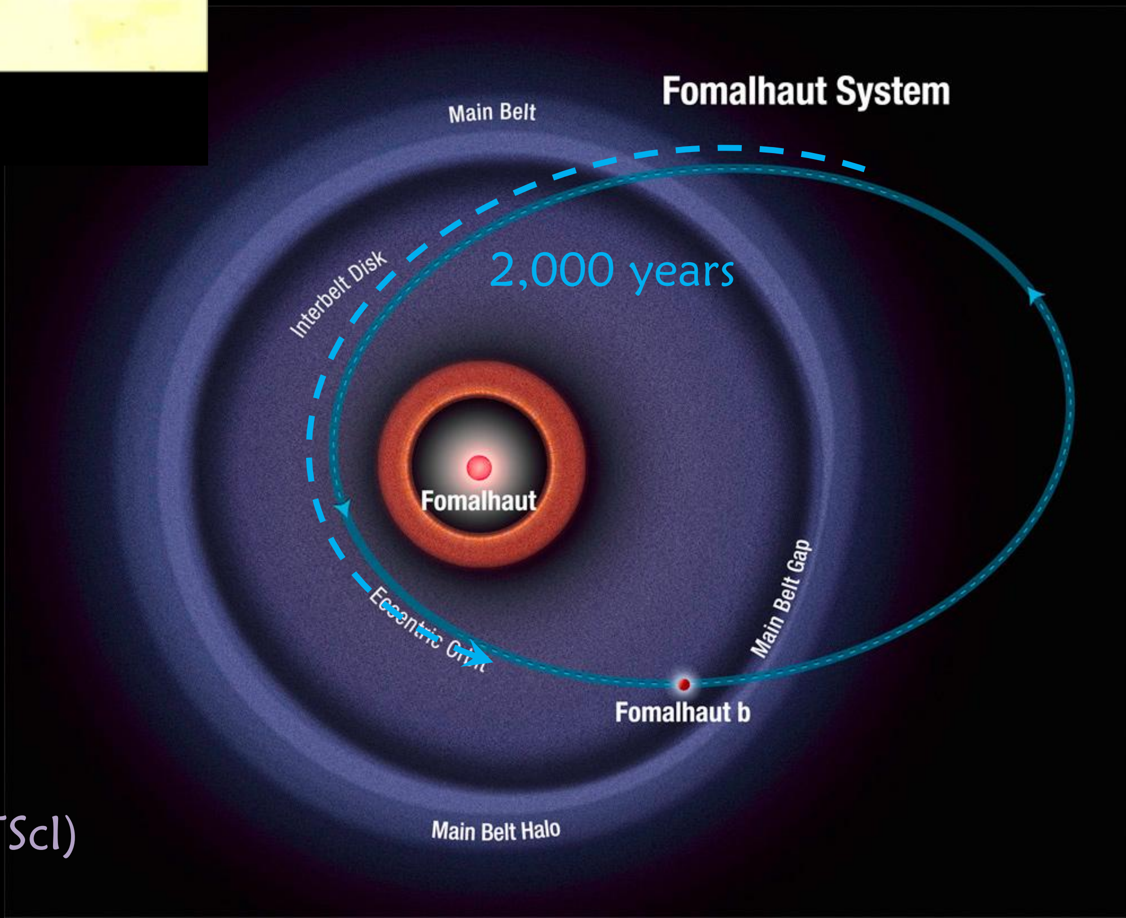


NASA, ESA , and P. Kalas (Uni Cal, Berkeley)

ESA; Hubble, M. Kornmesser; ESO, L. Calçada L. L. Christensen

FOMALHAUT B

mass ~ $3M_J$



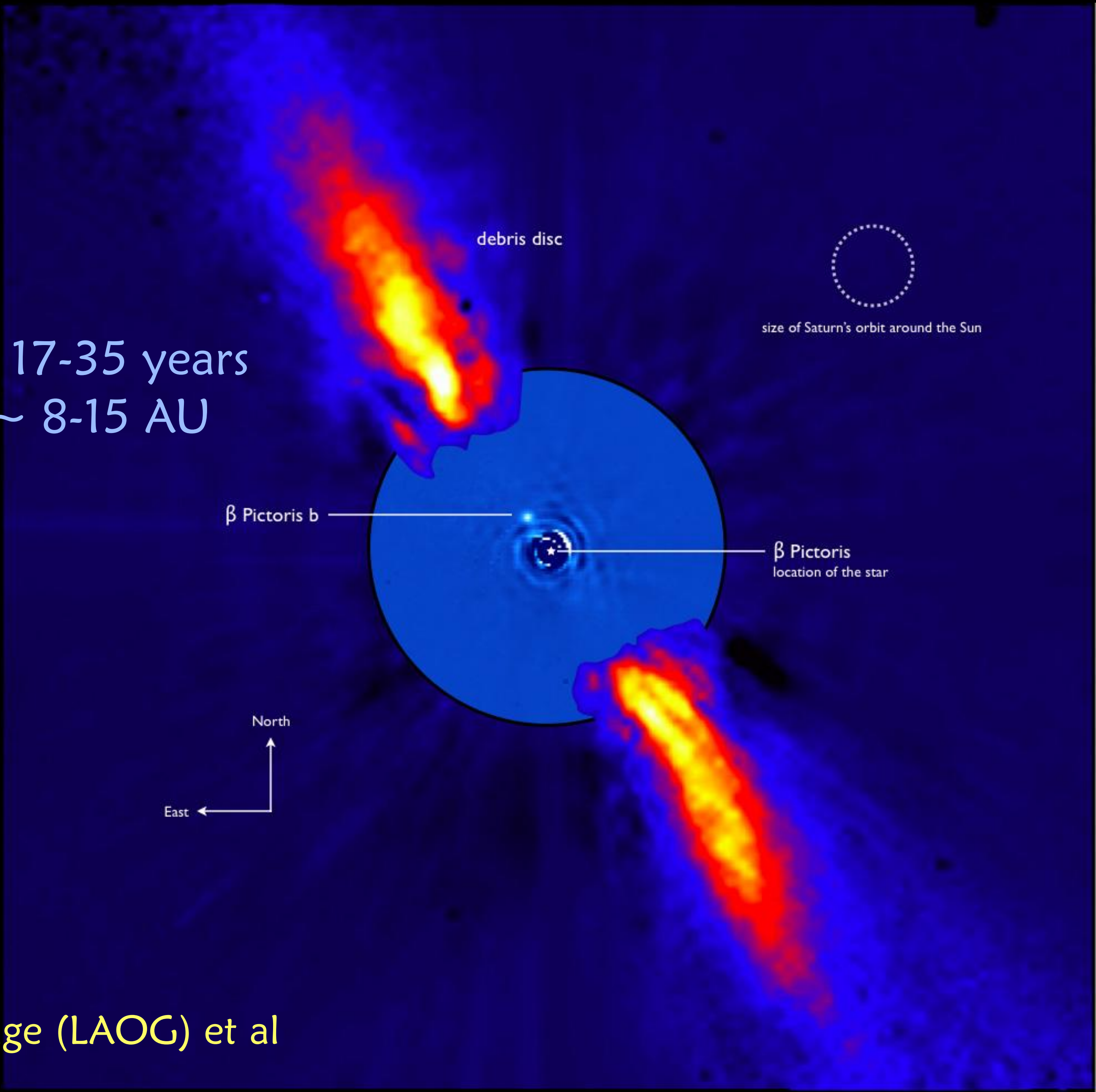
NASA, ESA , A Field (STScI)

β Pic b

mass ~ 8 M_J

orbital period ~ 17-35 years

orbital distance ~ 8-15 AU



ESO, A.-M. Lagrange (LAOG) et al

Direct imaging

2M 1207B

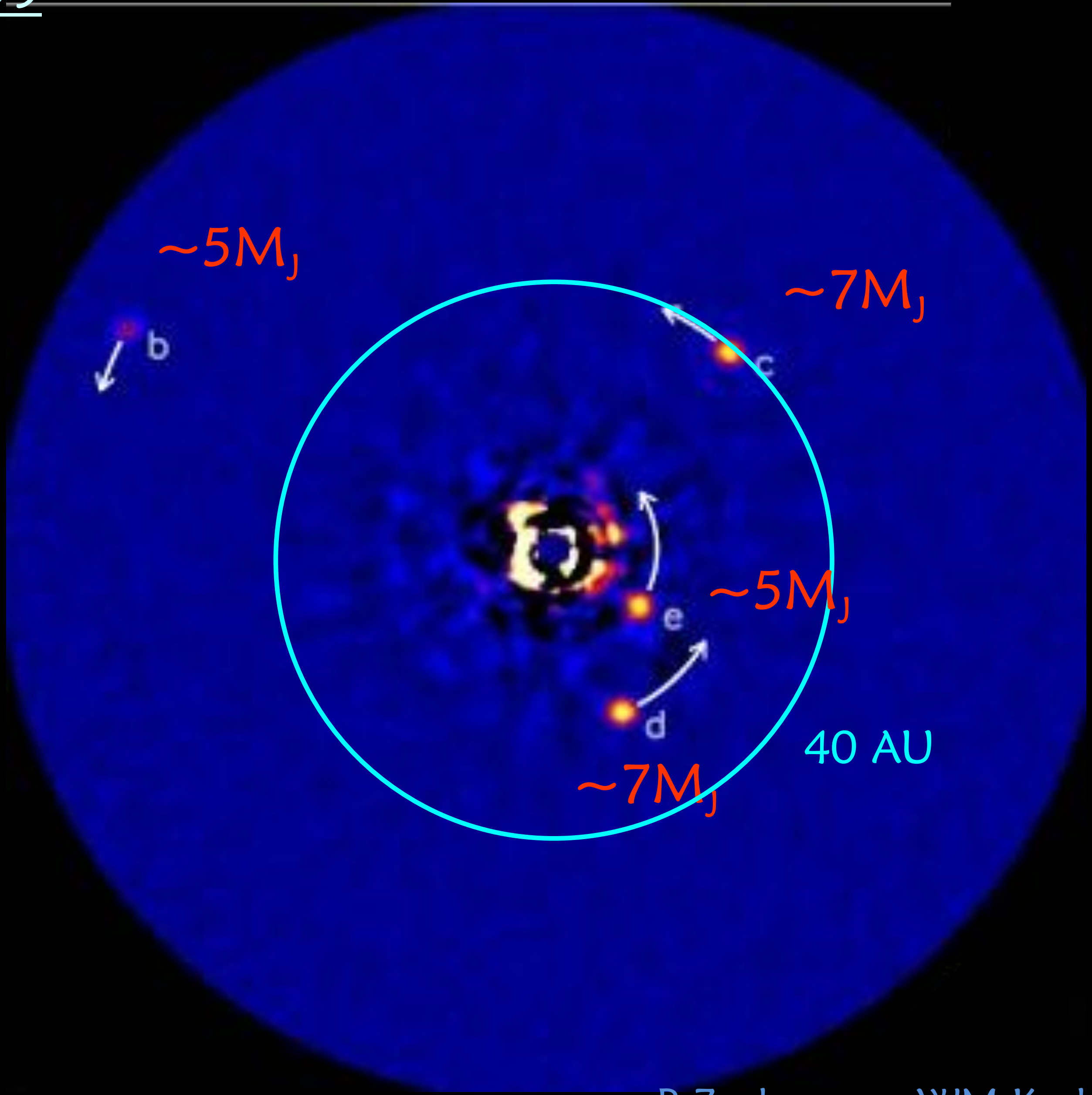
Mass ~4-10 M_J

Orbital period ~2,500 years

Orbital distance ~ 50 AU

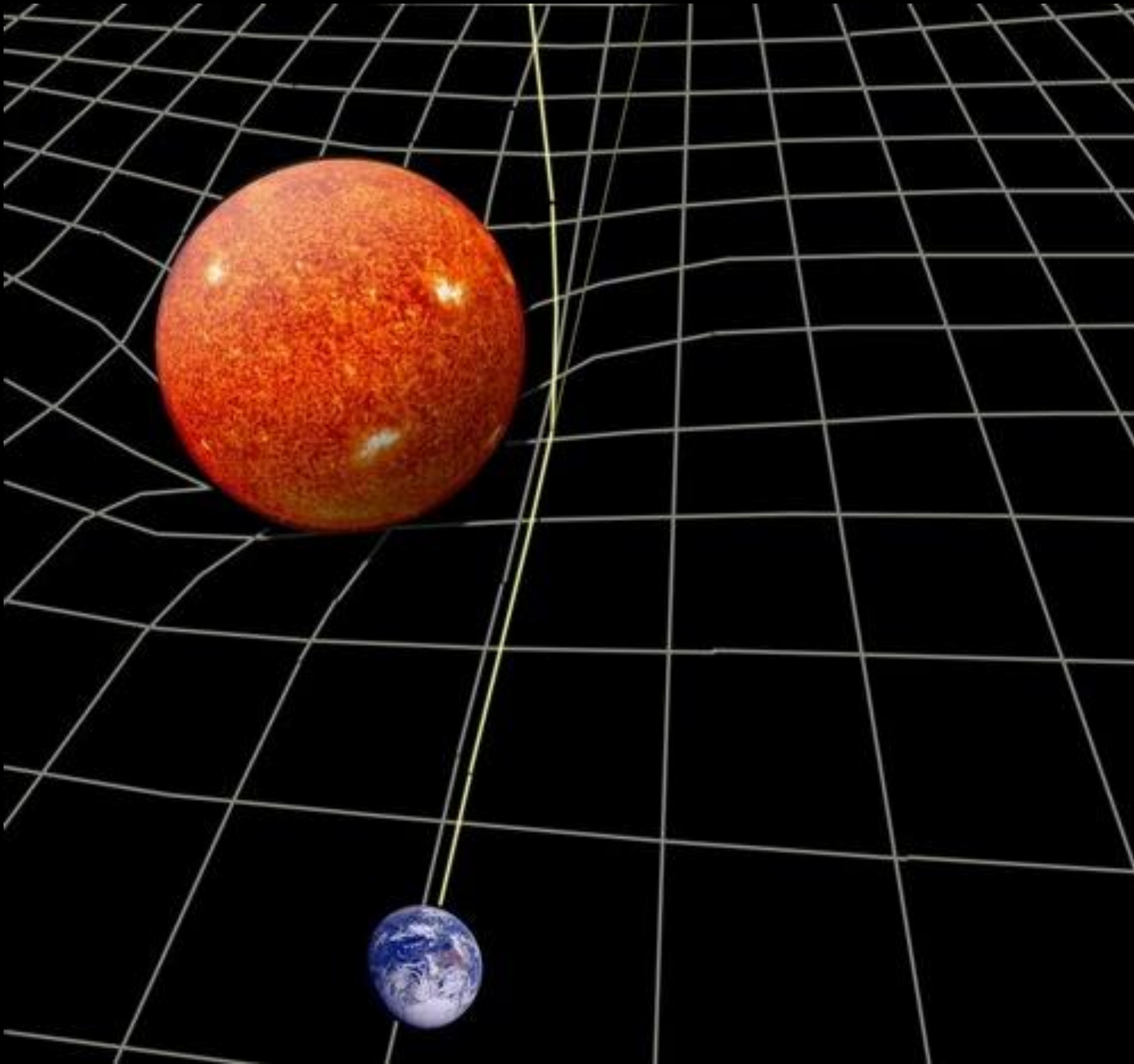
ESO

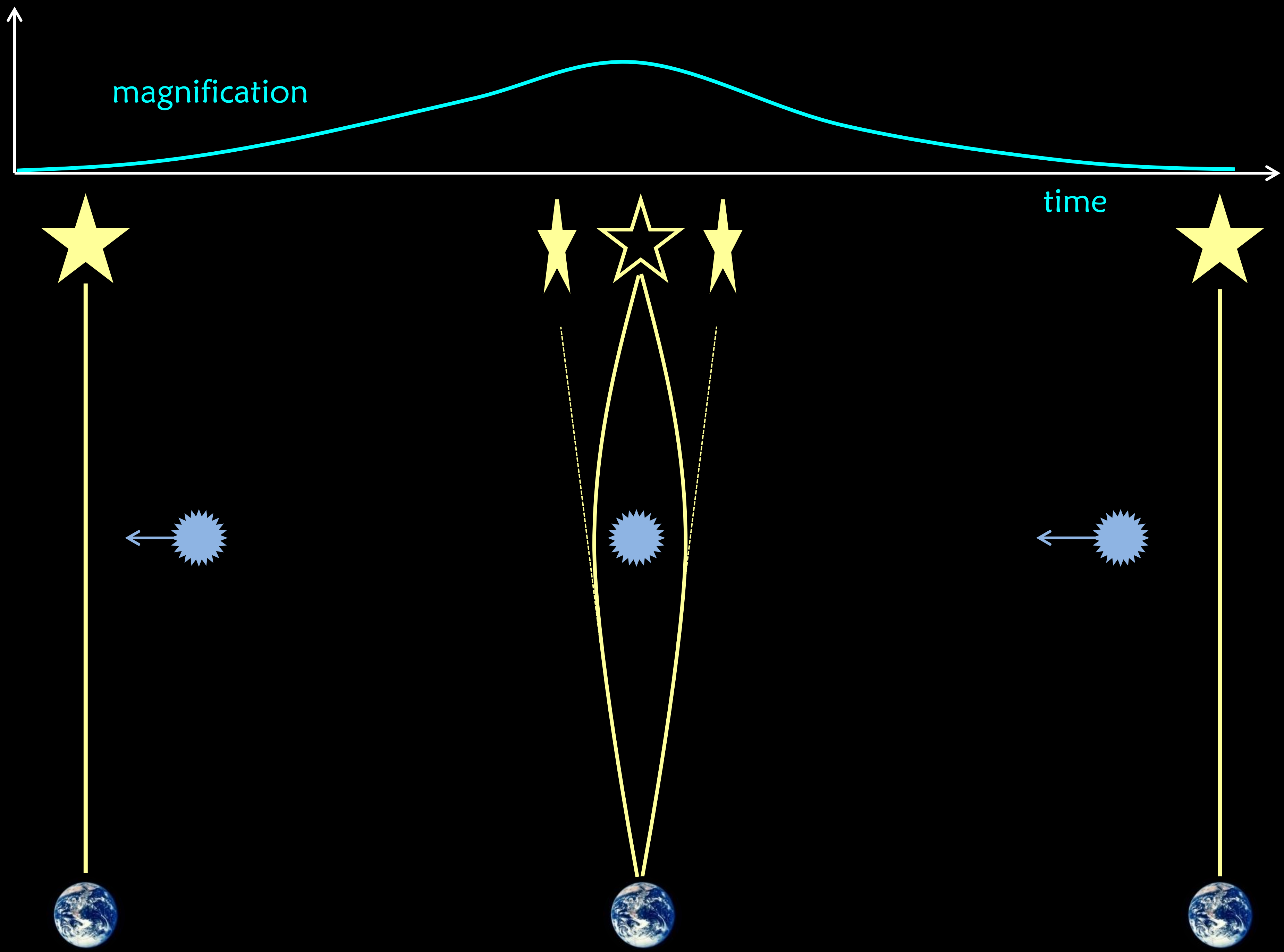
HR8799

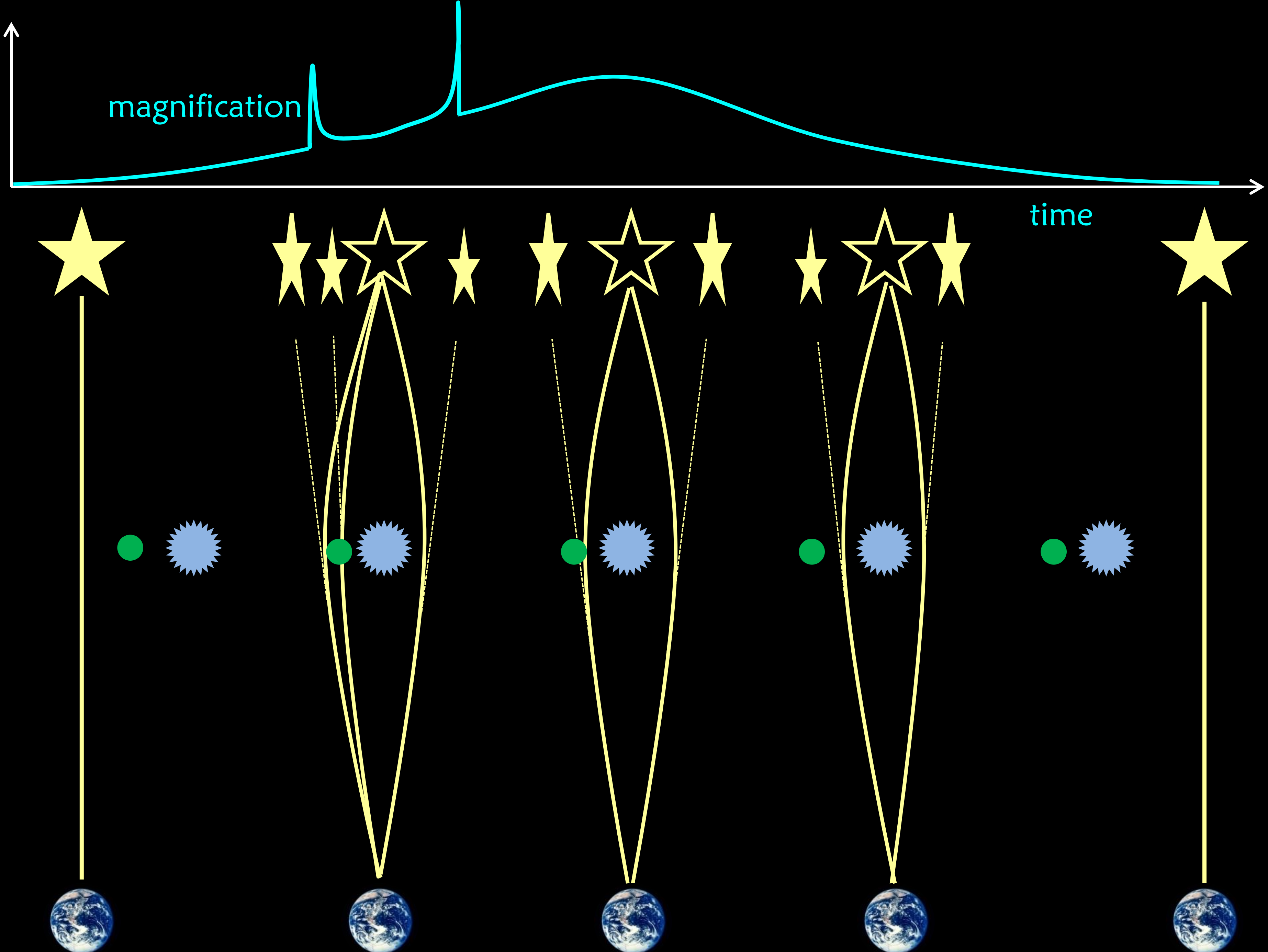


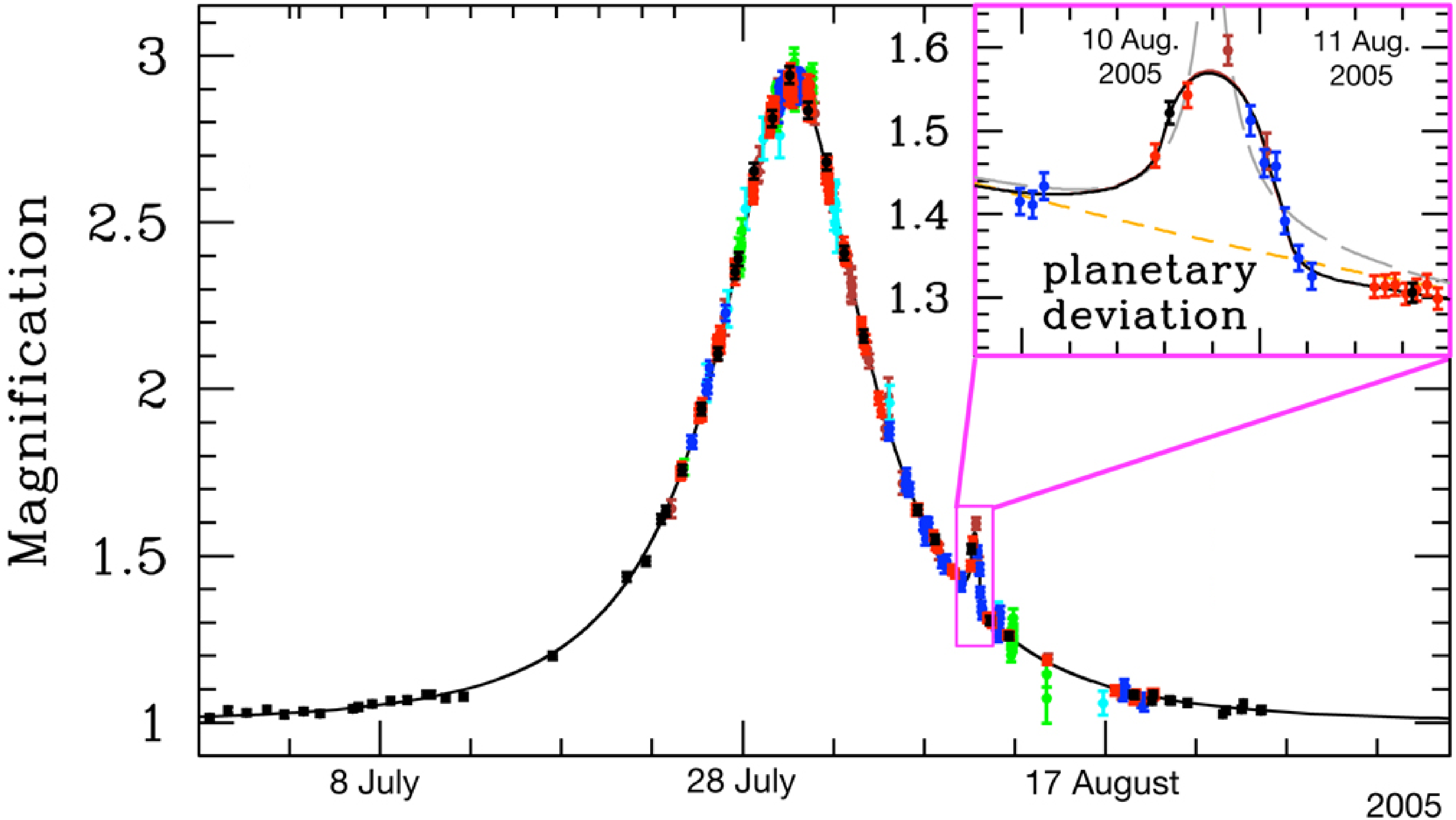
B Zuckerman, WM Keck Observatory

Gravitational microlensing



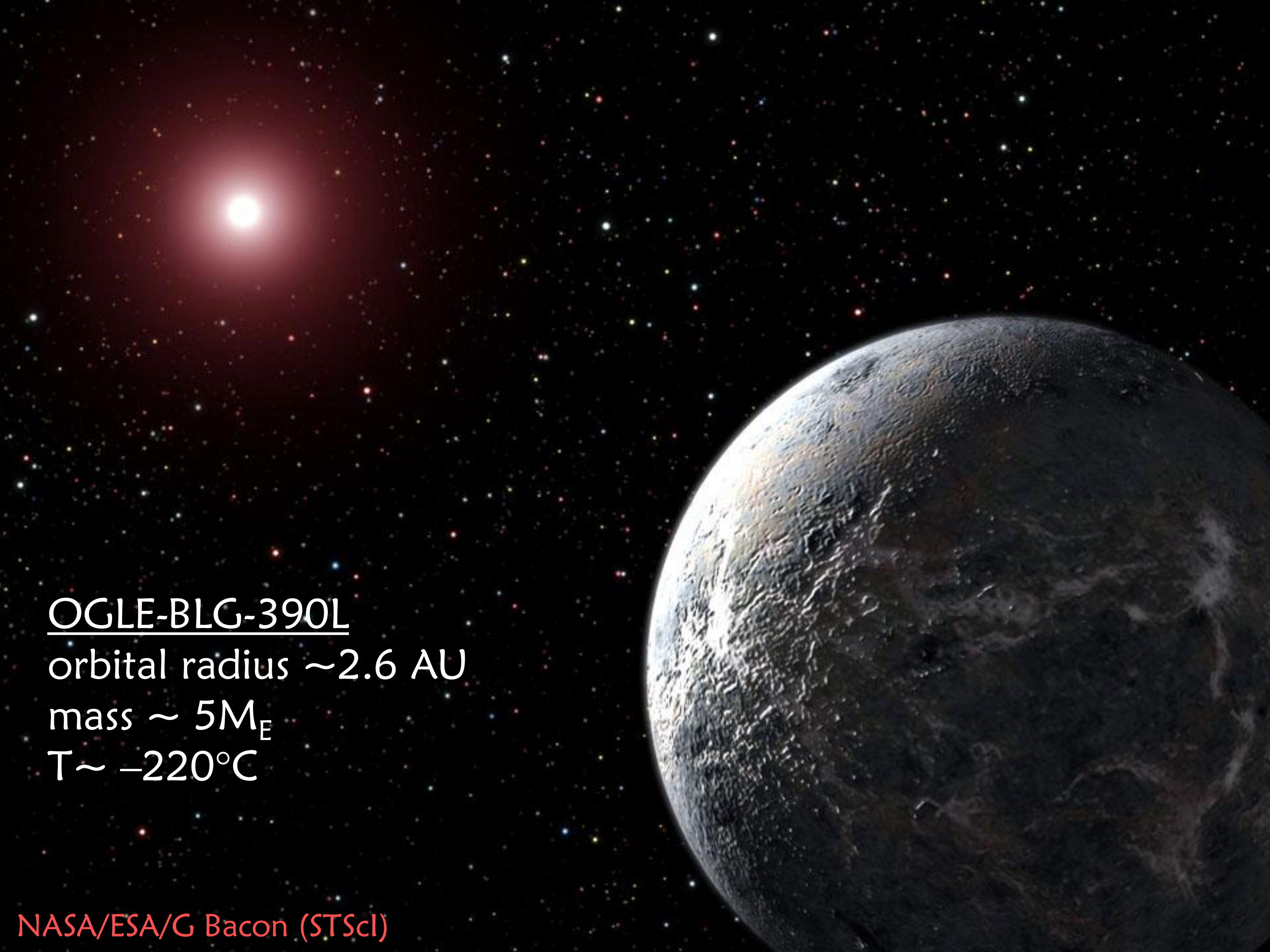

magnification
time


magnification
time

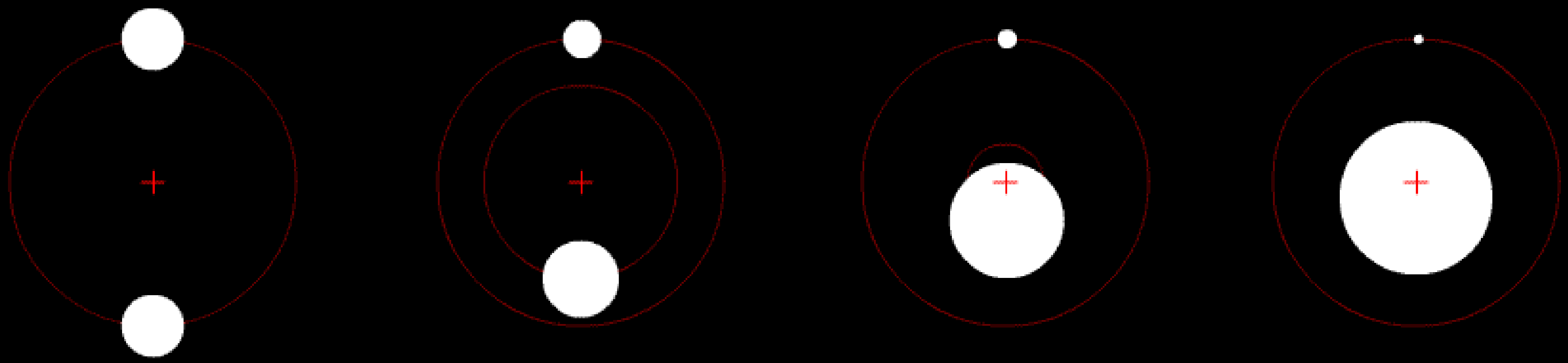


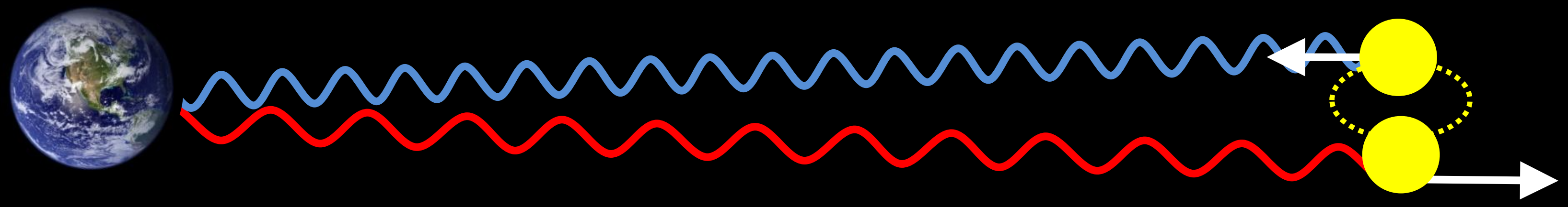
Light Curve of OGLE-2005-BLG-390

ESO

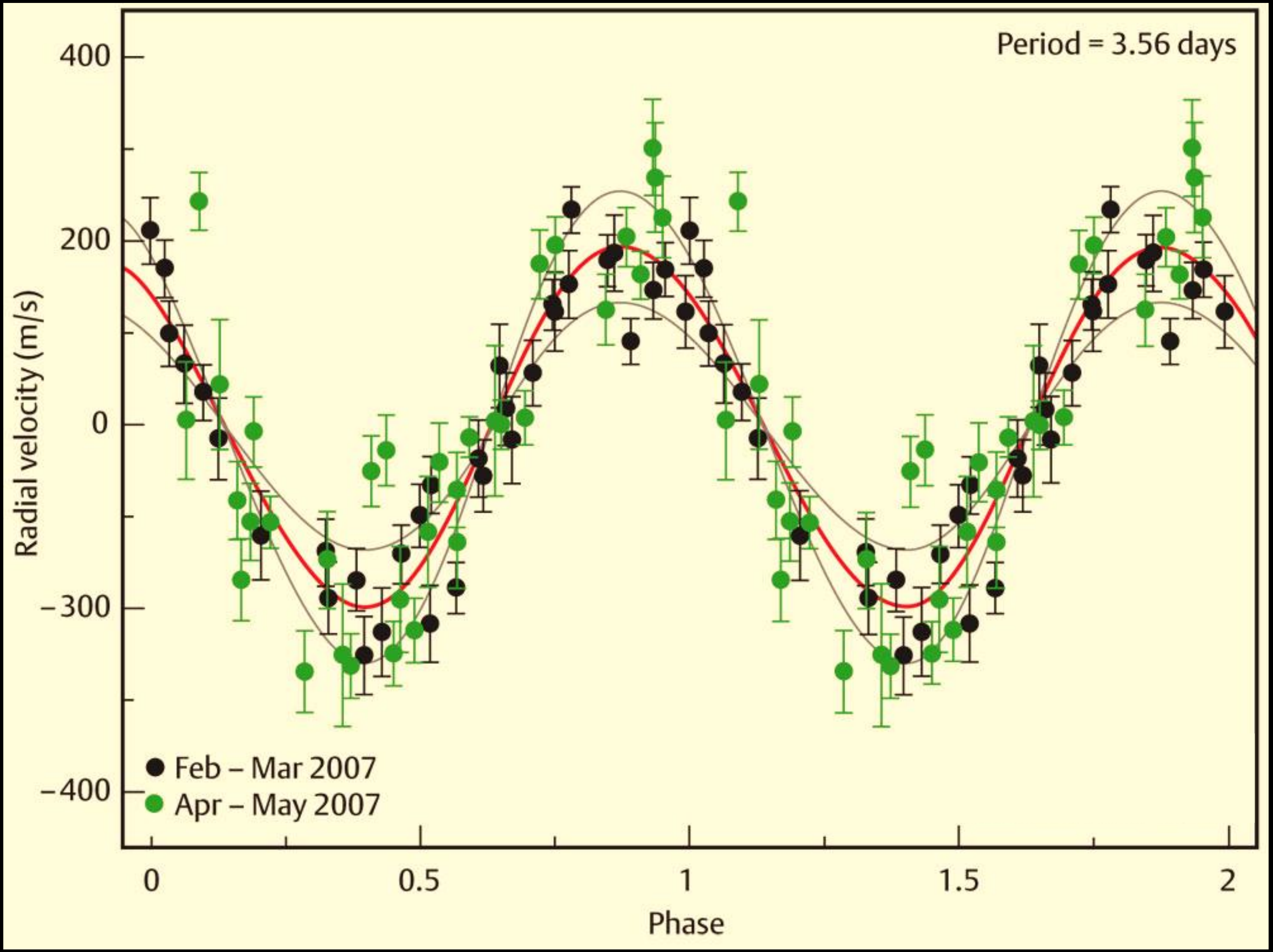

OGLE-BLG-390L
orbital radius ~2.6 AU
mass ~ $5M_E$
T~ –220°C
NASA/ESA/G Bacon (STScI)

Radial Velocity



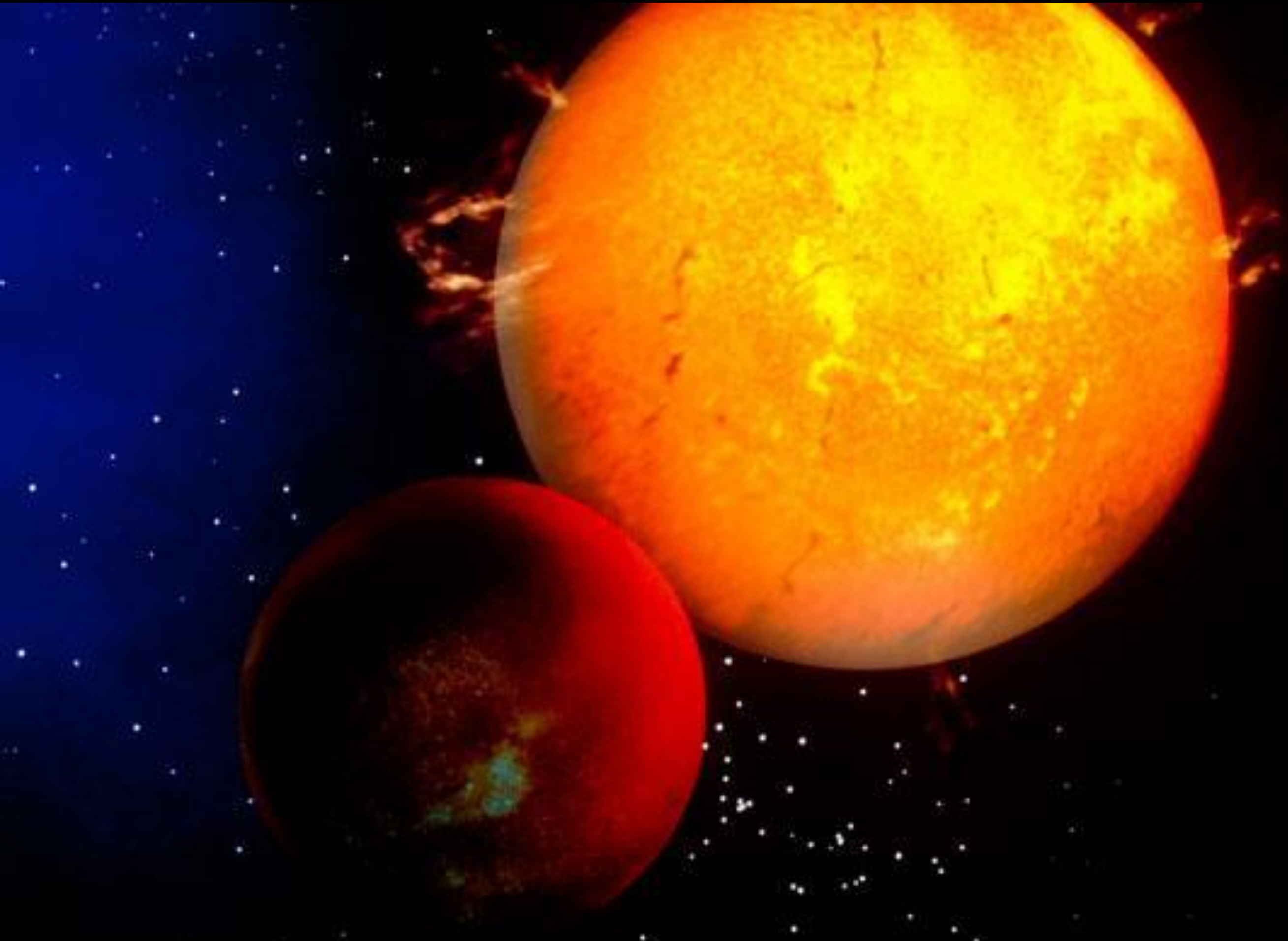


www.eso.org



Period = 3.56 days
400
200
0
−300
−400
Radial velocity (m/s)
0
0.5
1
1.5
2
Phase
Feb – Mar 2007
Apr – May 2007

MPIA/ESO



51 Peg b

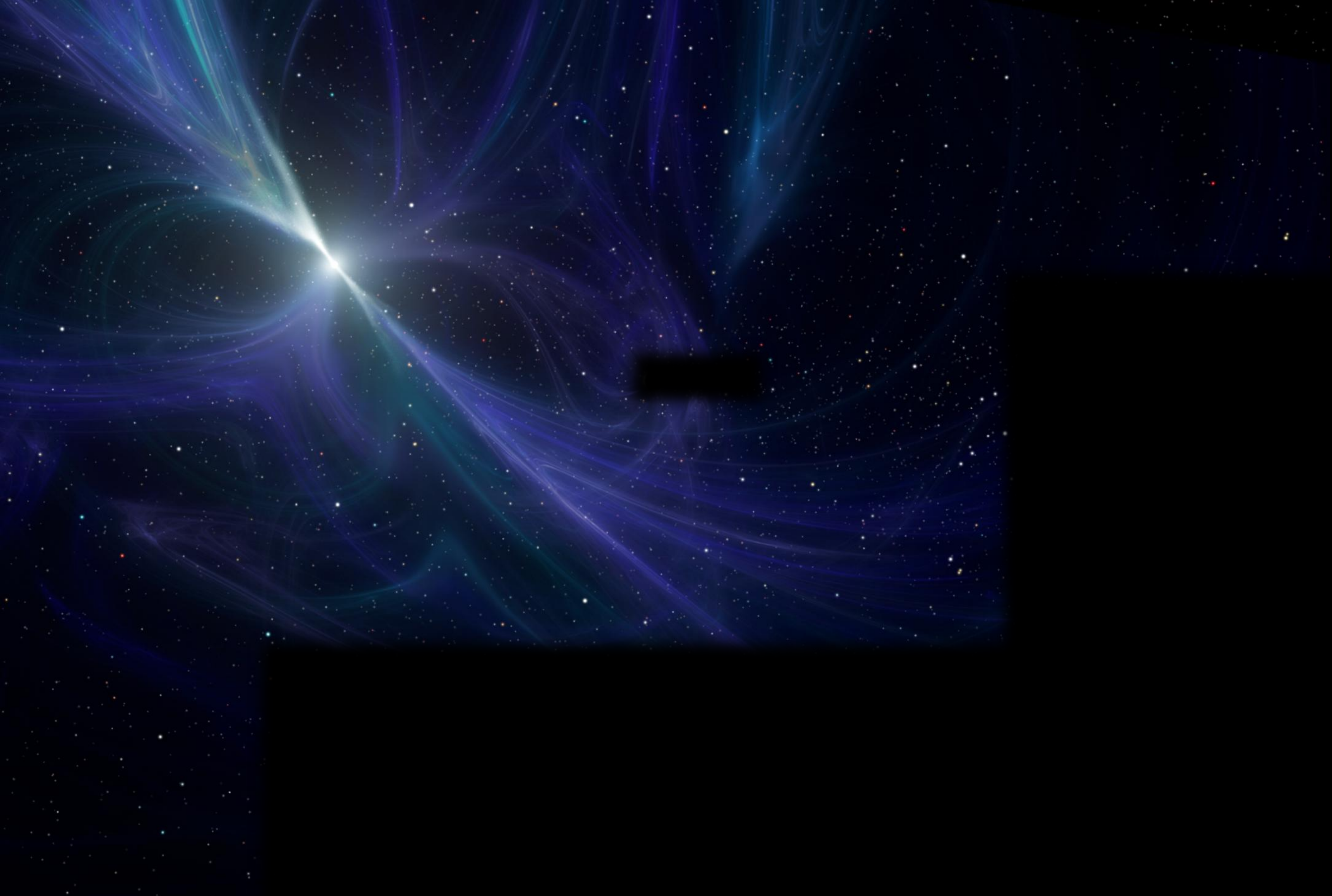
mass ~ ½ - 1 M_J

orbit ~ 4.3 days

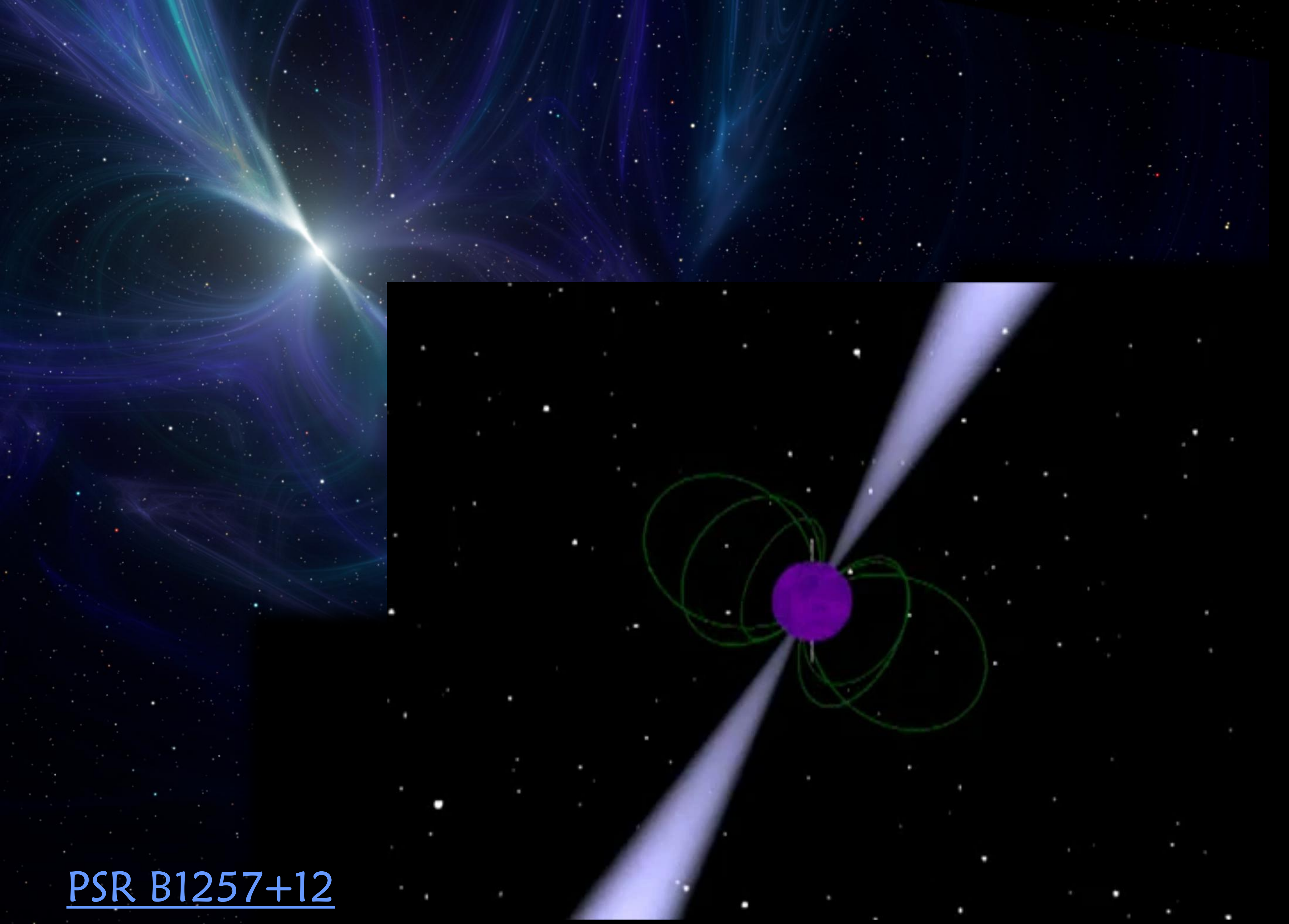
T~ 1,200°C

‘hot Jupiter’

Seth Shostak/SPL



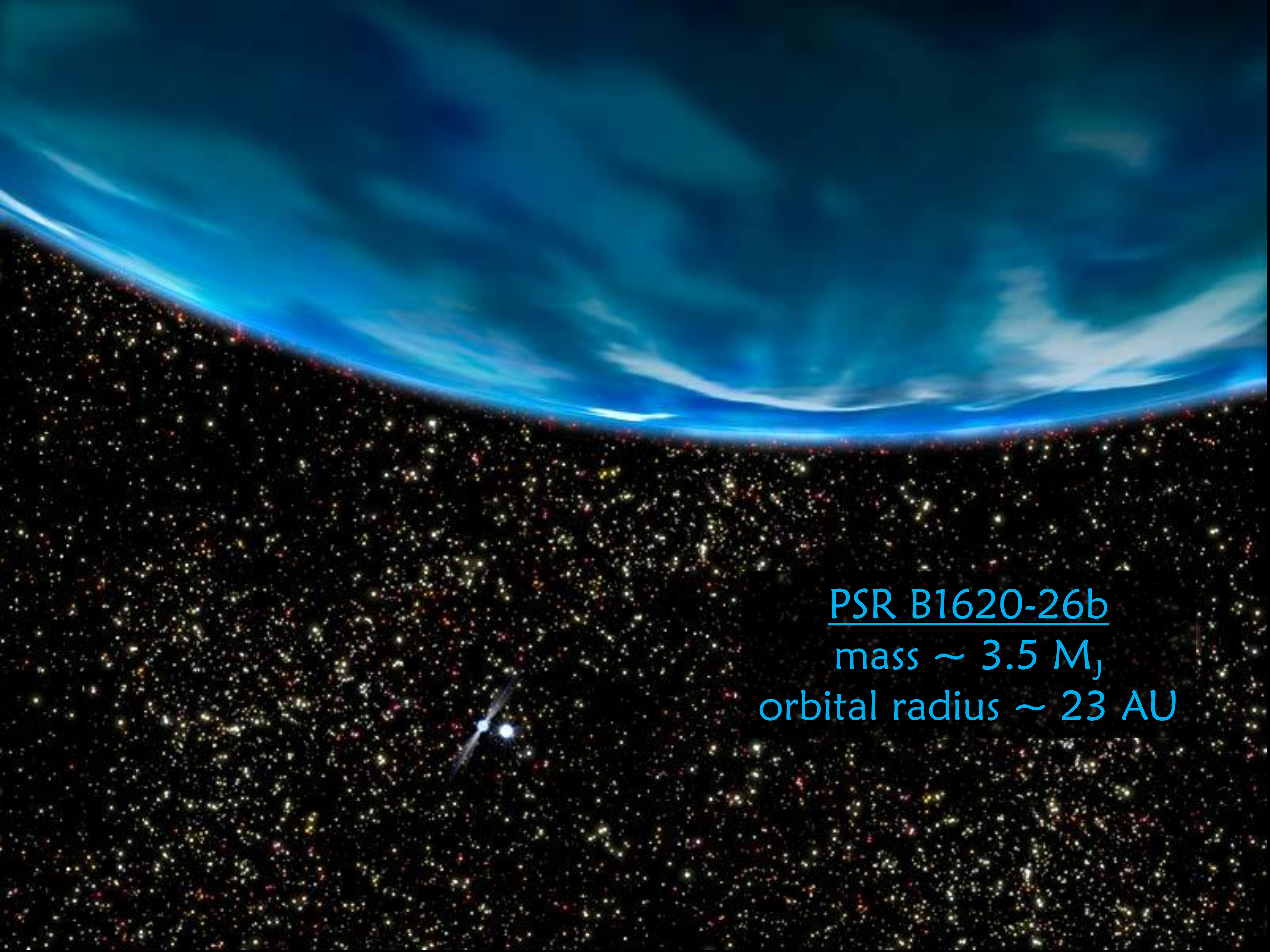
[PSR B1257+12]



[PSR B1257+12]

Planet	Mass (M_E)	Distance from pulsar (AU)	Length of year (days)
A	0.02	0.19	25
B	3.4	0.36	66
C	2.8	0.46	98

PSR B1257+12

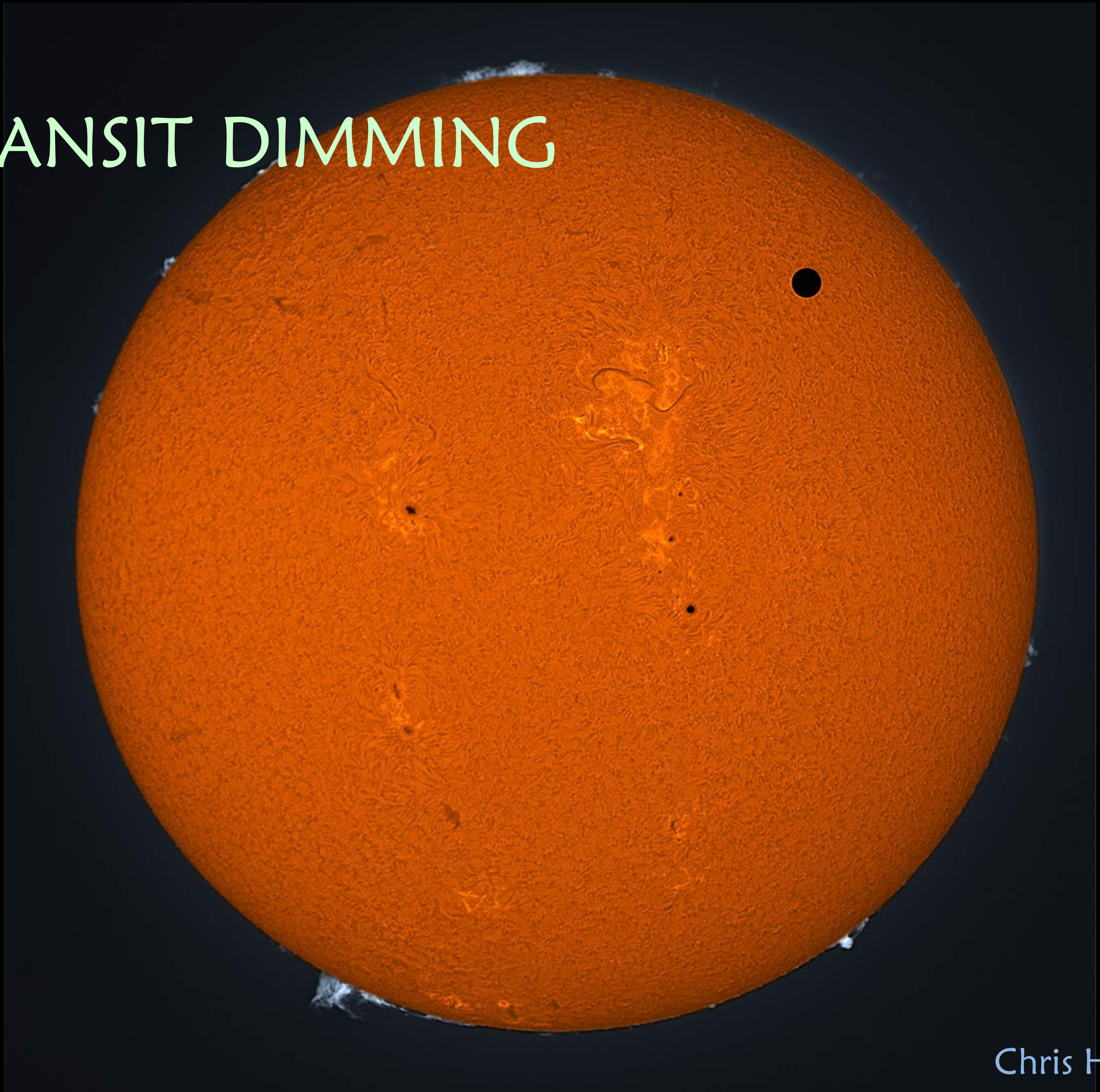


PSR B1620-26b

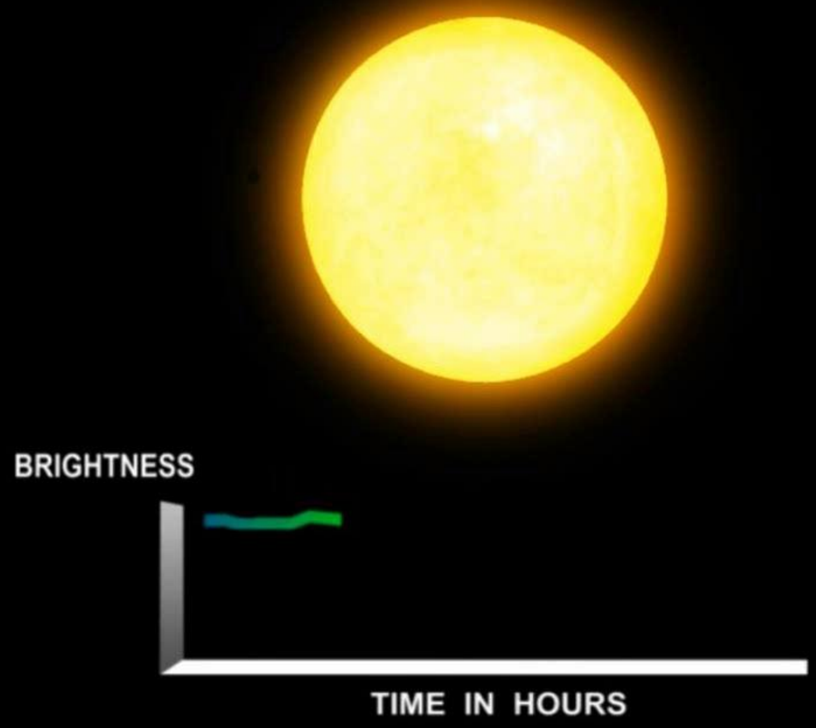
mass ~ 3.5 M_J

orbital radius ~ 23 AU

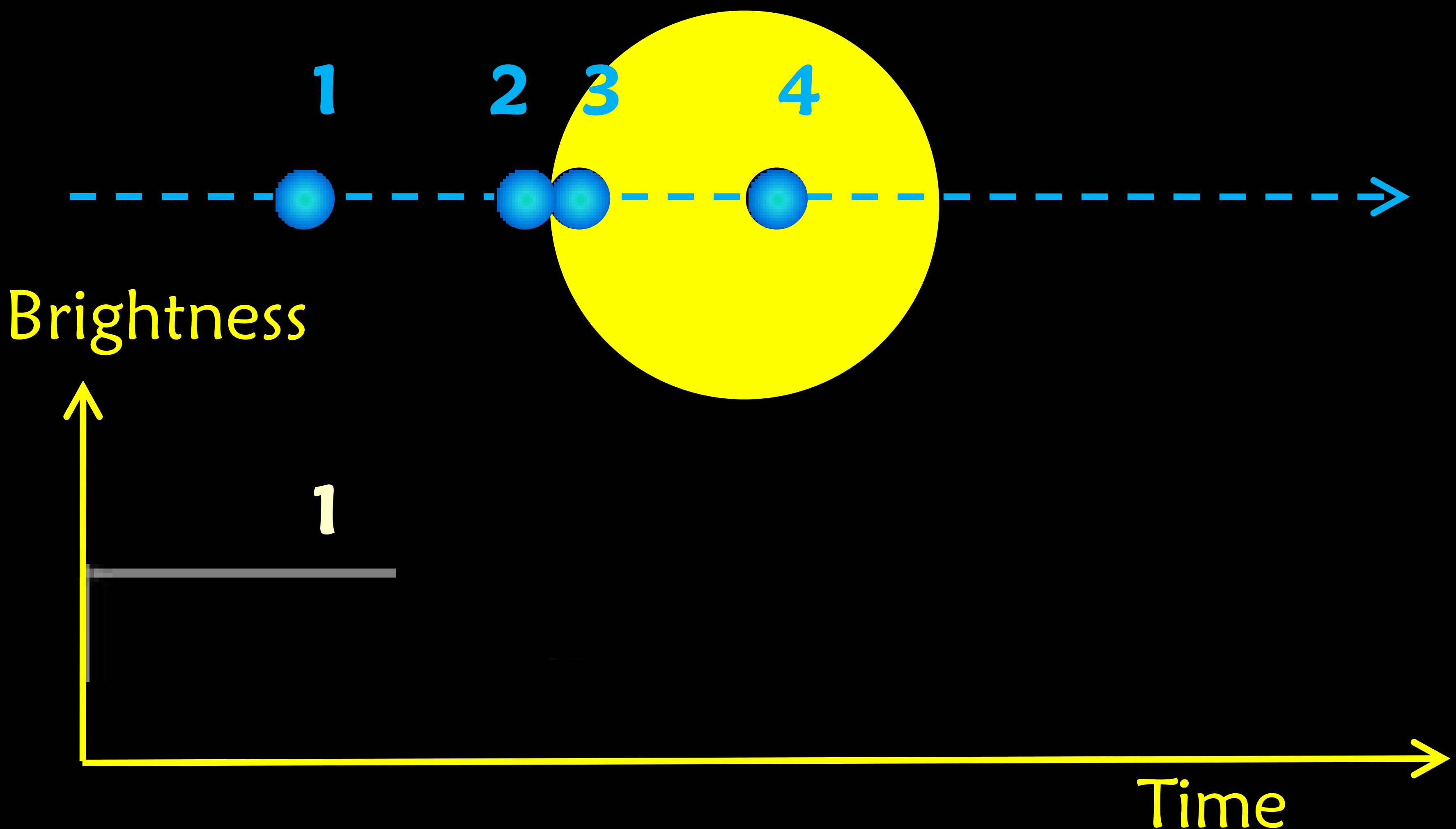
Transit dimming

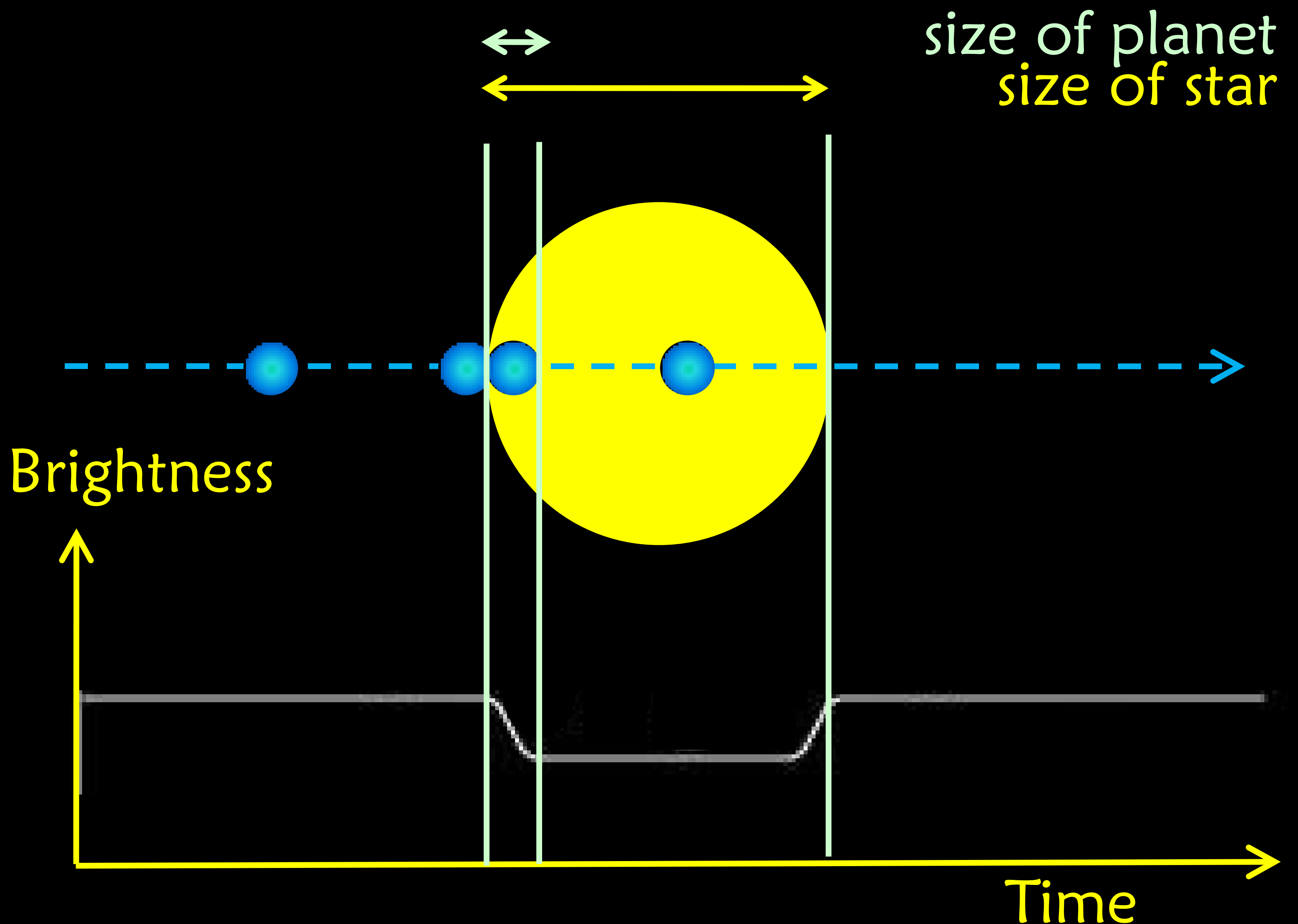


Chris Hetlage

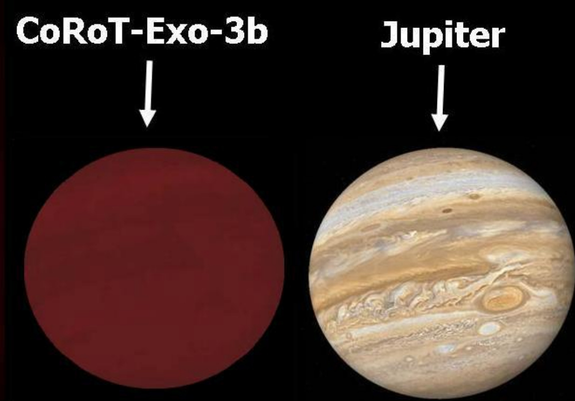


Kepler/NASA/ESA


1
2
3
4
Brightness
1
Time



size of planet
size of star
Brightness
Time

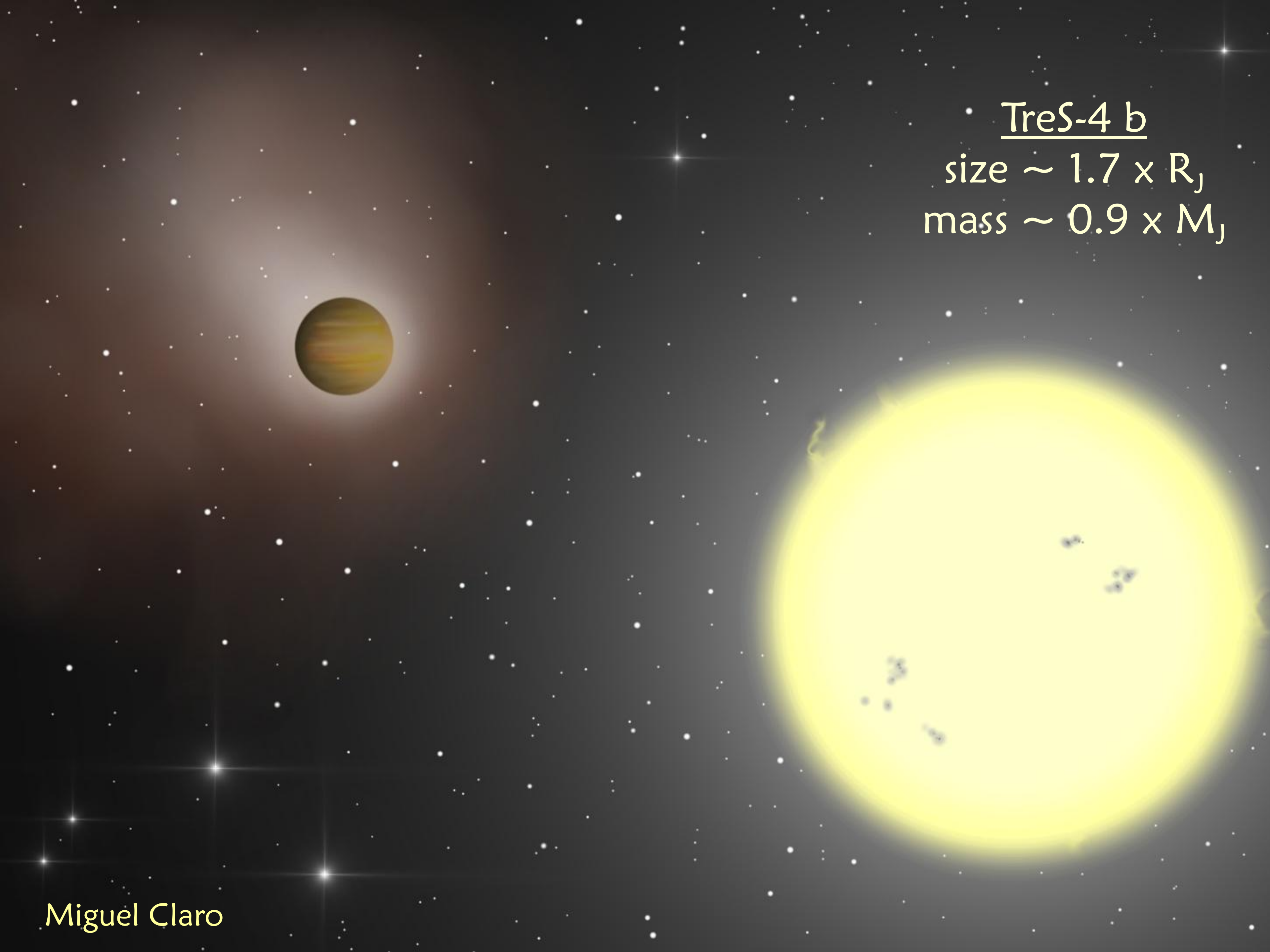


<u>CoRoT 3b</u>

mass ~ 22 M_J

Size ~ 1 R_J

L'Observatoire Astronomique Marseille-Provence


TreS-4 b
size ~ 1.7 x R_J
mass ~ 0.9 x M_J
Miguel Claro

ESO/AC Cameron

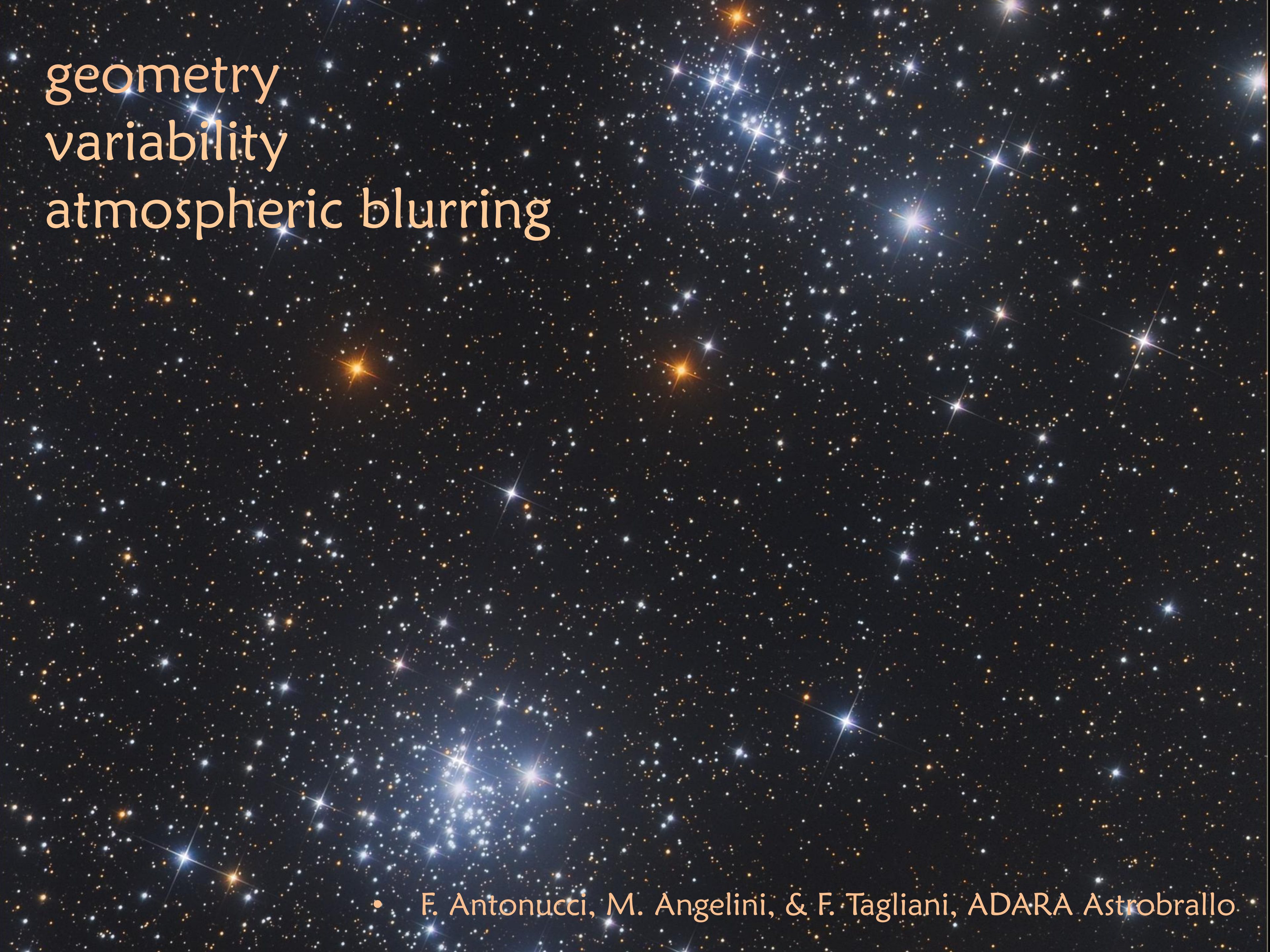
geometry

- F. Antonucci, M. Angelini, & F. Tagliani, ADARA Astrobrallo

geometry
variability

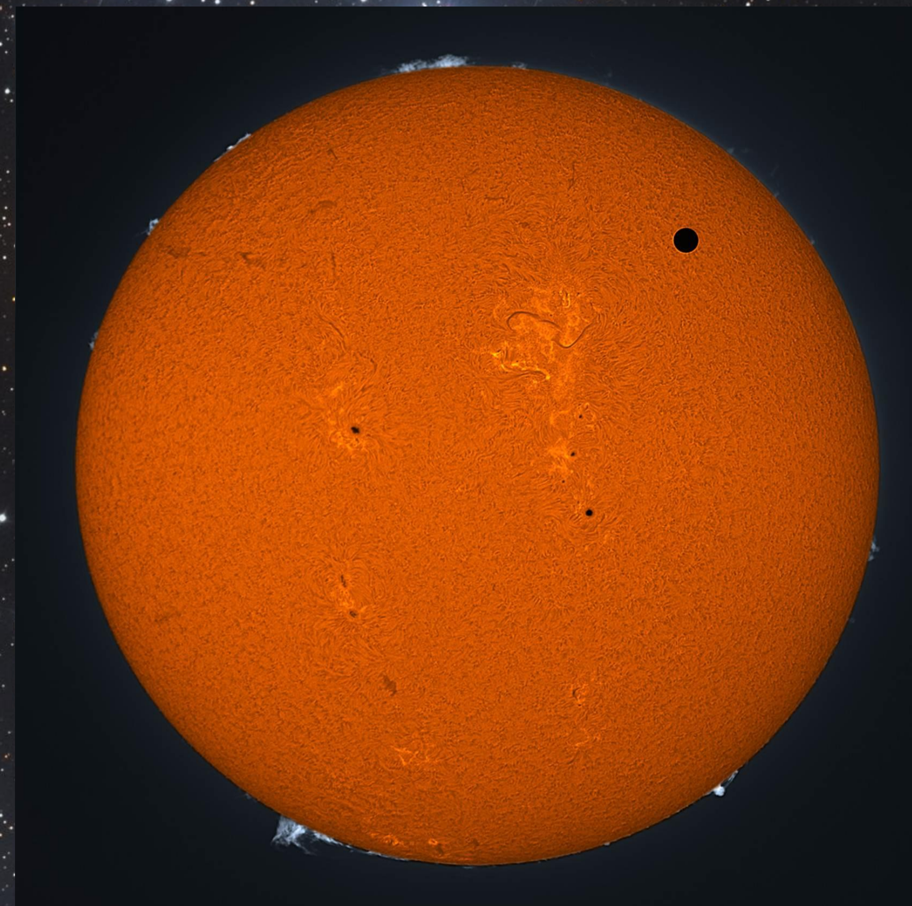
- F. Antonucci, M. Angelini, & F. Tagliani, ADARA Astrobrallo

geometry
variability
atmospheric blurring



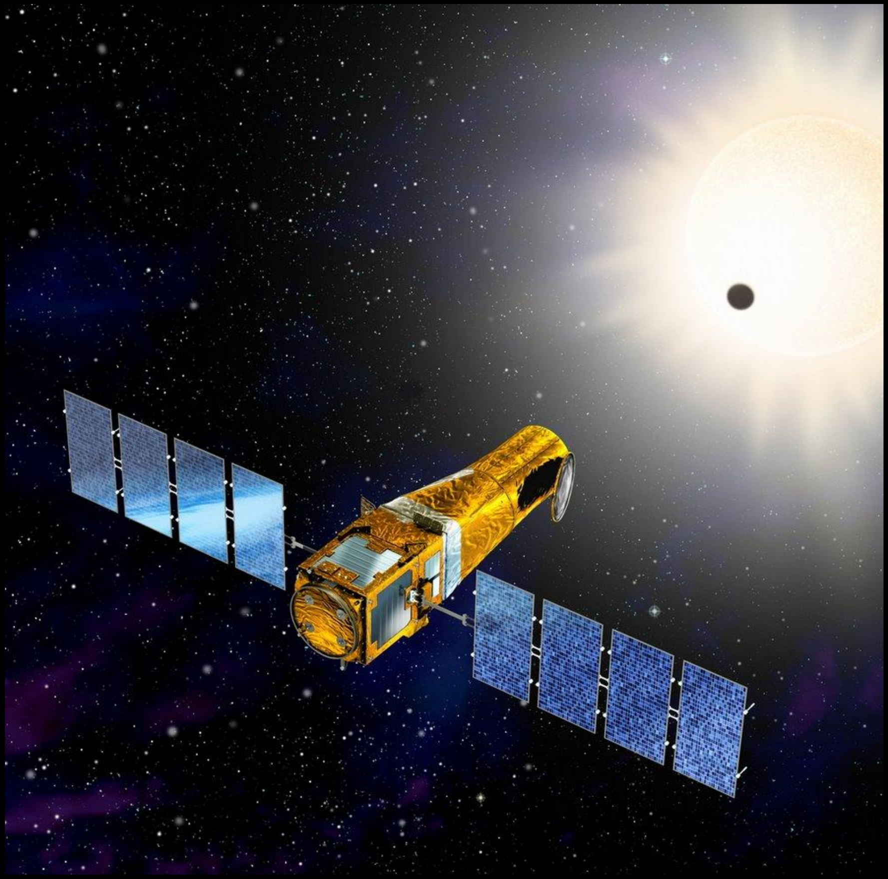
- F. Antonucci, M. Angelini, & F. Tagliani, ADARA Astrobrallo

geometry
variability
atmospheric blurring
starspots



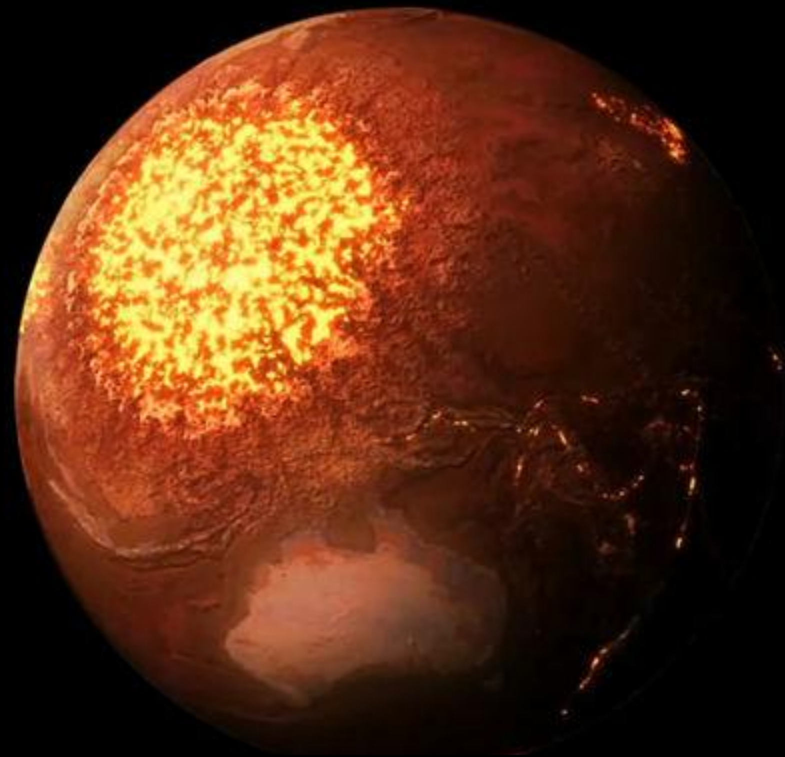
- Chris Hetlage
- F. Antonucci, M. Angelini, & F. Tagliani, ADARA Astrobrallo

CoRoT



Moon

Earth



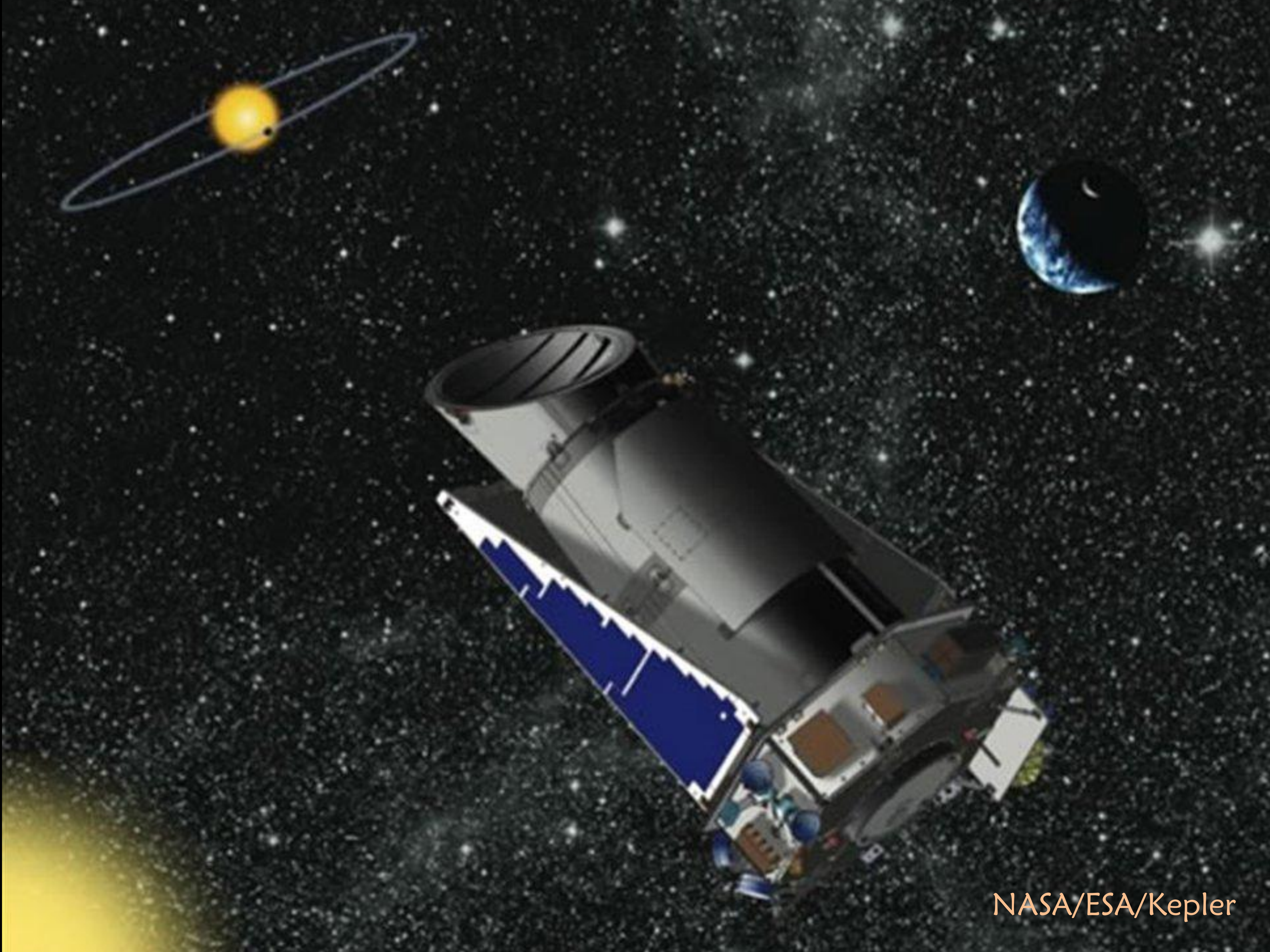
CoRoT-7b

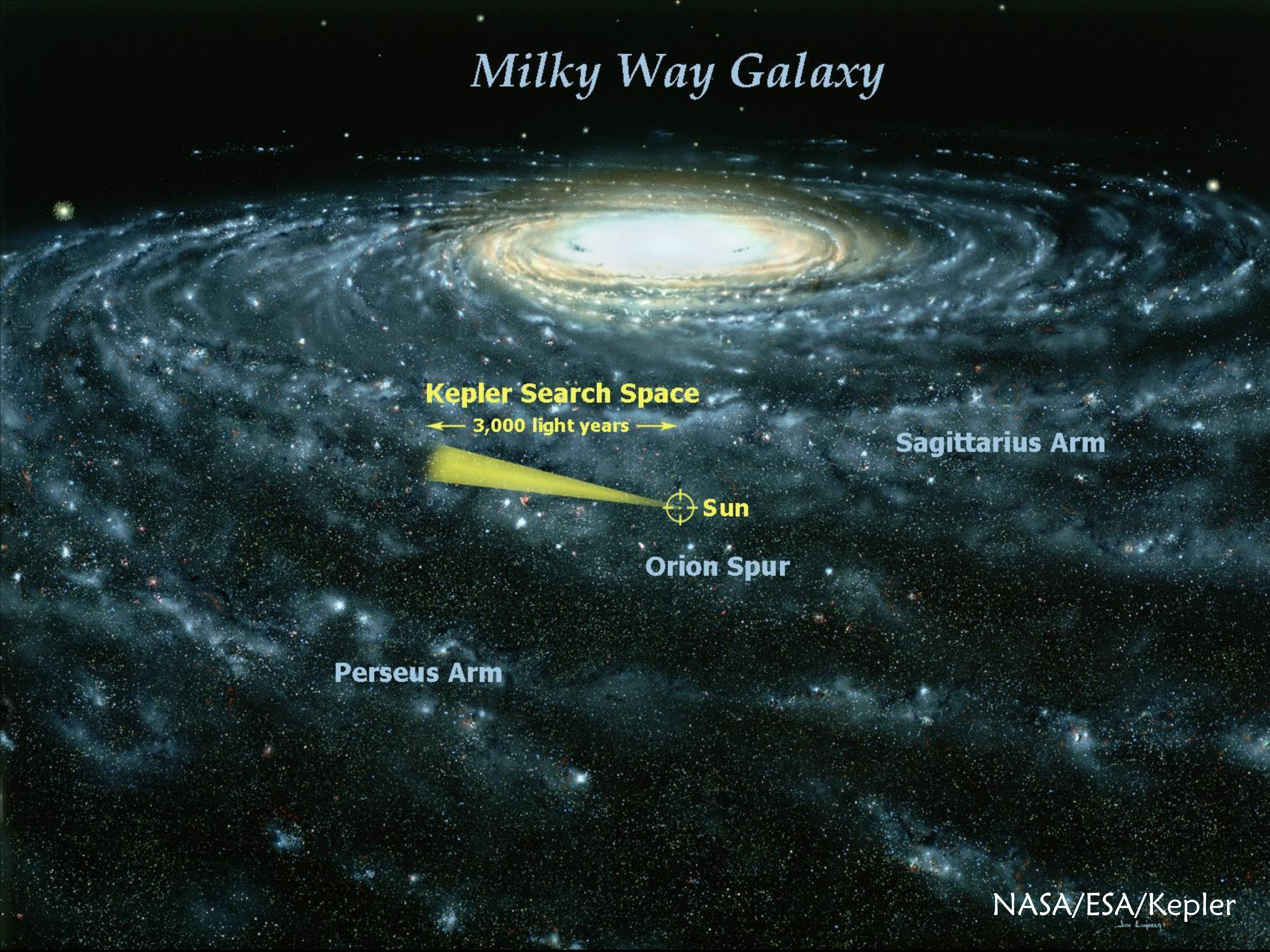
mass ~ 5 M_E

radius ~ 1.7 R_E

orbit ~ 20.4 hours

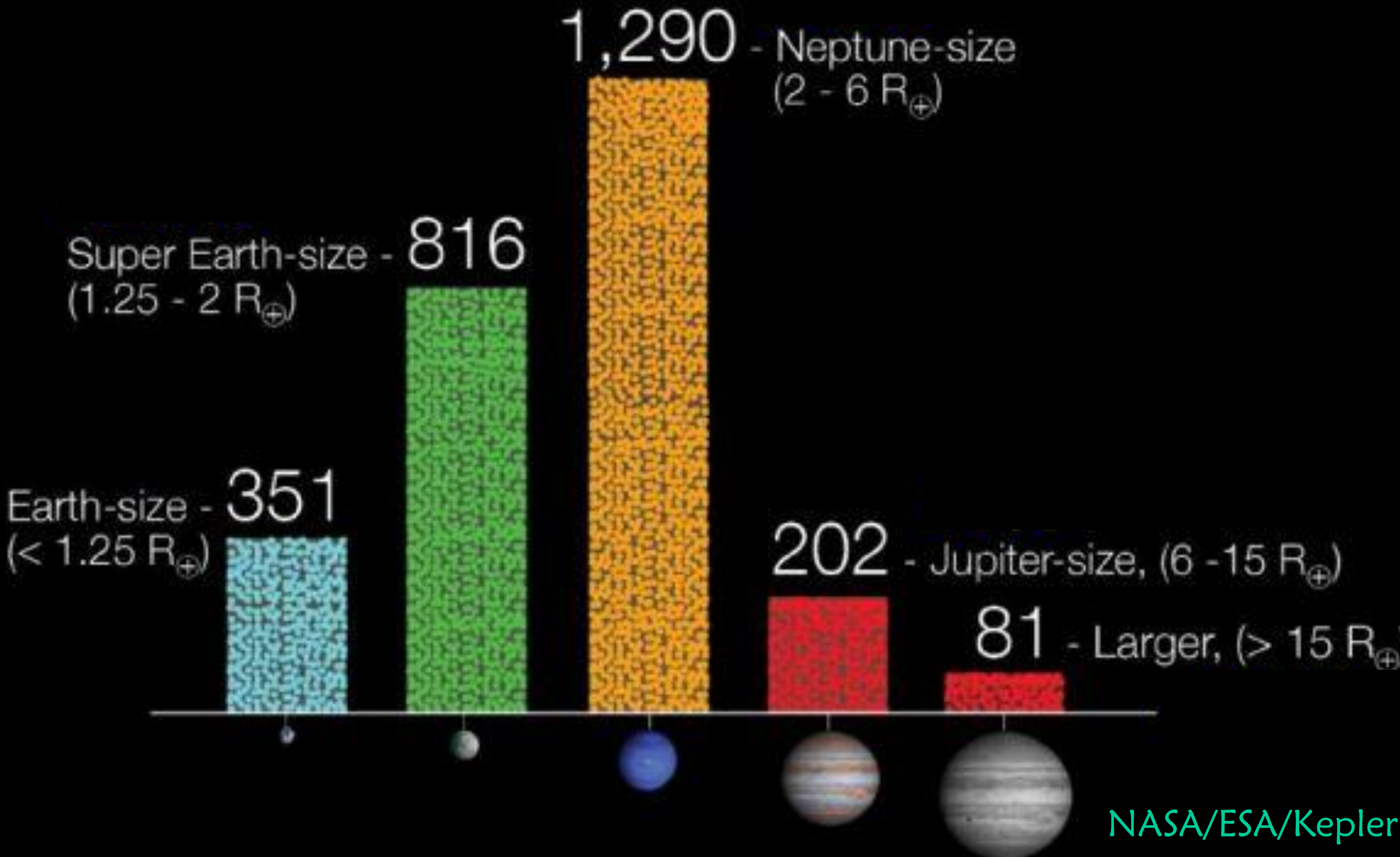

CoRoT-9b
mass ~ 1 M_J
radius ~ 1 R_J
orbit ~ 95 days
IAC


NASA/ESA/Kepler

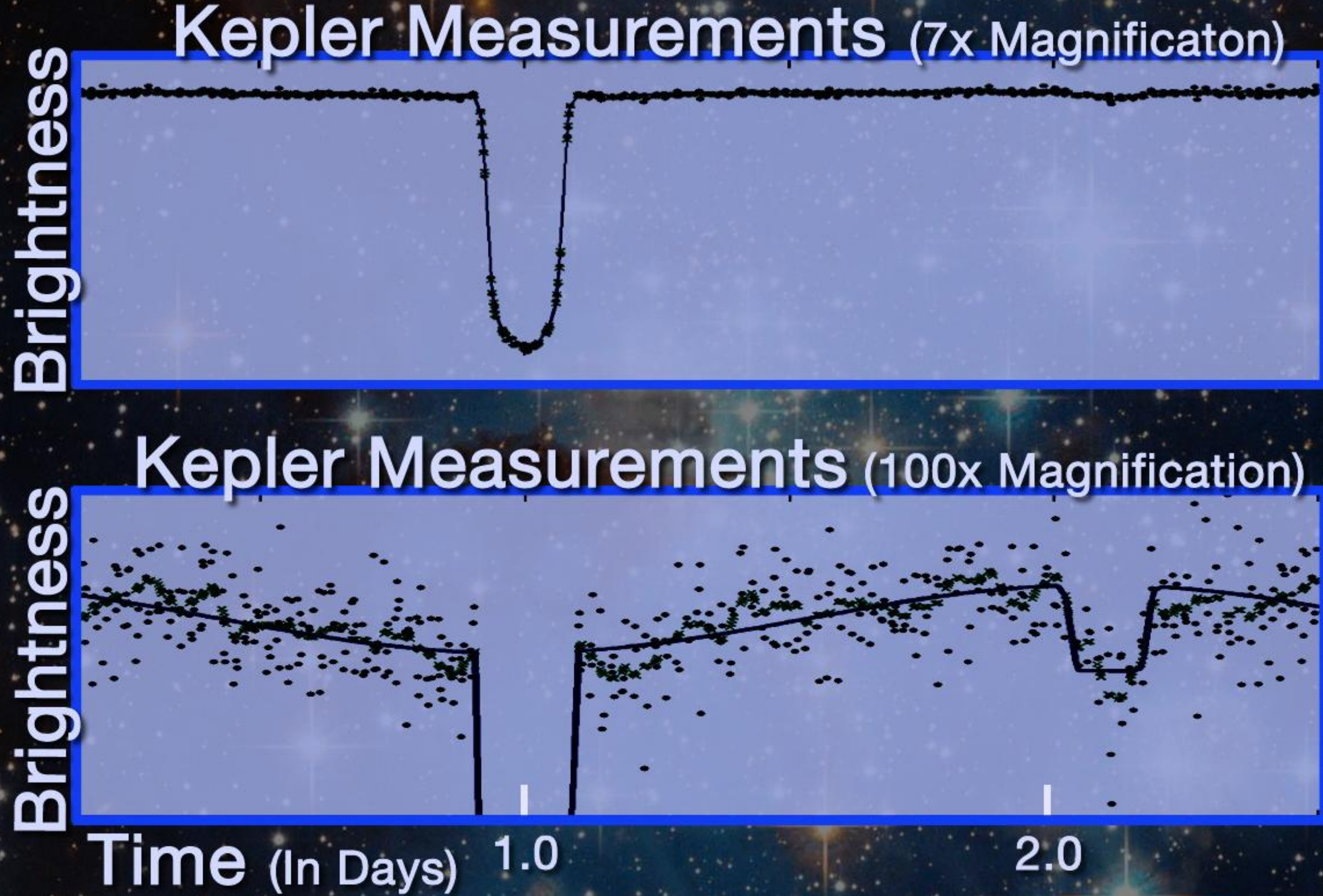

Milky Way Galaxy
Kepler Search Space
3,000 light years
Sun
Sagittarius Arm
Orion Spur
Perseus Arm
NASA/ESA/Kepler

Sizes of Planet Candidates

As of January 7, 2013



NASA/ESA/Kepler

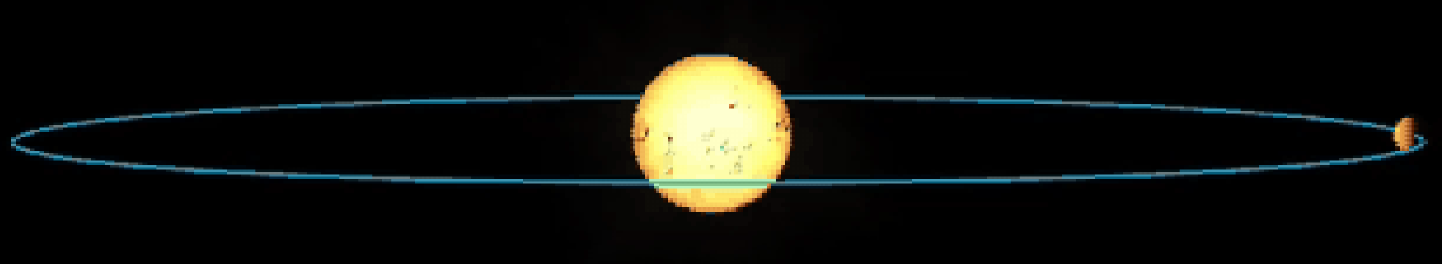


HAT-P-7B

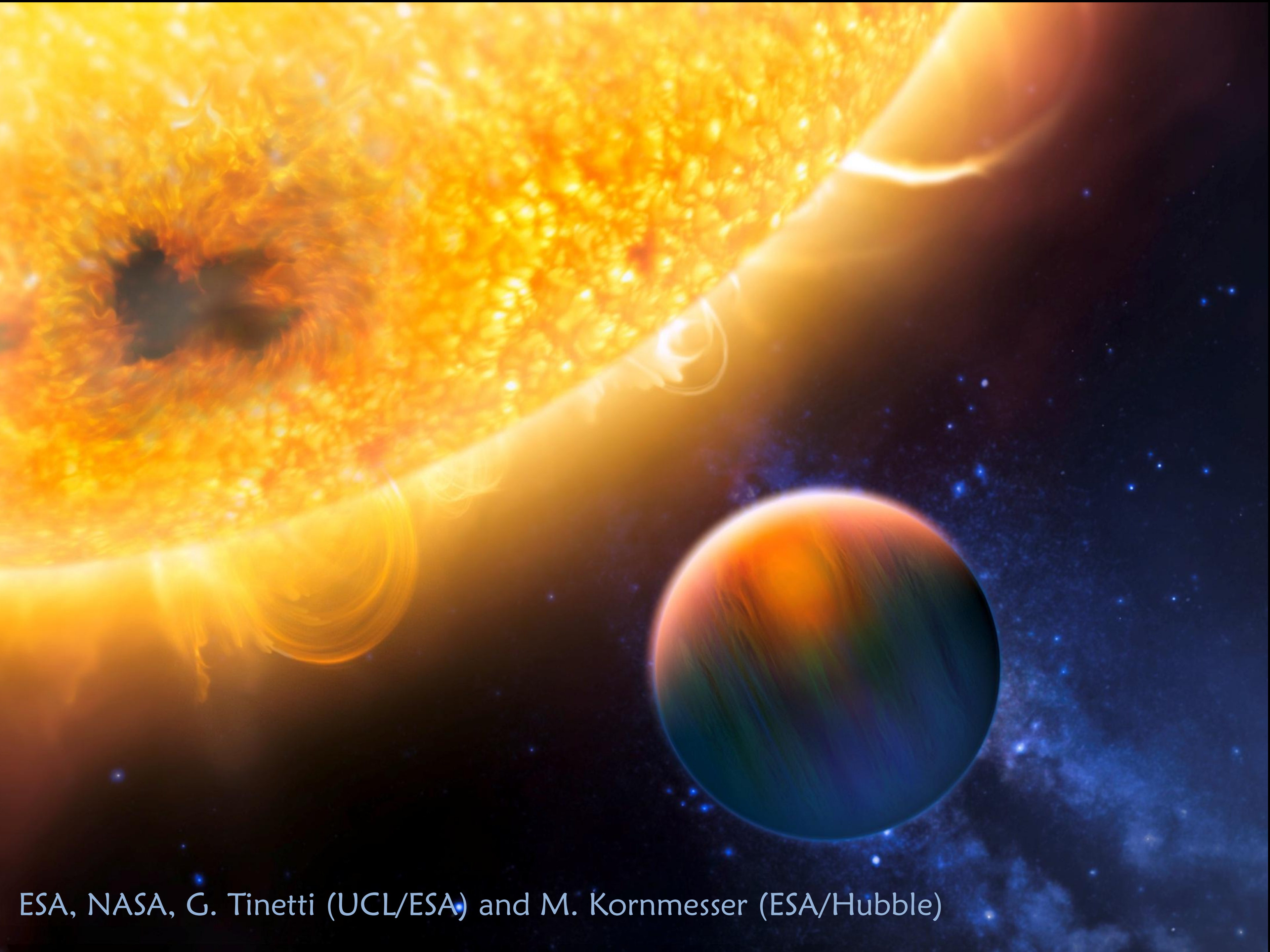
mass ~ 1 M_J

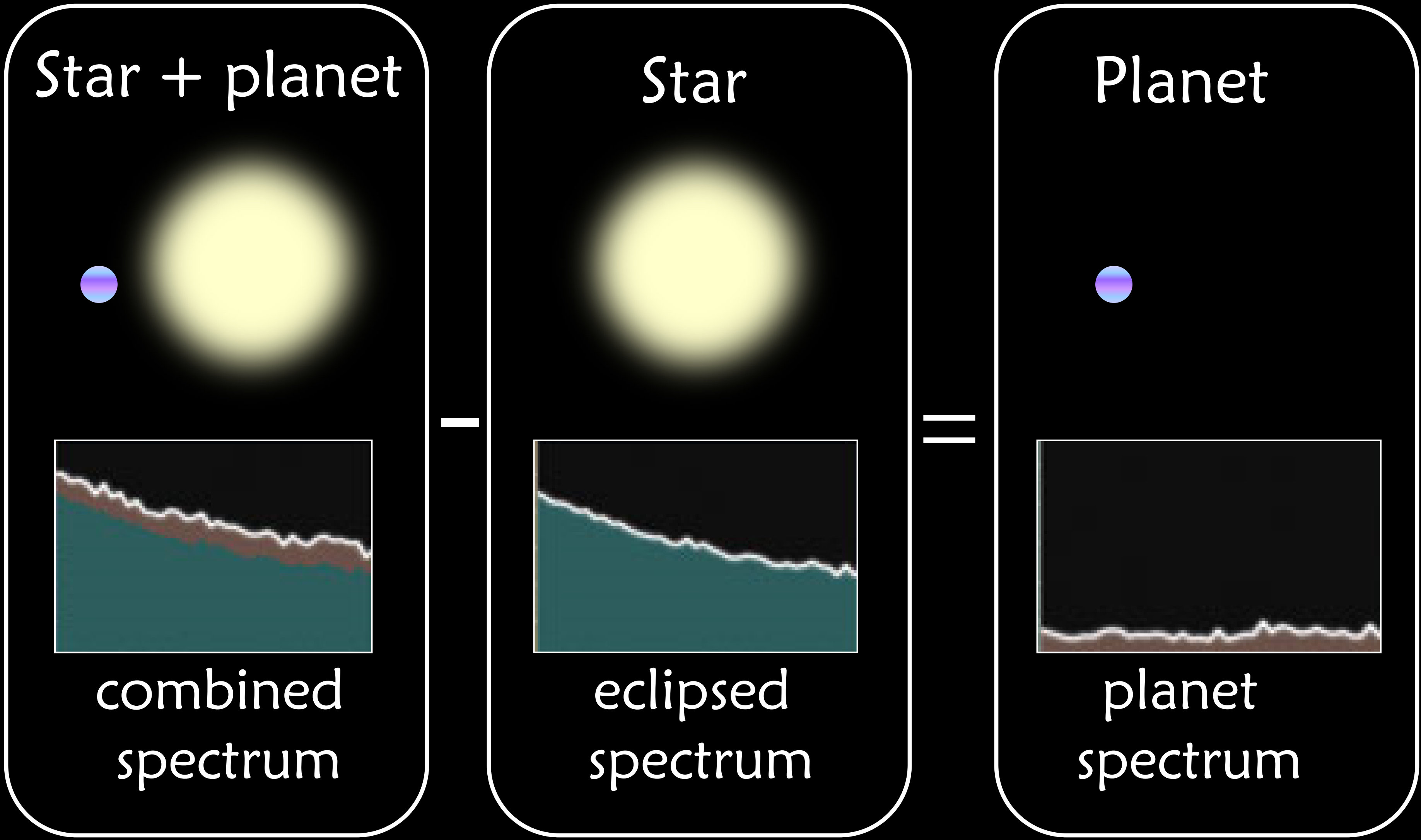
orbit ~ 2 days

NASA Ames Research Centre

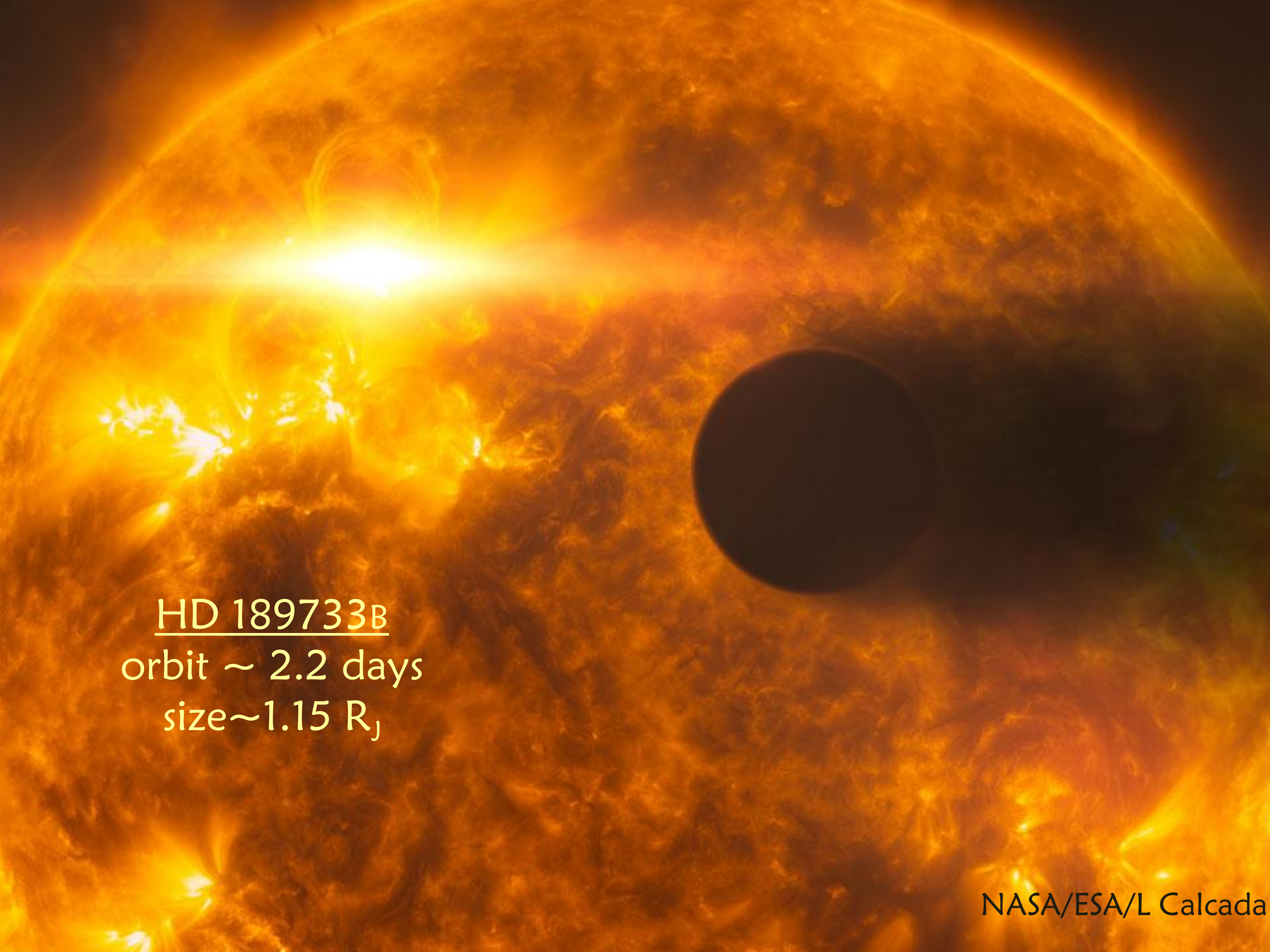


NASA/Kepler mission/Dana Berry

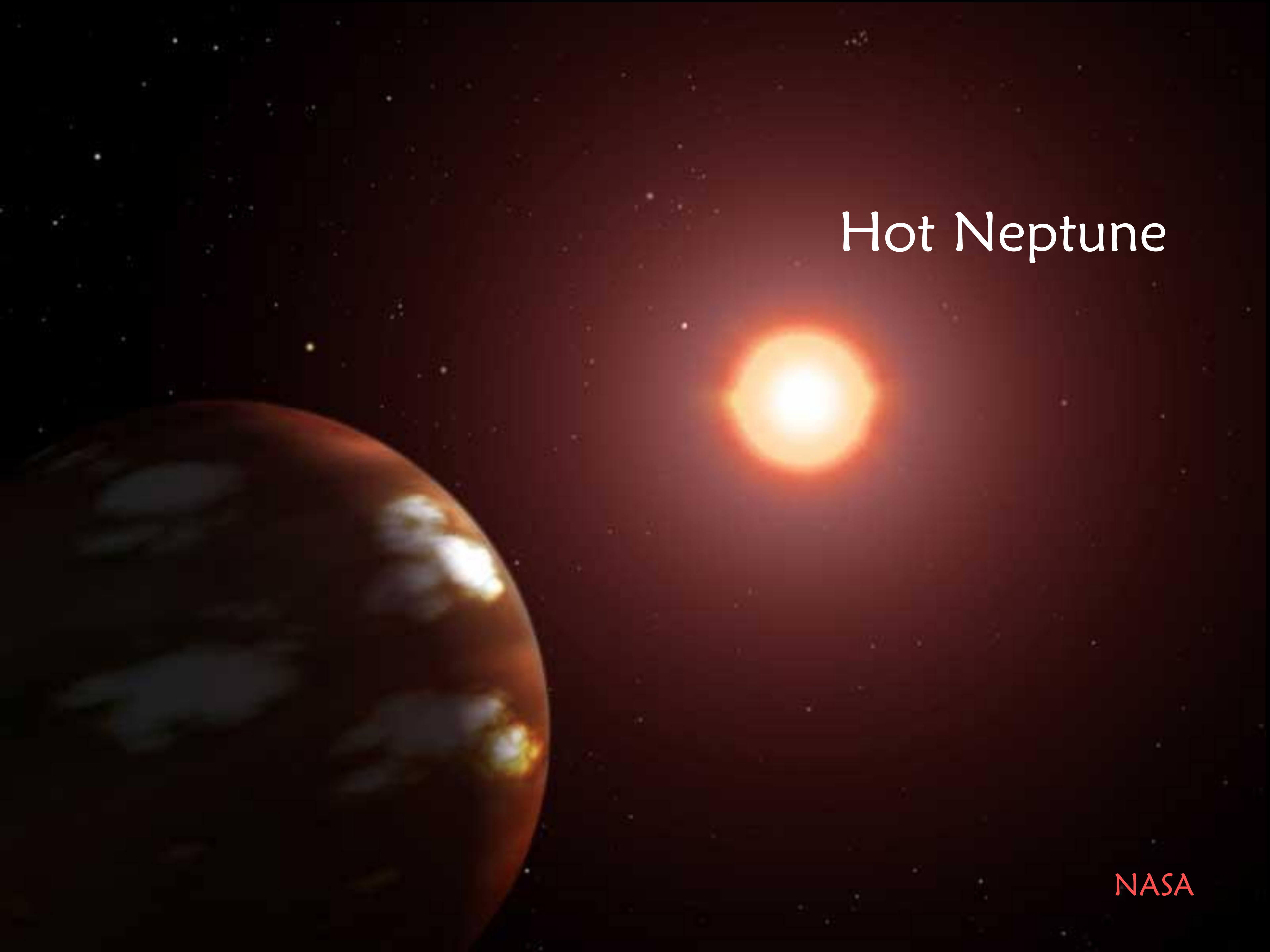

ESA, NASA, G. Tinetti (UCL/ESA) and M. Kornmesser (ESA/Hubble)

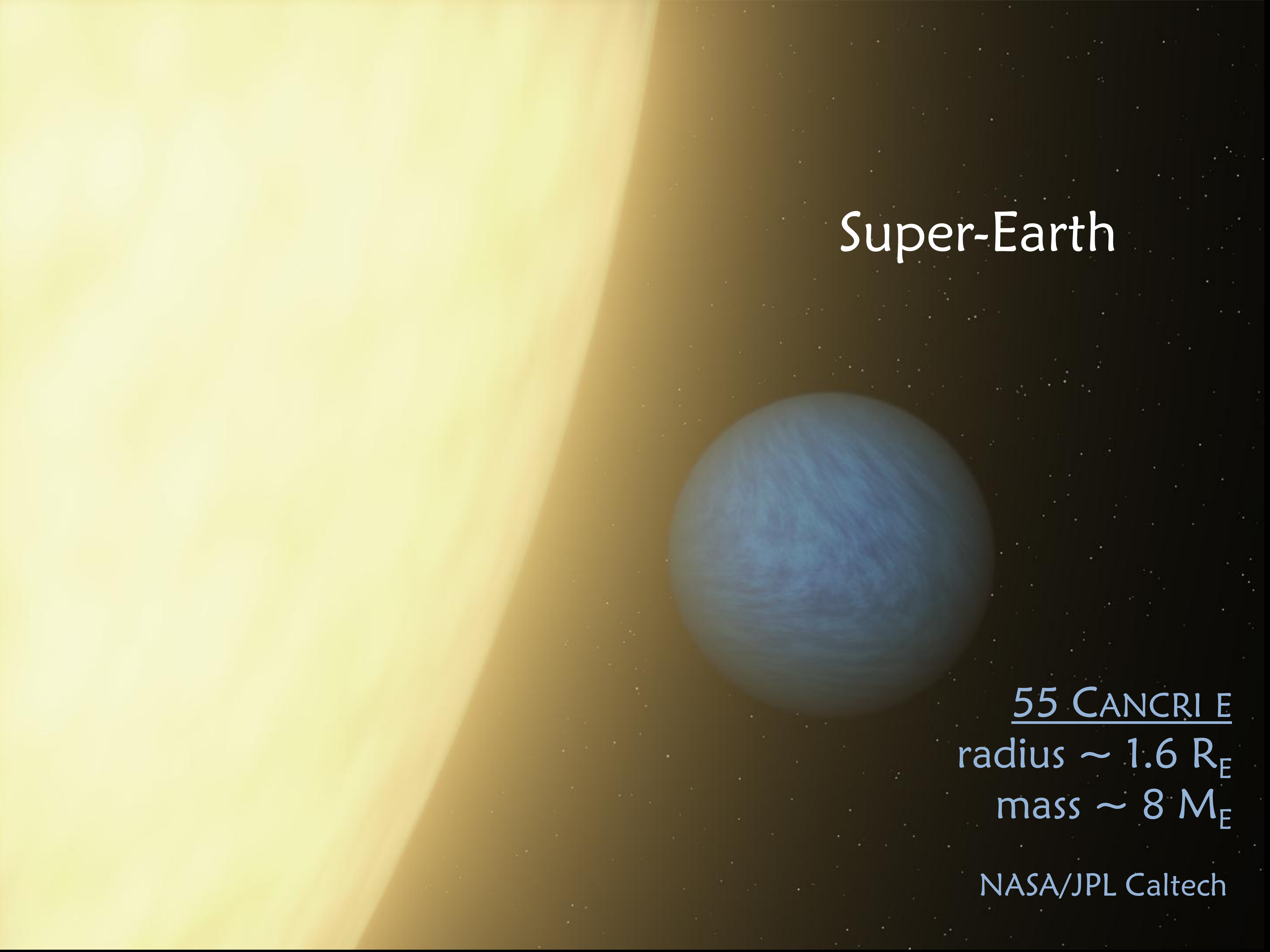


Star + planet
combined spectrum
–
Star
eclipsed spectrum
=
Planet
planet spectrum

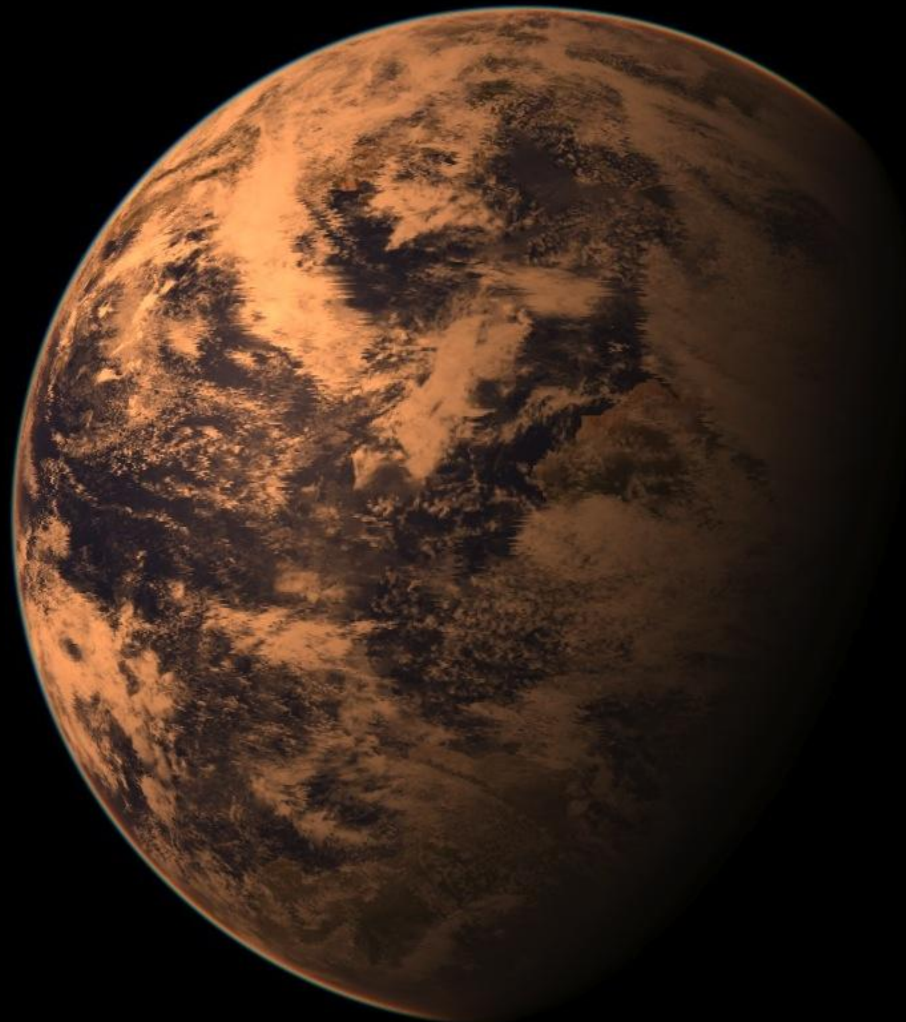

HD 189733B
orbit ~ 2.2 days
size~1.15 R_J
NASA/ESA/L Calcada


Hot Jupiter
M. Hernon Obispo


Hot Neptune
NASA

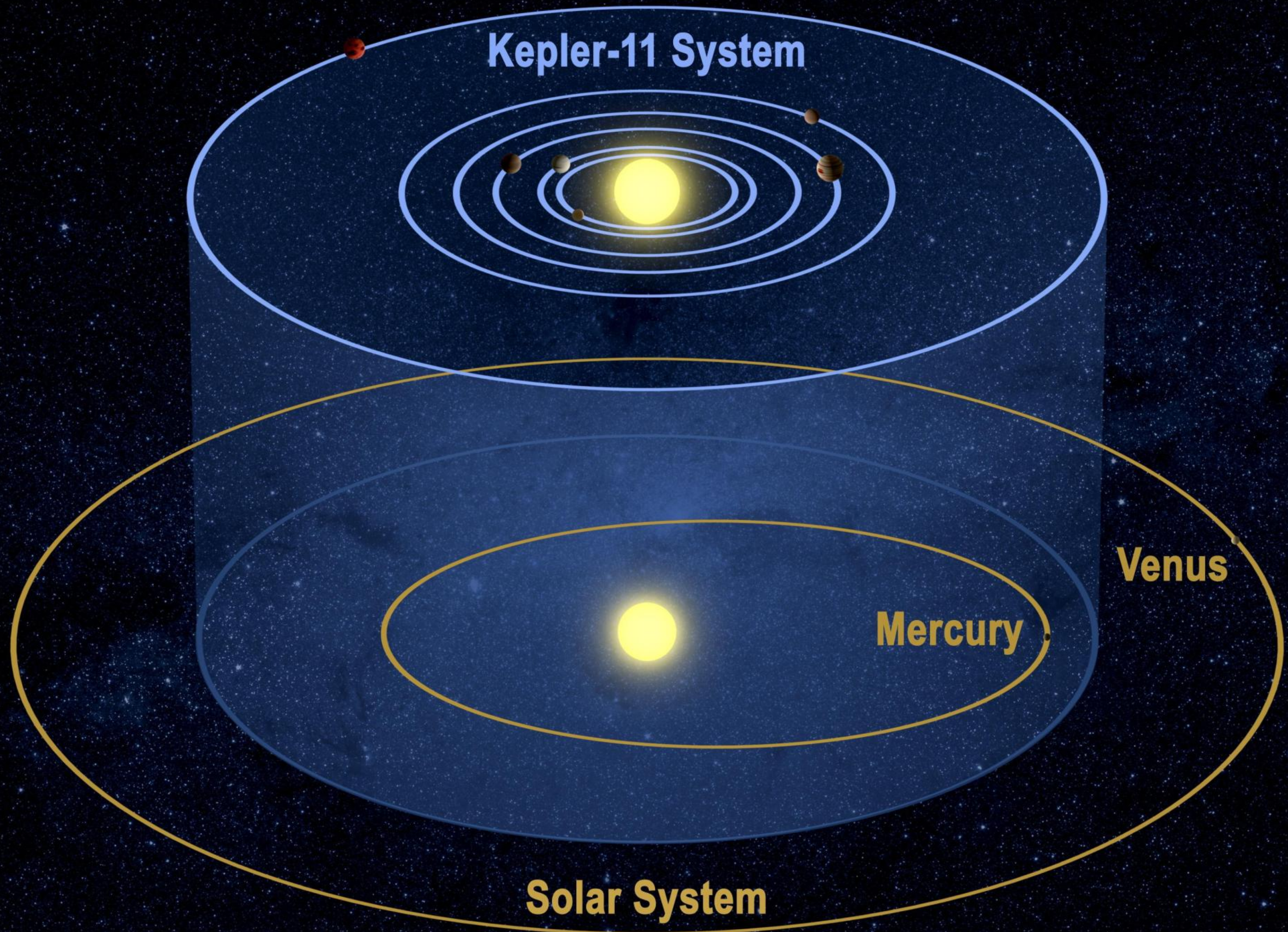

Super-Earth
55 Cancri e
radius ~ 1.6 R_E
mass ~ 8 M_E
NASA/JPL Caltech

Earth

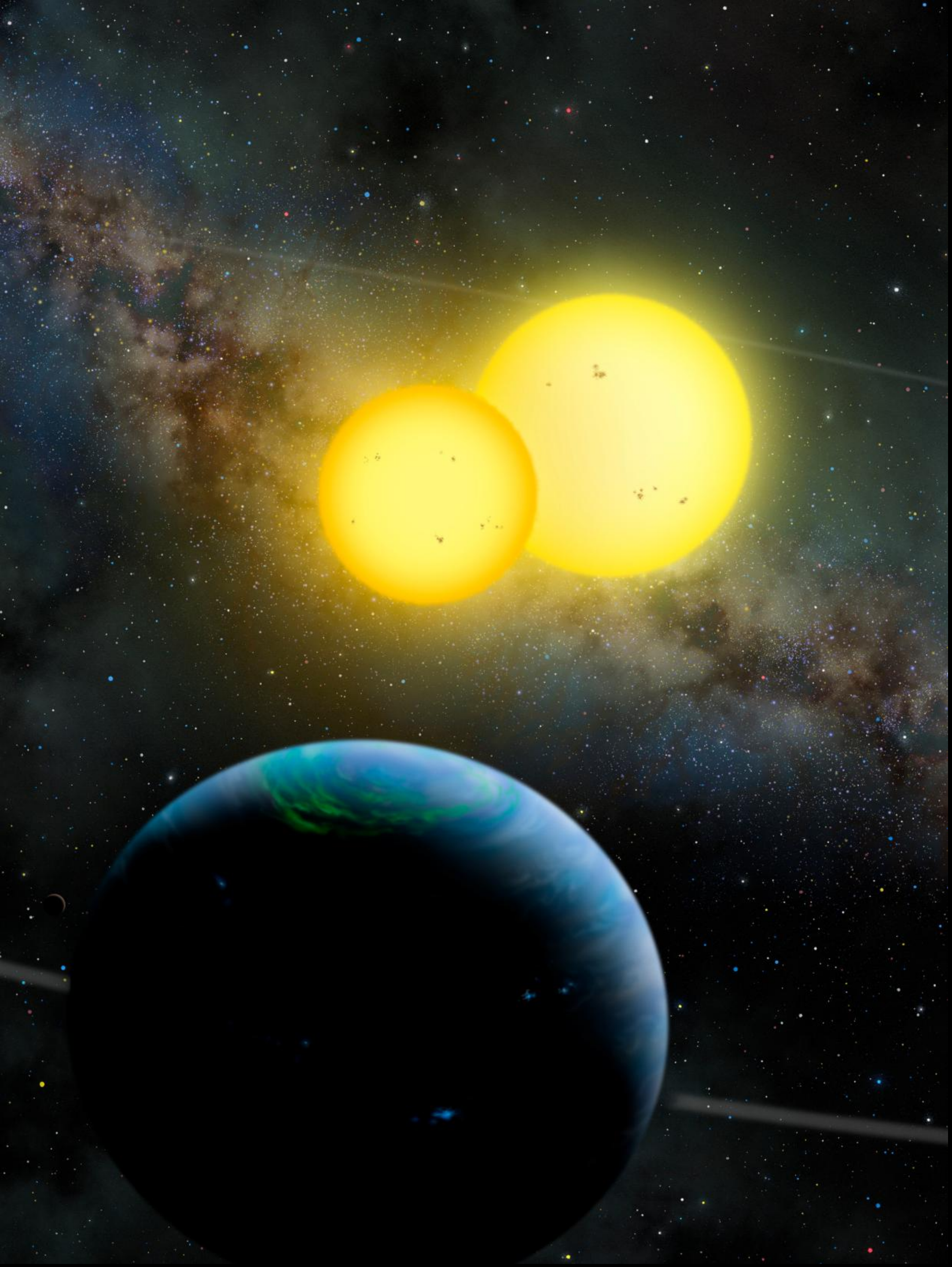


GLIESE 667CC
orbit ~ 28 days
mass ~ 4.5 M_E

Planetary Habitability Laboratory



Tim Pyle, NASA



<u>Kepler-34b</u>

planetary orbit ~ 289 days

stellar orbit ~ 28 days

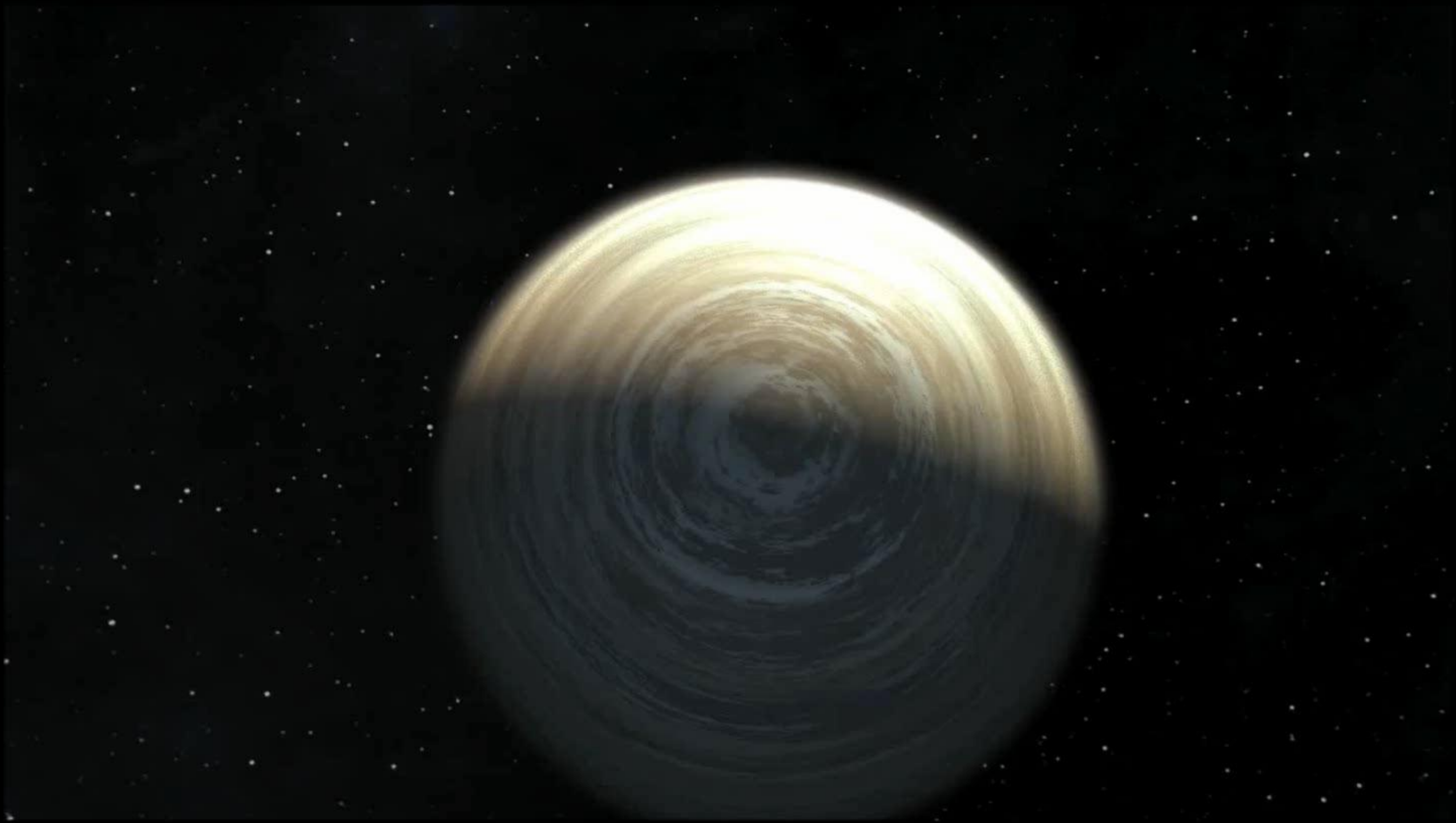
<u>Kepler-35b</u>

planetary orbit ~ 131 days

stellar orbit ~21 days

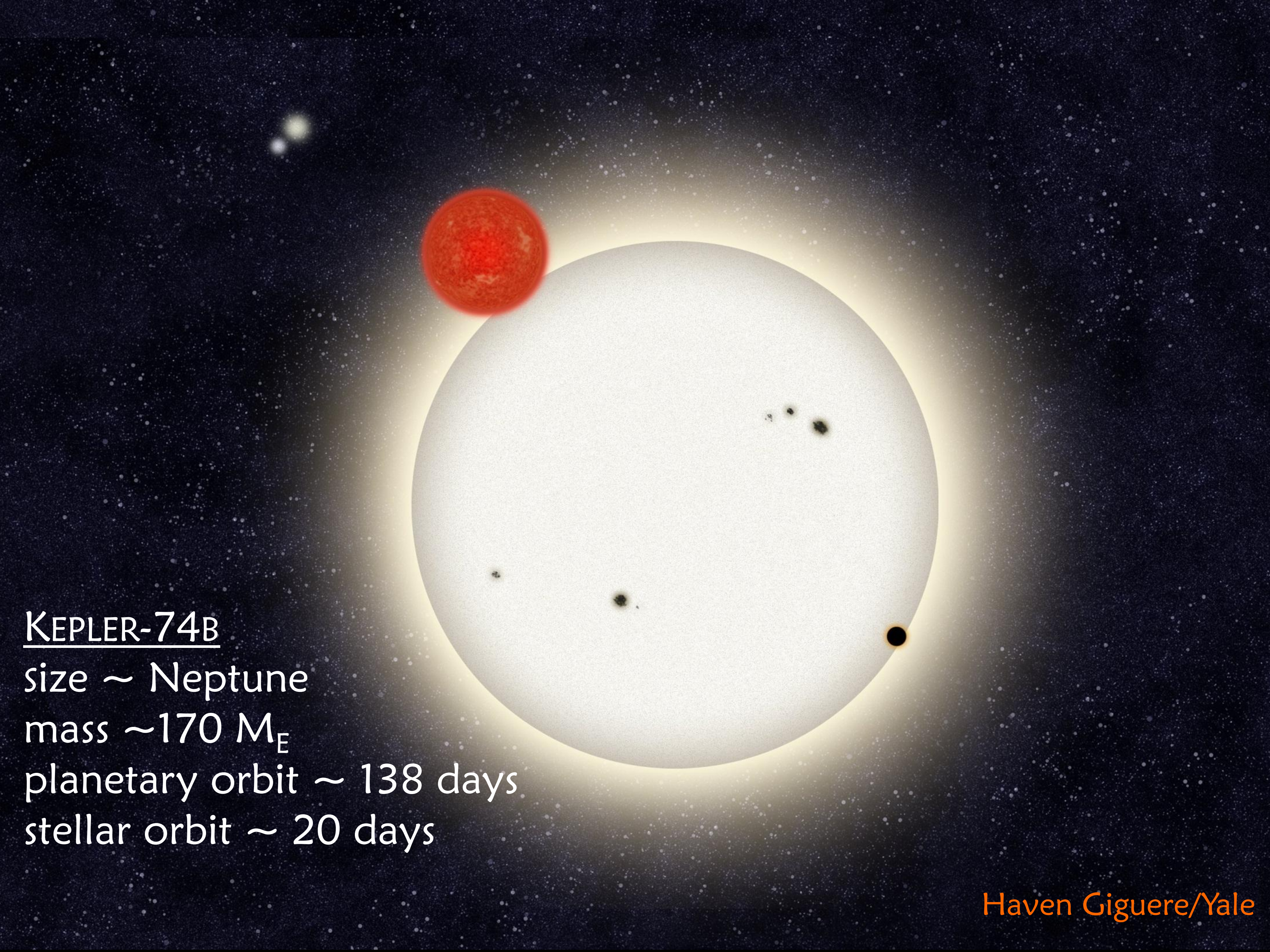
sizes~Saturn

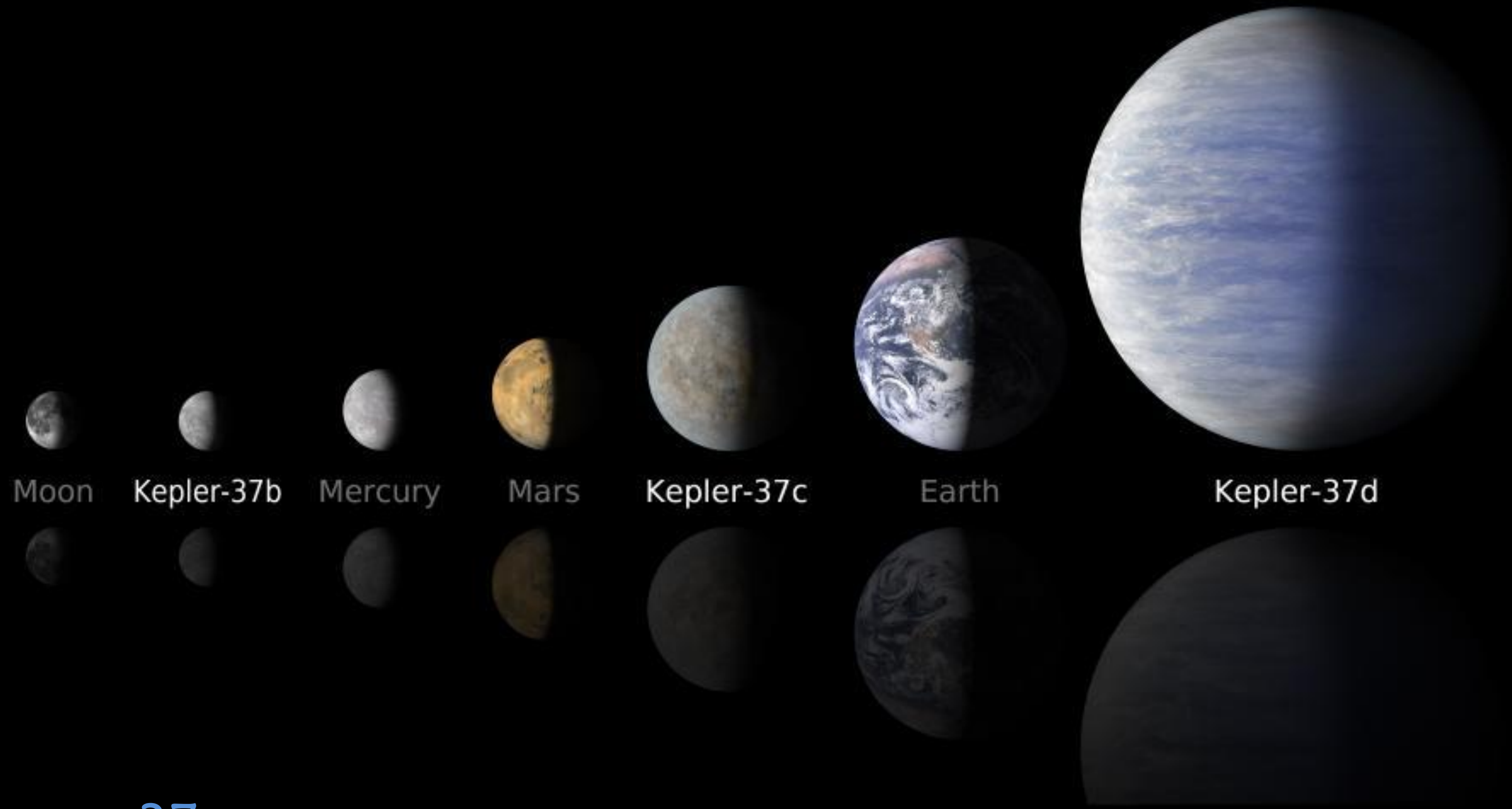
Lynette Cook



KEPLER 16B

NASA/JPL-Caltech/T Pyle

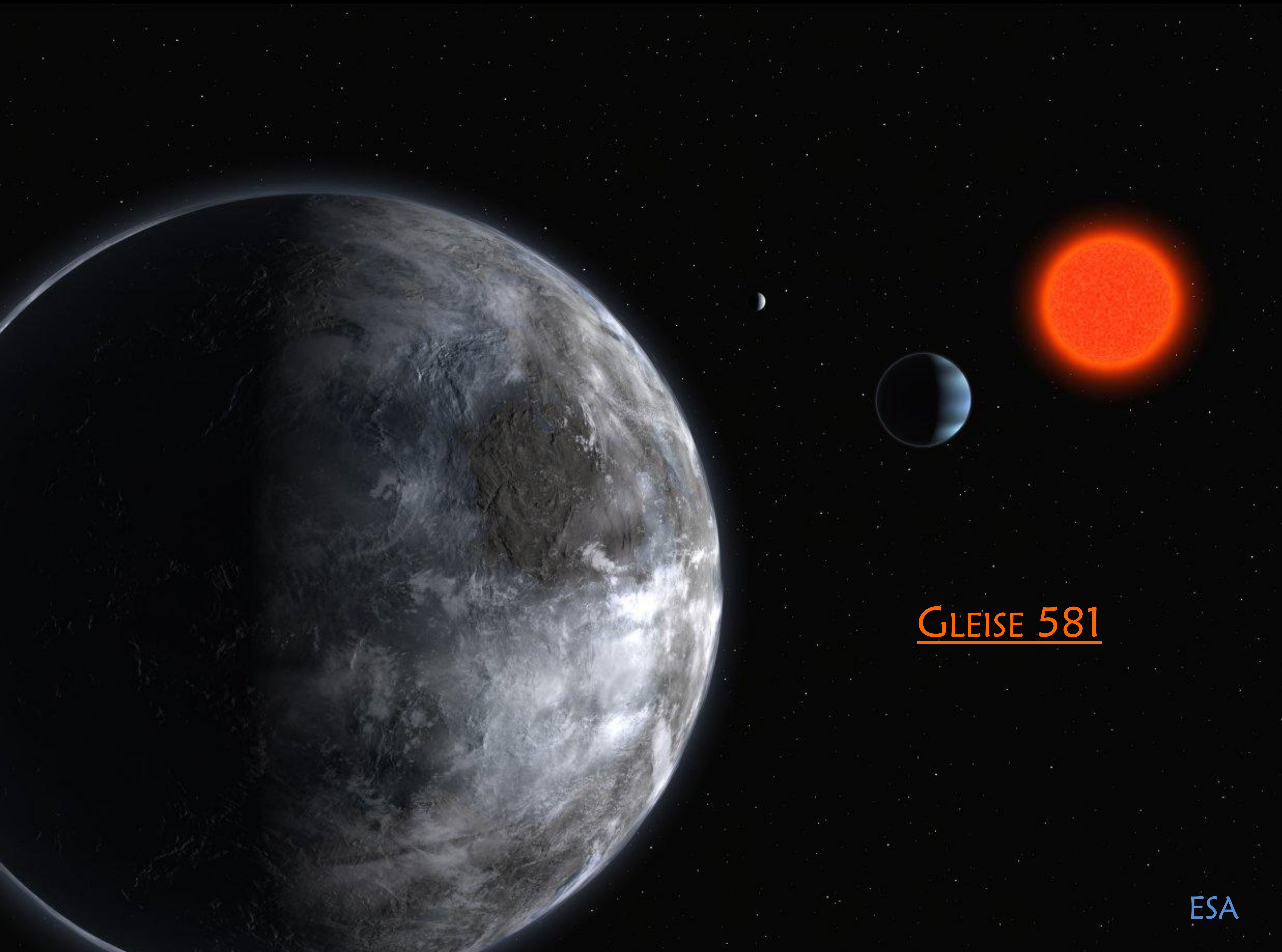

KEPLER-74B
size ~ Neptune
mass ~170 M_E
planetary orbit ~ 138 days
stellar orbit ~ 20 days
Haven Giguere/Yale

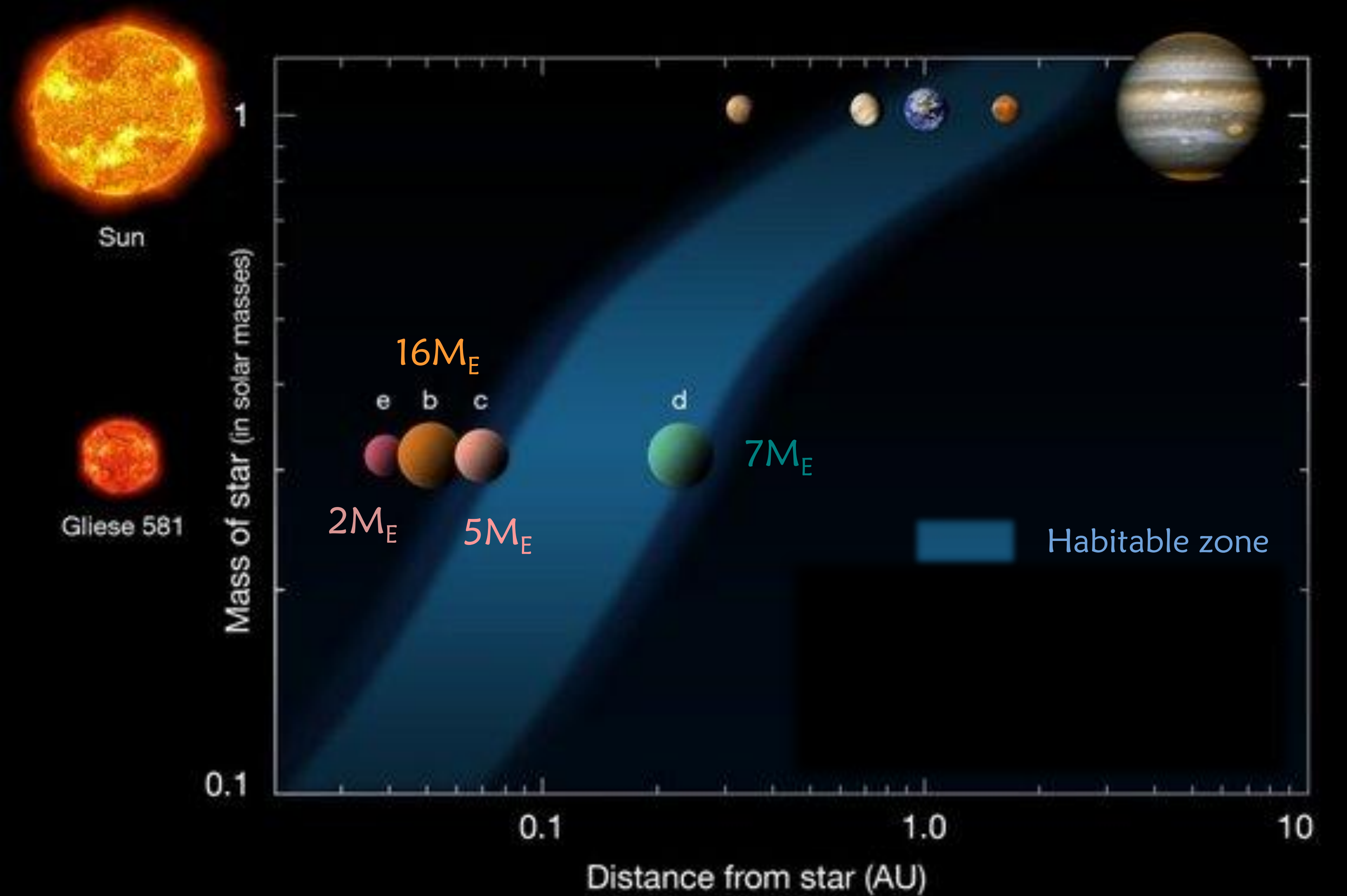


<u>Kepler-37b</u>

orbit ~ 13 days

NASA/Ames/JPL-Caltech


GLEISE 581
ESA



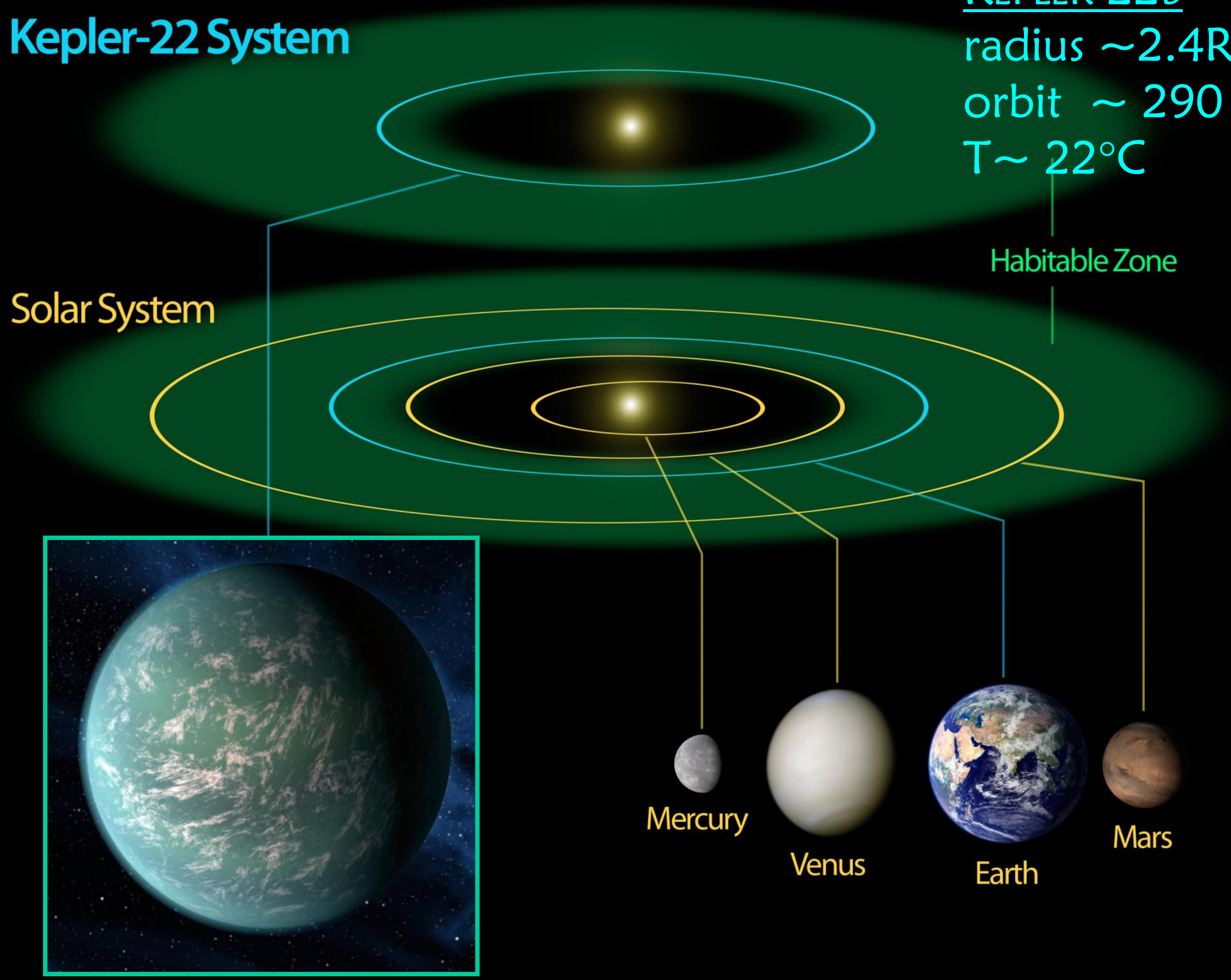
Sun
Gliese 581
Mass of star (in solar masses)
1
0.1
16M_E
e
b
c
d
2M_E
5M_E
7M_E
Habitable zone
0.1
1.0
10
Distance from star (AU)

Kepler 22b

radius ~$2.4R_E$

orbit ~ 290 days

T~ 22°C



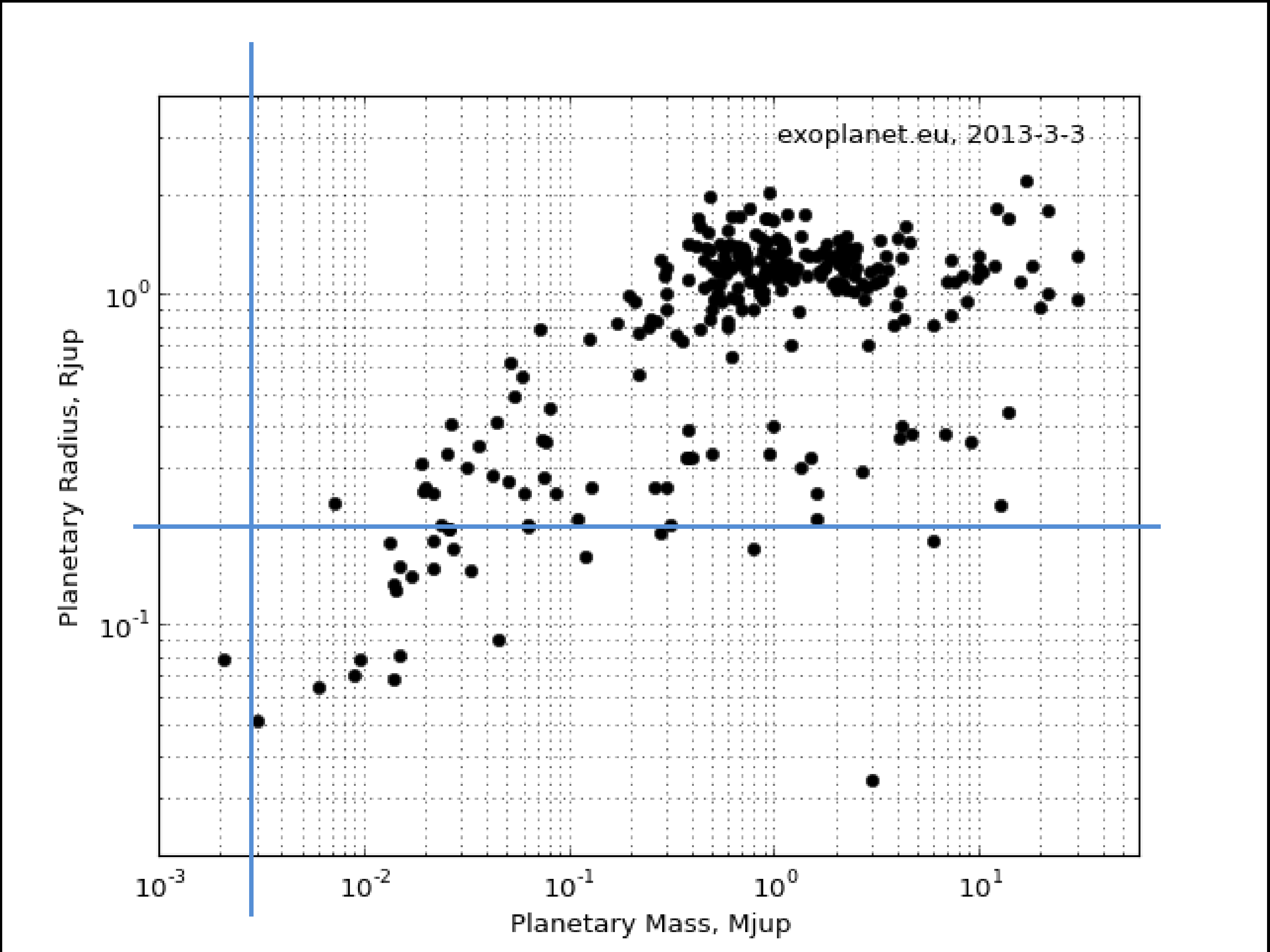
KOI 172.02

radius ~$1.5R_E$

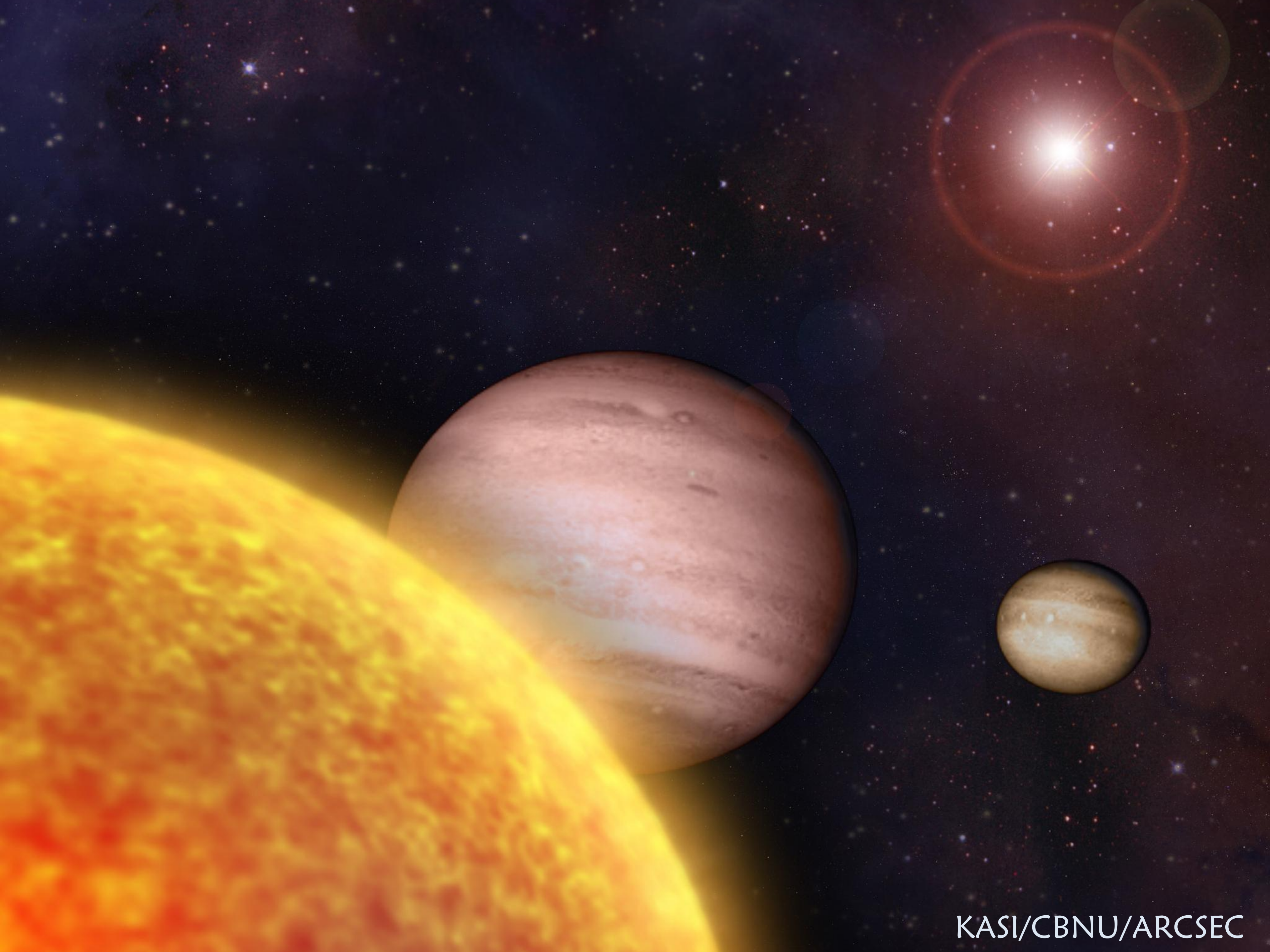
orbit ~ 242 days, 0.75 AU

NASA-Ames Research Center

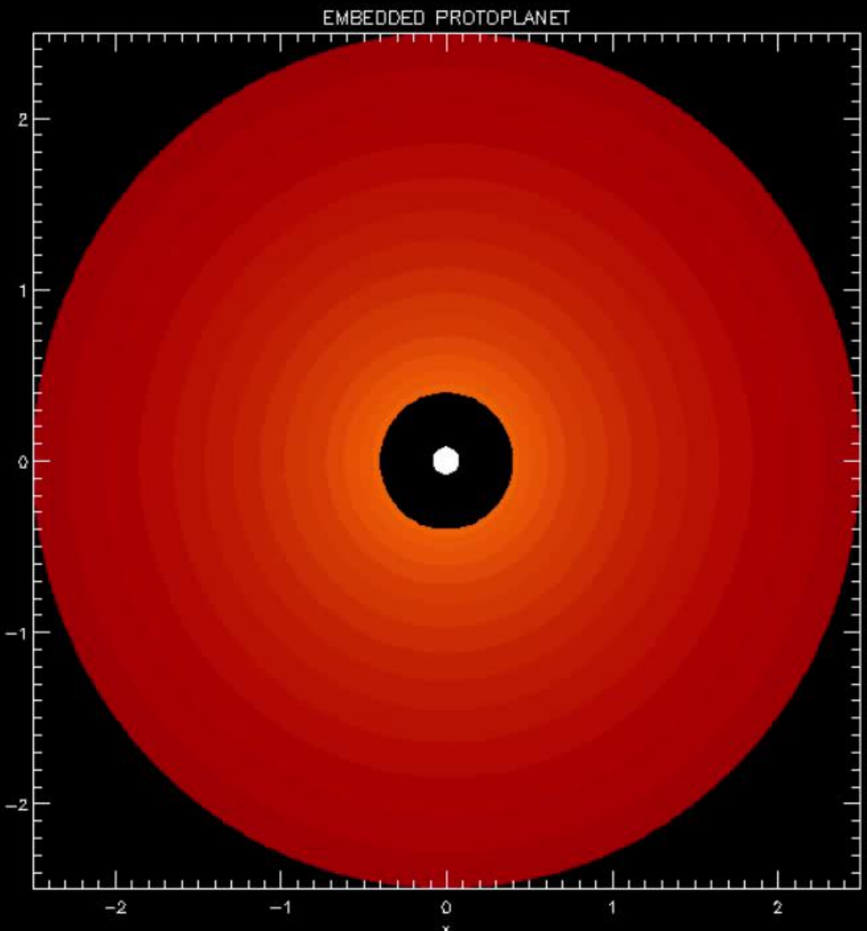
	Planetary systems	**Planets**	**Multiple planet systems**
all	683	861	124
transit dimming	238	294	37
radial velocity	389	502	81
microlensing	16	18	2
imaging	28	32	2
[illegible]	[illegible]	[illegible]	[illegible]

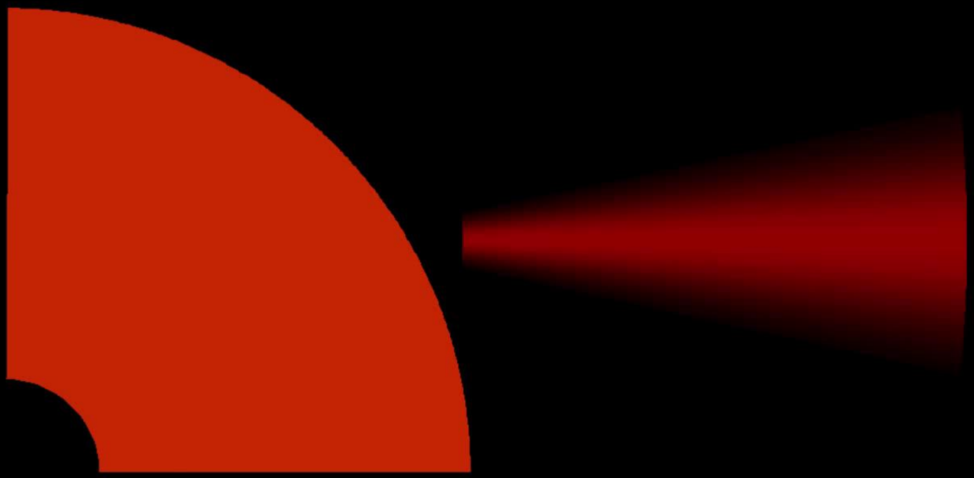


Exoplanets Encyclopedia

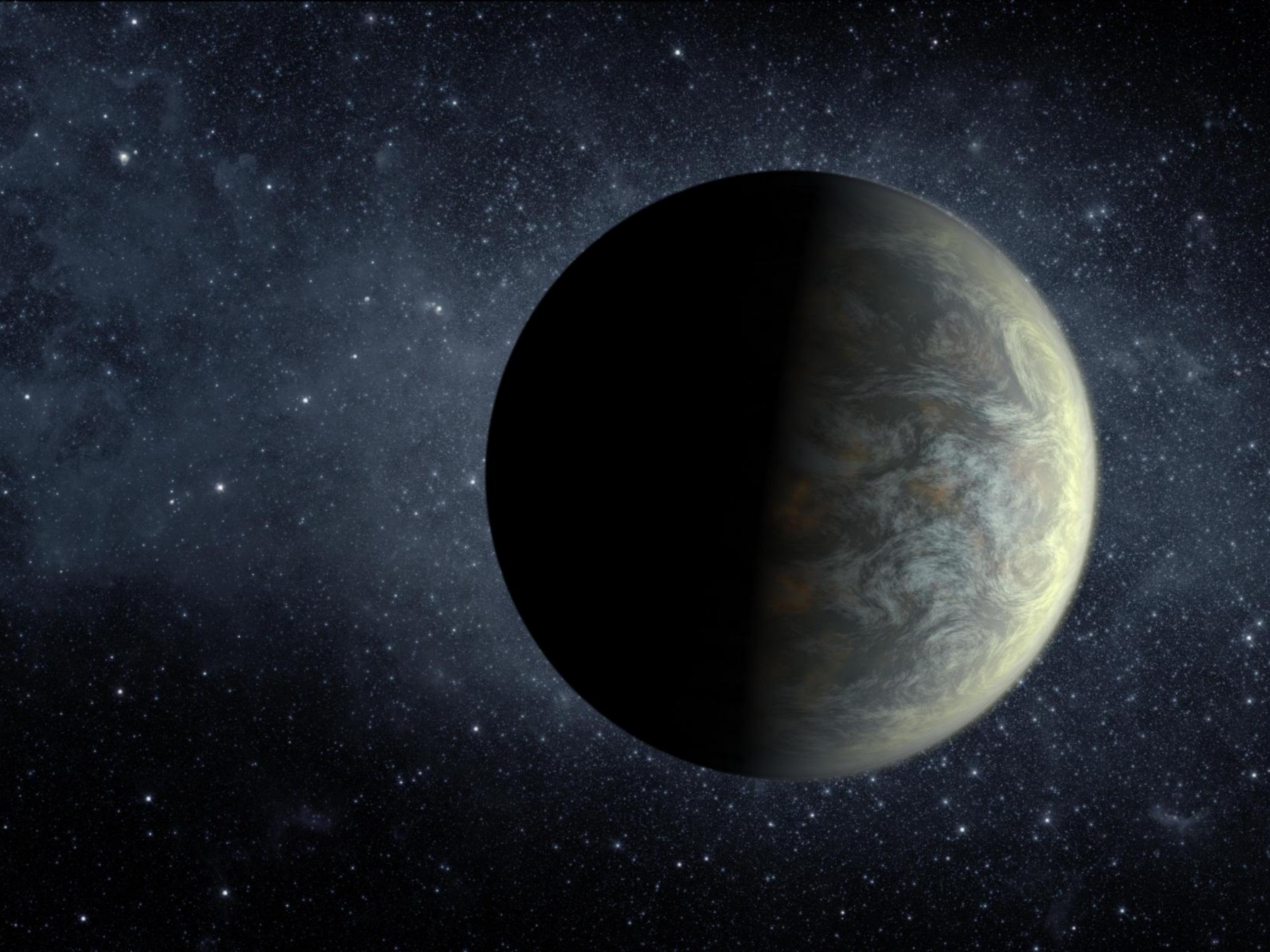

KASI/CBNU/ARCSEC

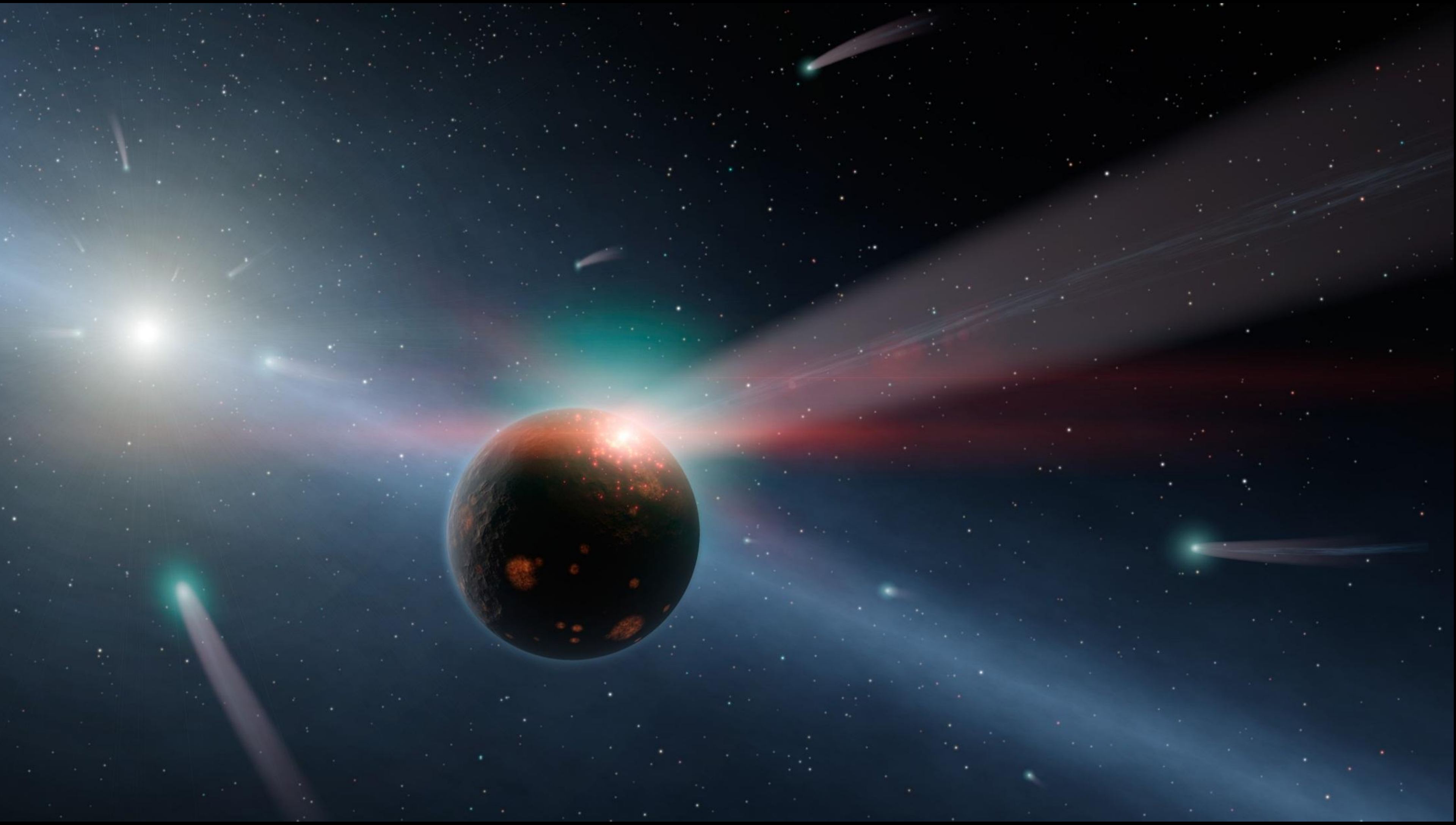
Planetary migration





Kley & Nelson 2012 Ann Rev





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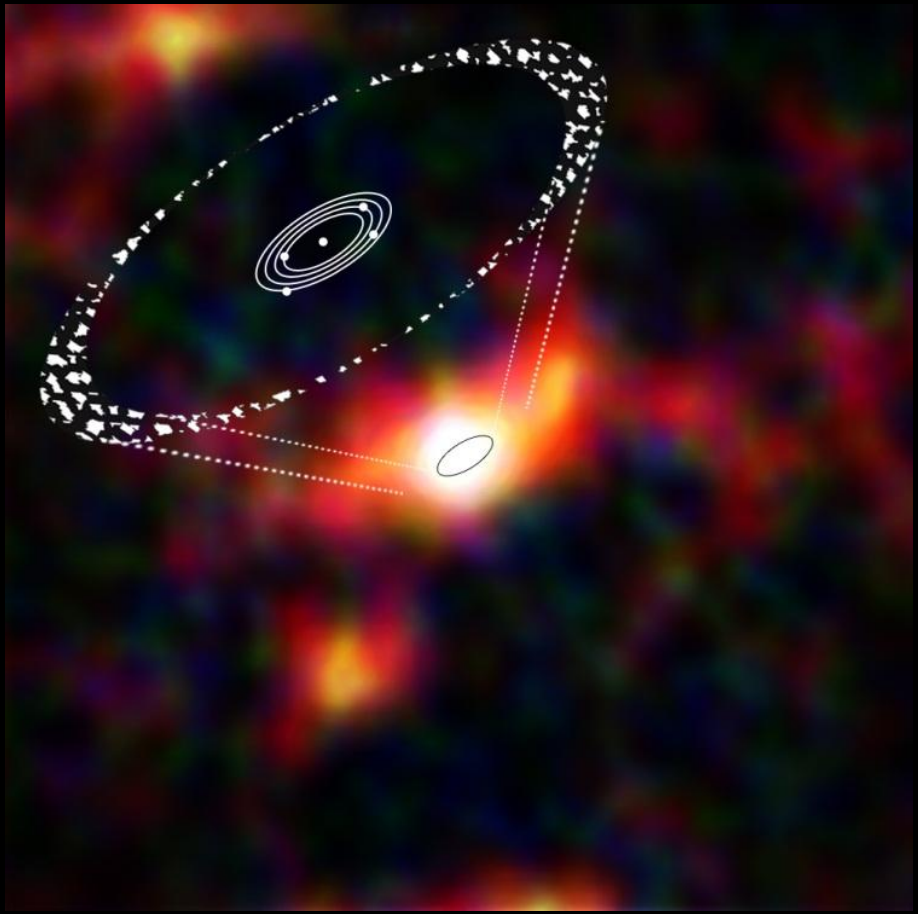
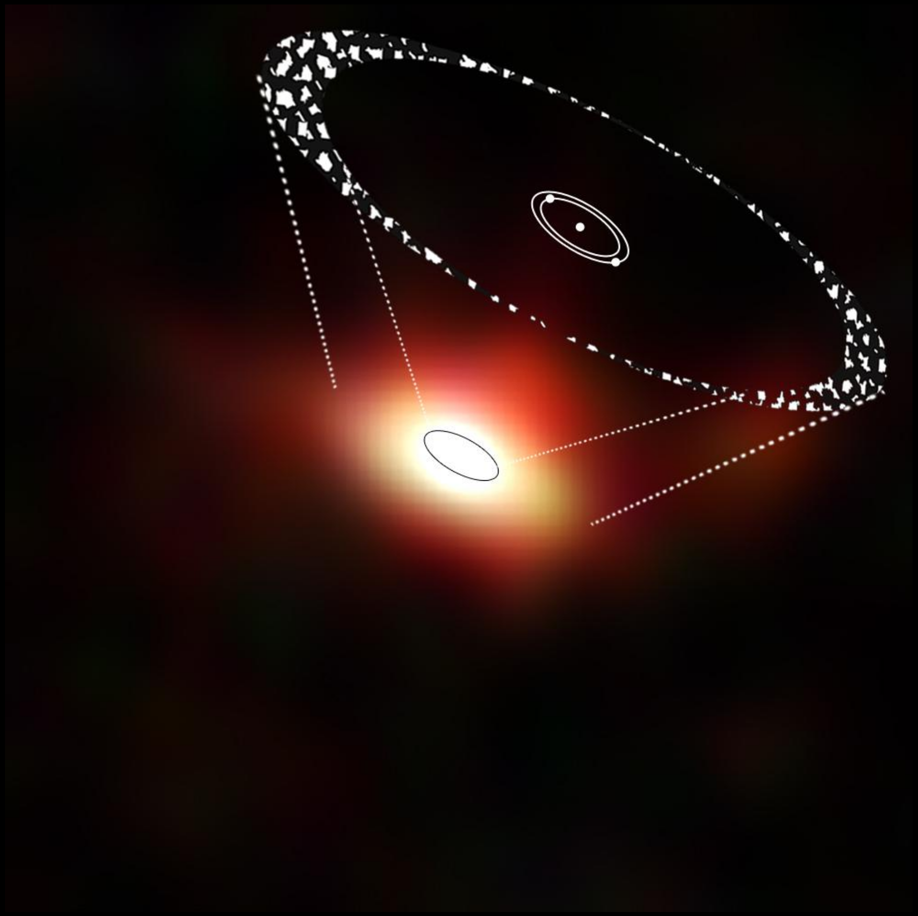


61 VIR



ESA/Herschel/PACS/ M Wyatt & JF Lestrade


NASA/JPL/Caltech


ESO/M Kornmesser

When galaxies collide...

Wednesday 17th April 1pm