Exoplanets: the cosmic context

Sprial Galaxy *NGC 1352*

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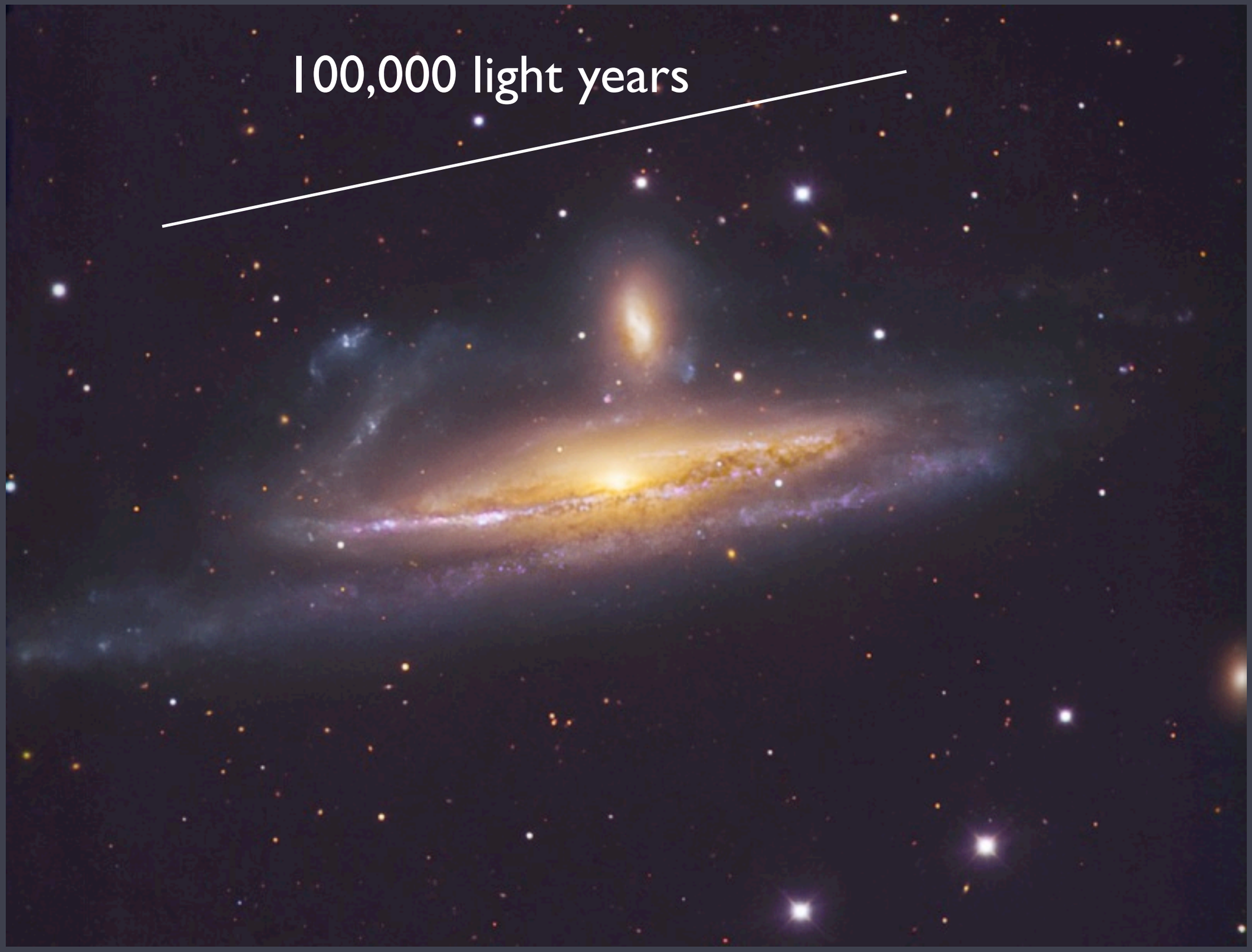
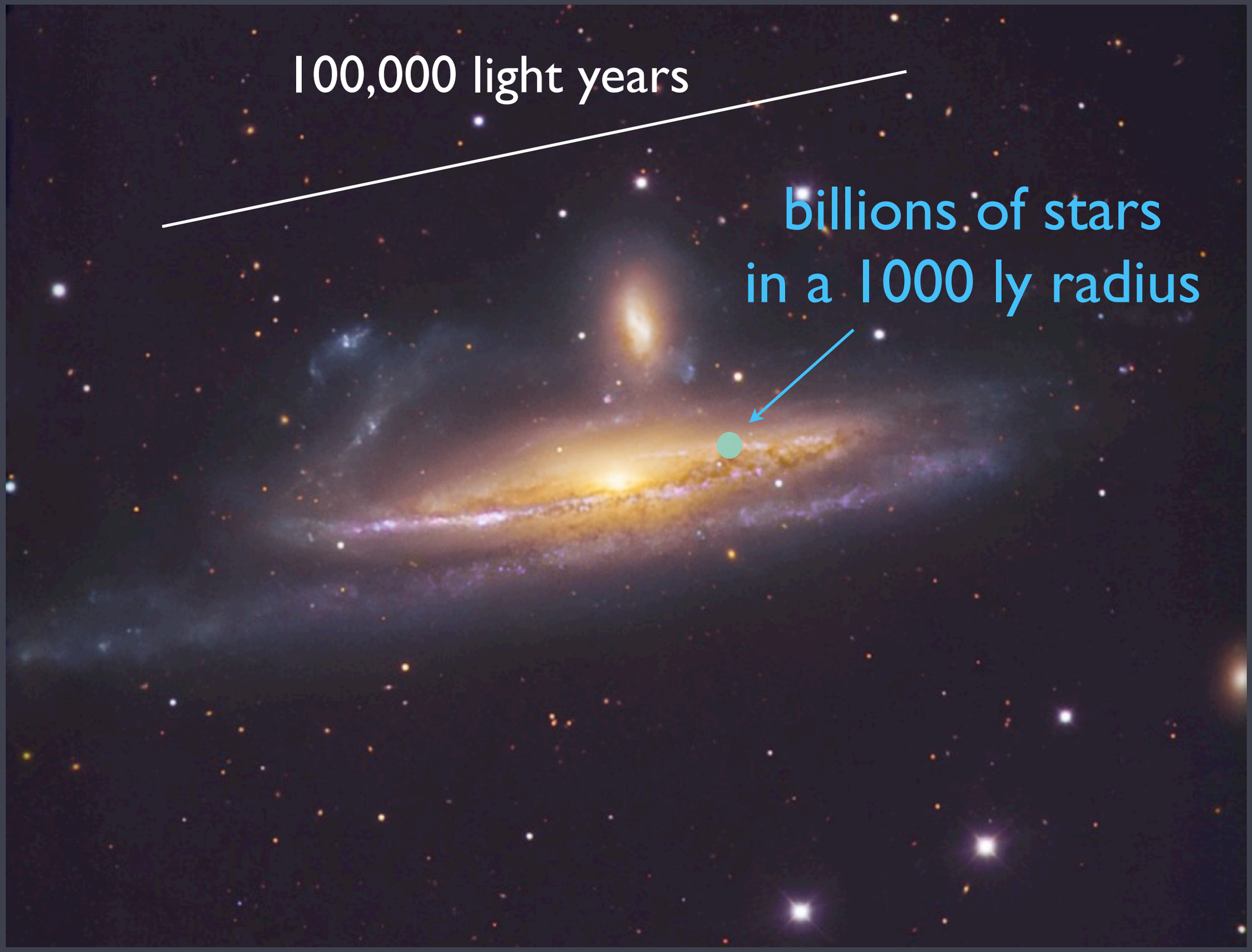


Sprial Galaxy *NGC 1352*

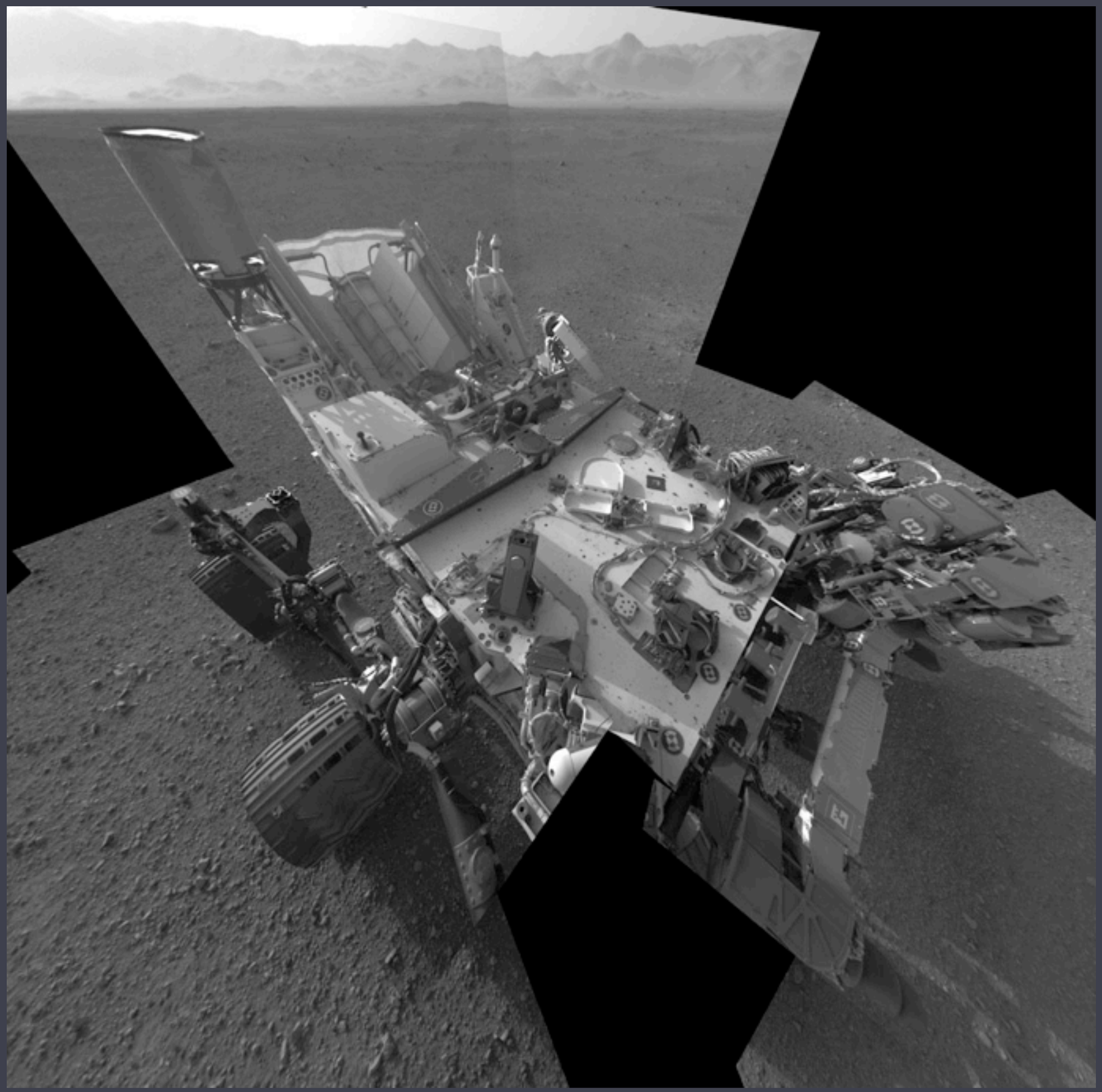


every star we see at night is in the Milky Way

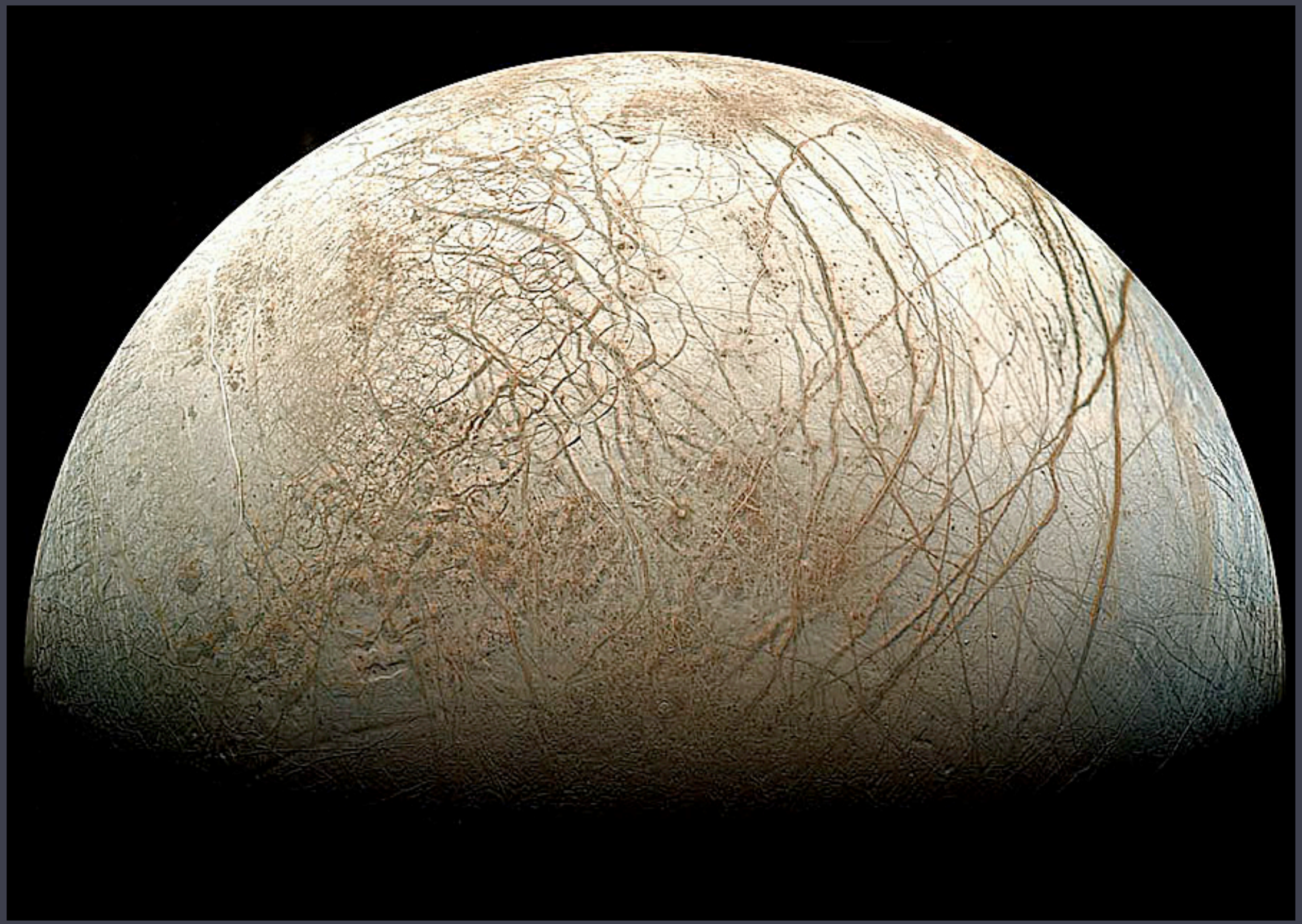
The surface of a planet is good place for life to...live

a nearby star provides energy; atmosphere and water may be key ingredients

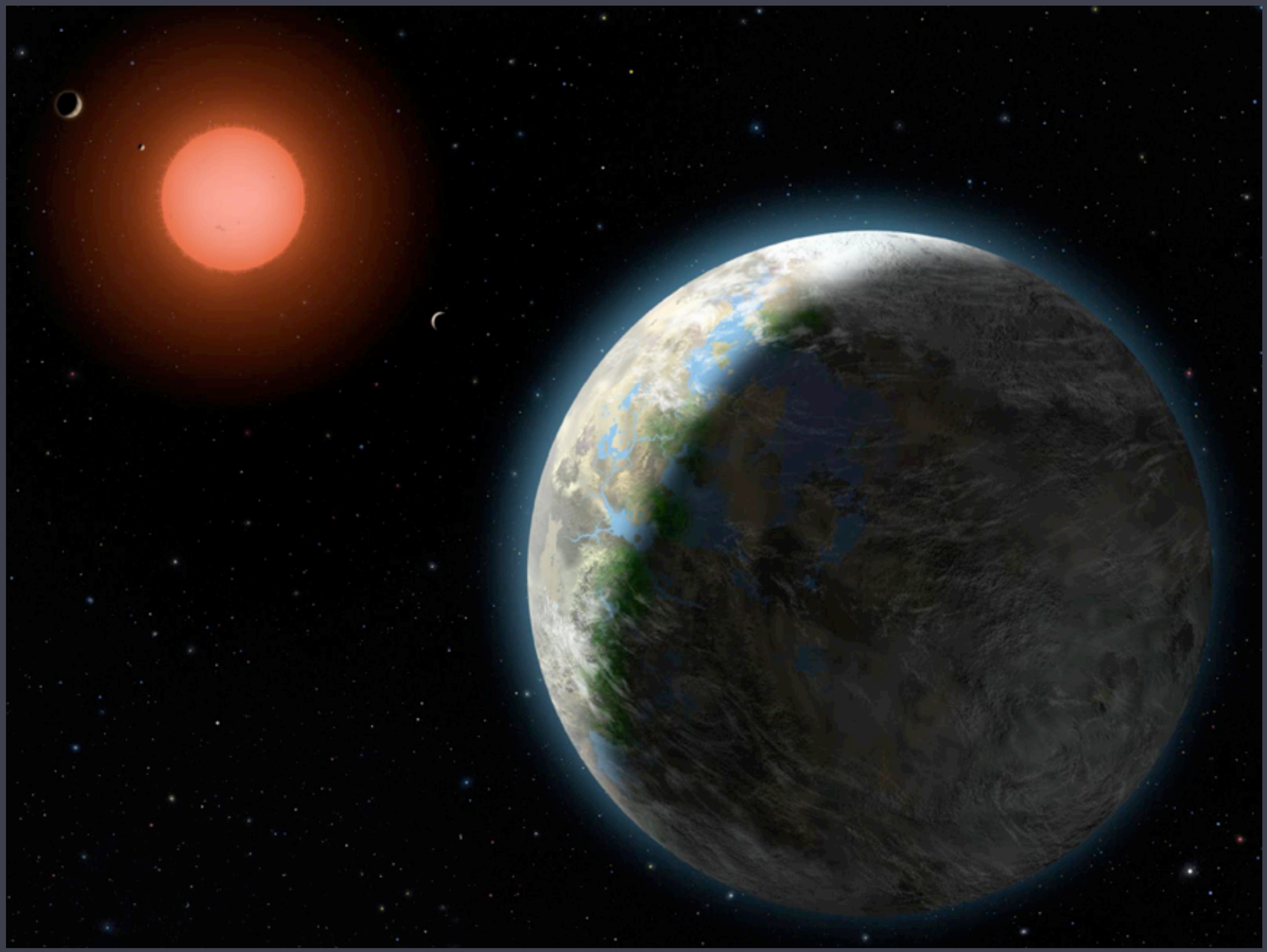
Curiosity rover on Mars



Jupiter's moon Europa: salt-water oceans



How common are habitable worlds?

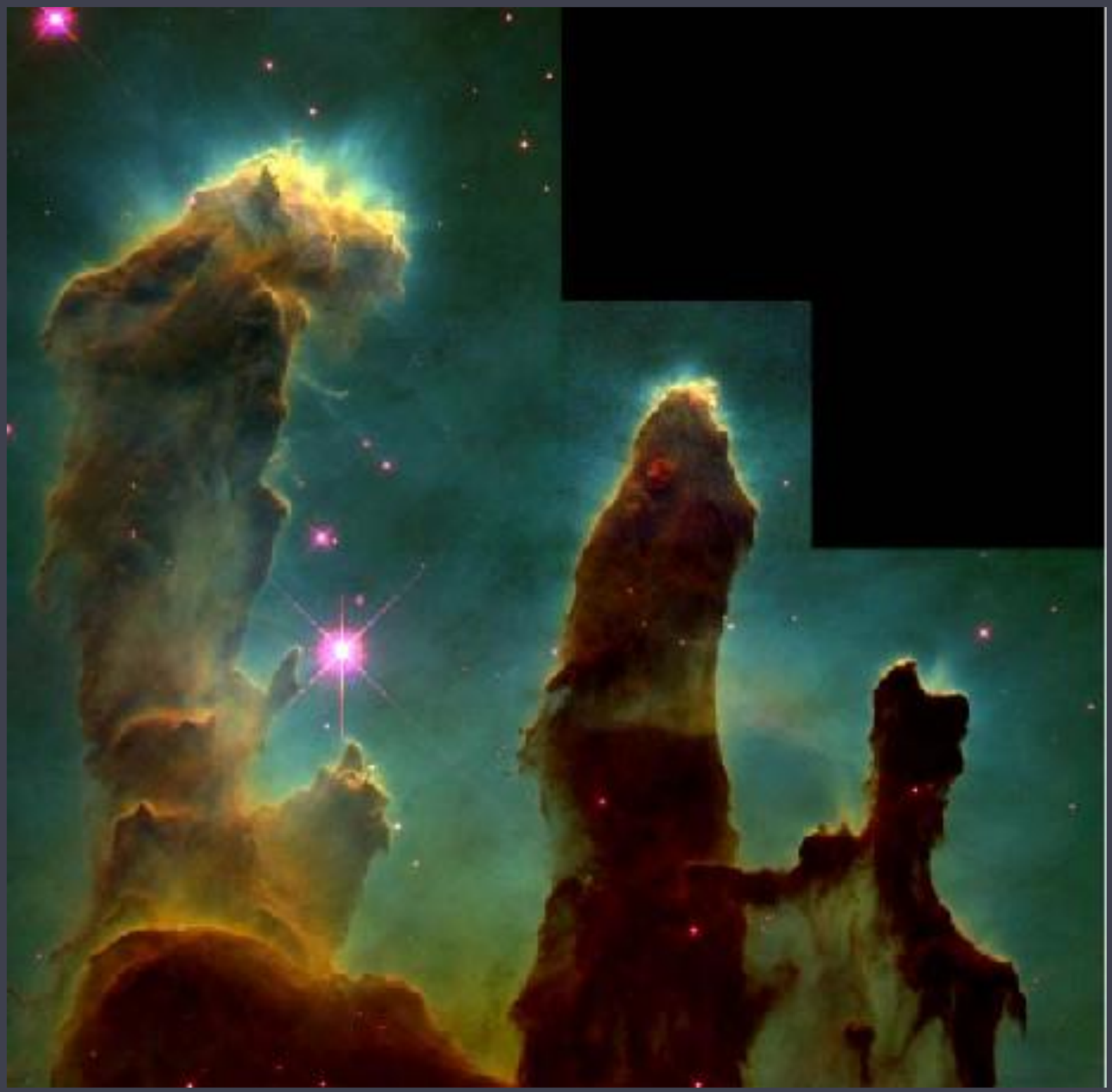


Artist's rendition: Lynette Cook

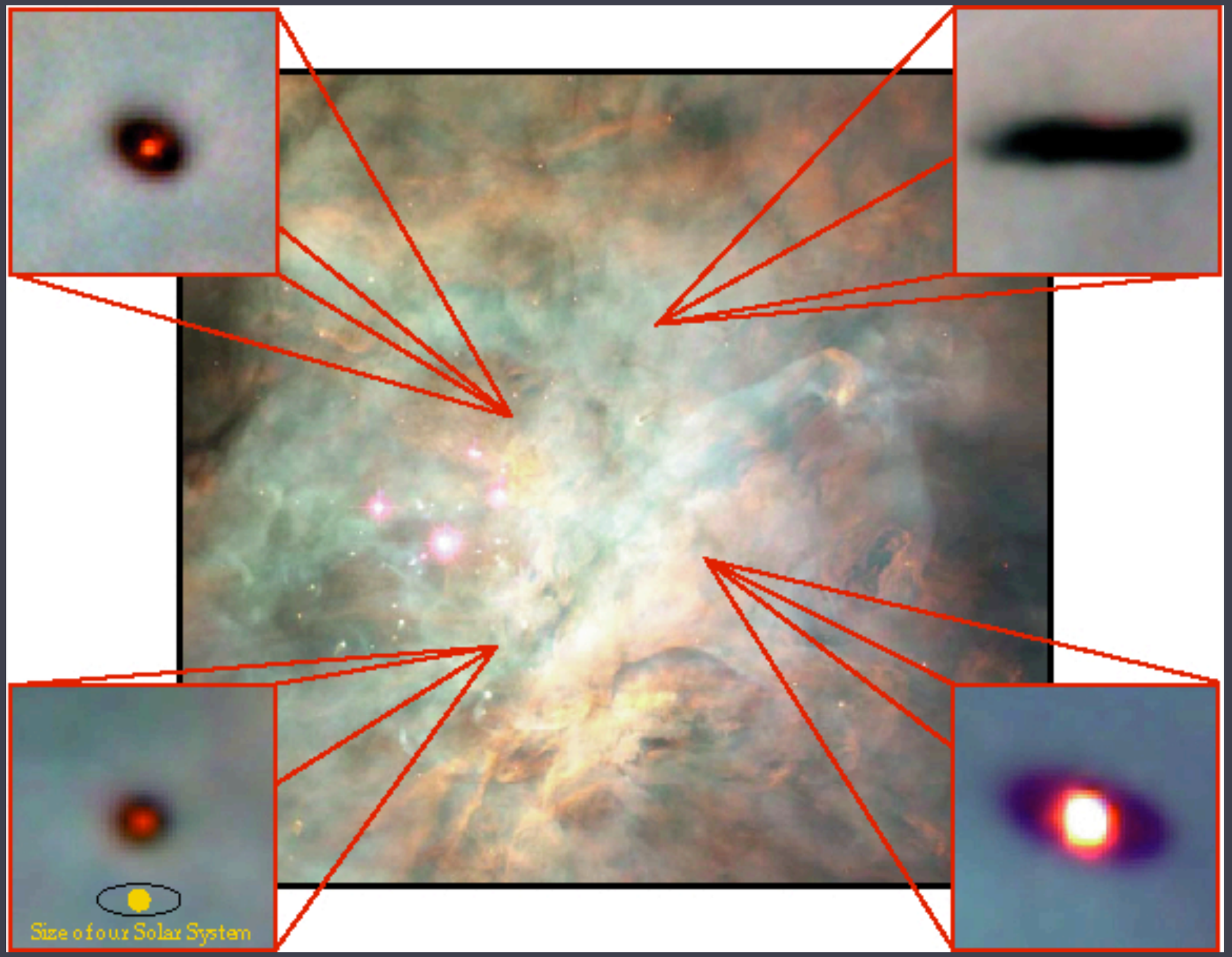
Galactic context for planets and life

Dense, cold clouds of gas and dust

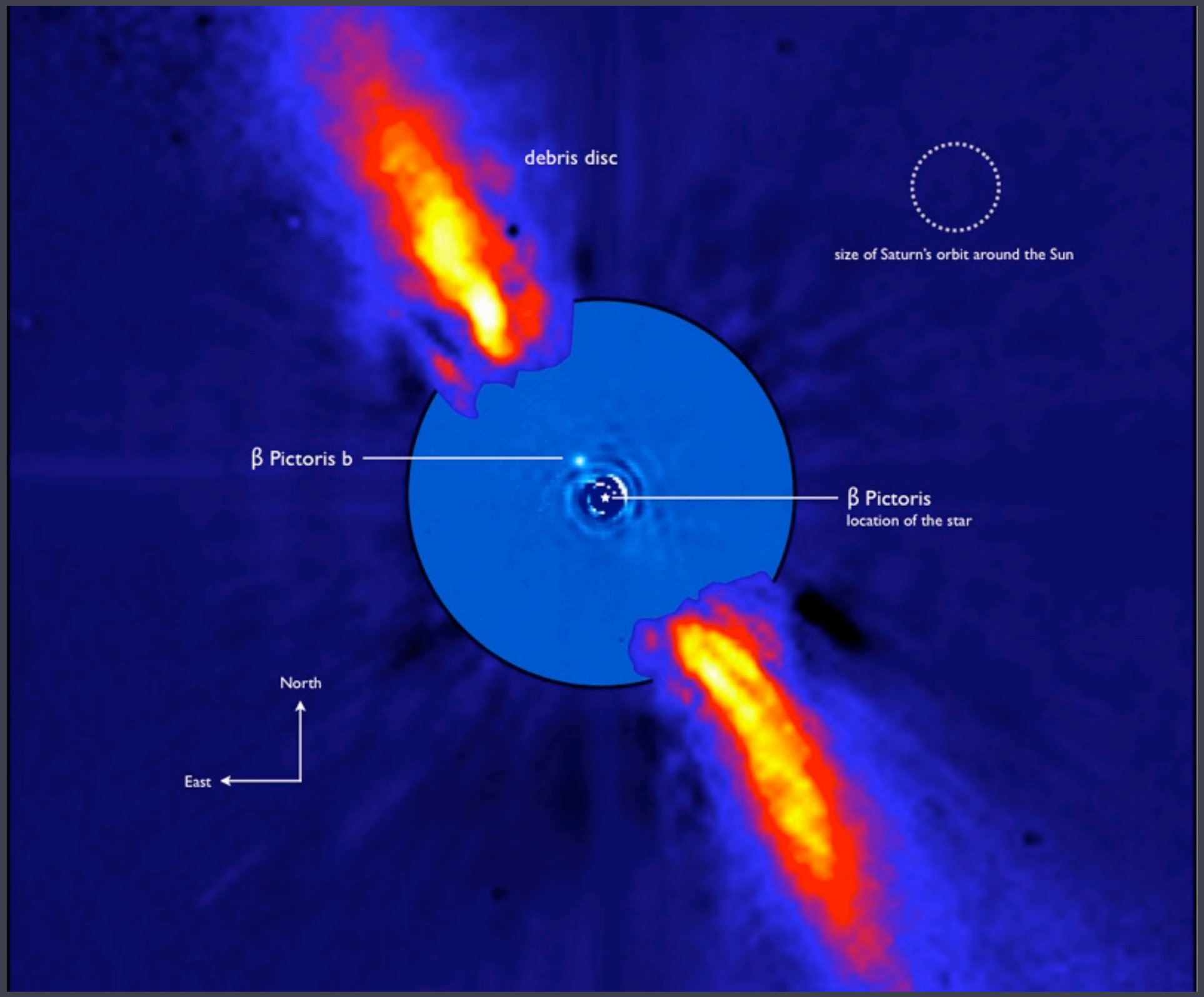
Eagle Nebula (10s of light years across)



Star (and planet?) formation


Size of our Solar System

“Debris disk” around the young star beta Pictoris

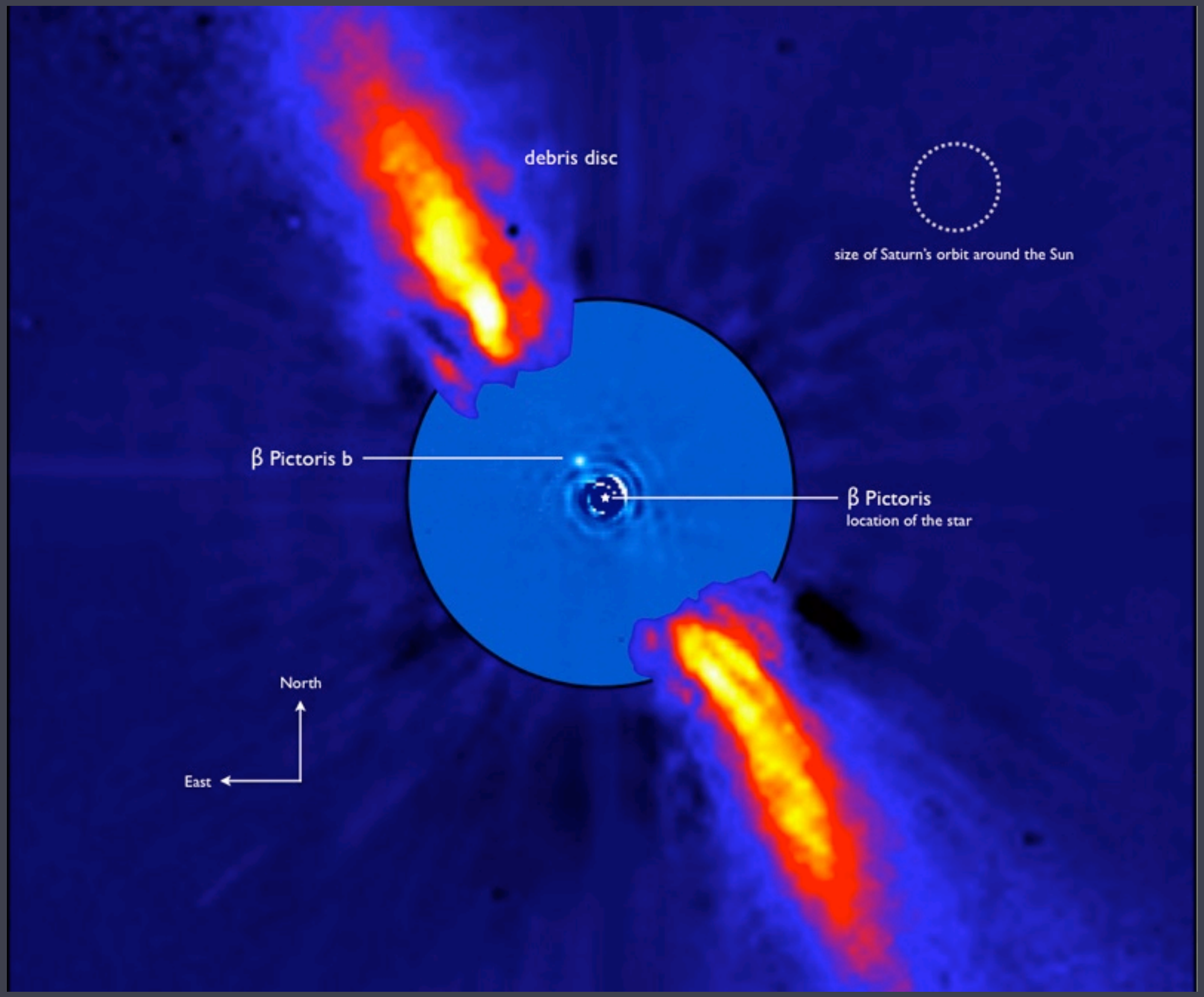


note: coronograph image; direct light from the star is physically blocked in front of the telescope

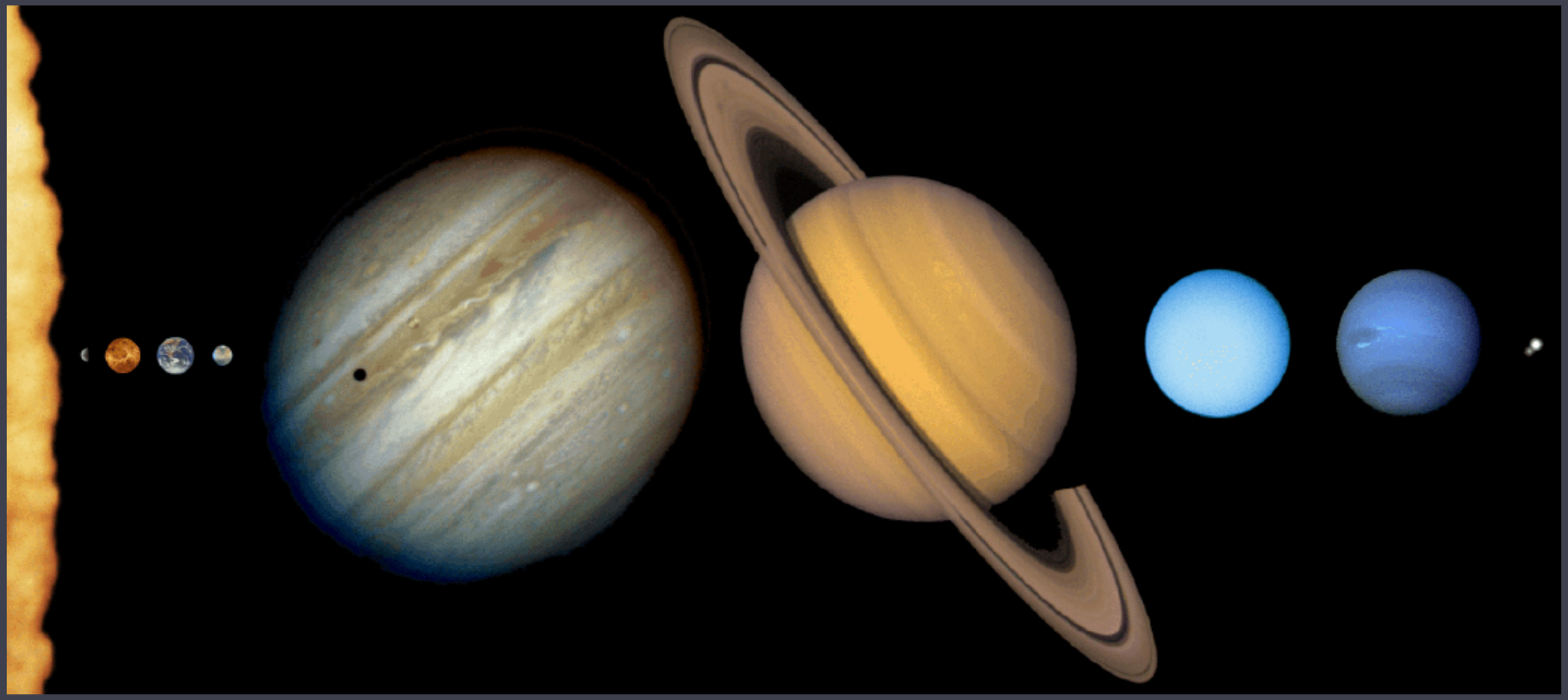
What *is* a planet?

break: mass limits on blackboard...

“Debris Disk” around the young star beta Pictoris



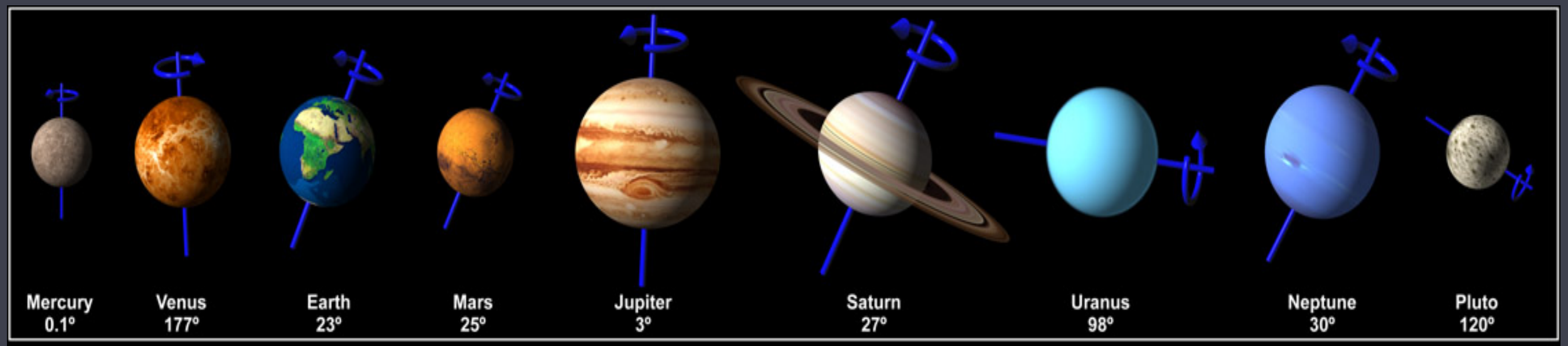
Our Solar System (sizes to scale)



Inner, terrestrial, planets: small, close together, rocky and metallic

Outer, Jovian, planets: large, spread out, gaseous

Coplanar, most angular momentum vectors are aligned



Obliquity of the Nine Planets

Nebula collapsing under its own gravity -- spins faster – is is flattened into a disk

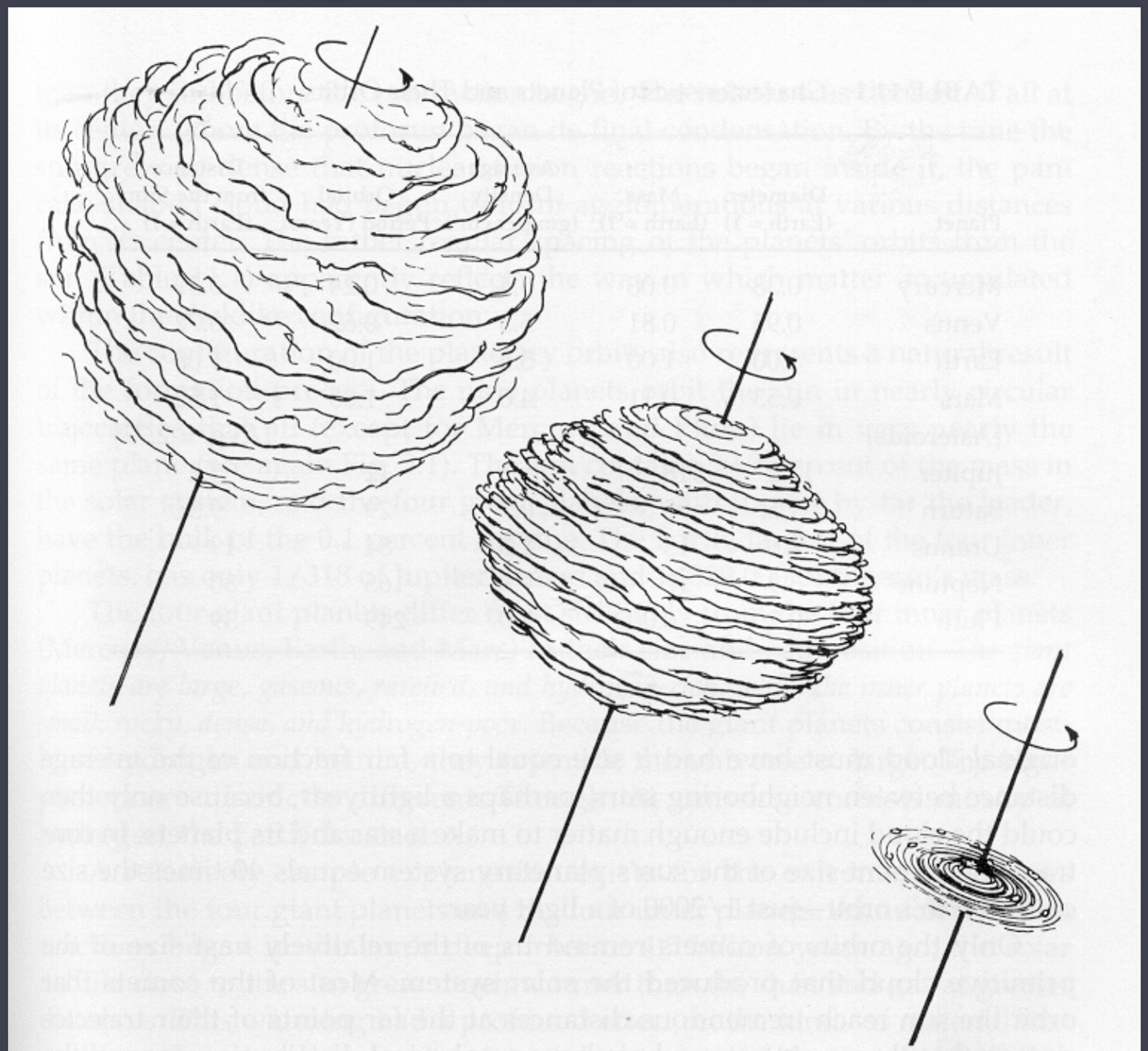


Figure 11.2 As the cloud of gas and dust that formed the solar system began to contract, it must have acquired some rotation, which led to more rapid rotation as the cloud grew smaller. This rotation tended to support the cloud against contraction in directions perpendicular to the axis of rotation, and thus led to a pancake-like shape for the contracted, rotating cloud. Within the disklike configuration, the individual planets accreted from the matter revolving at their present distances from the sun.

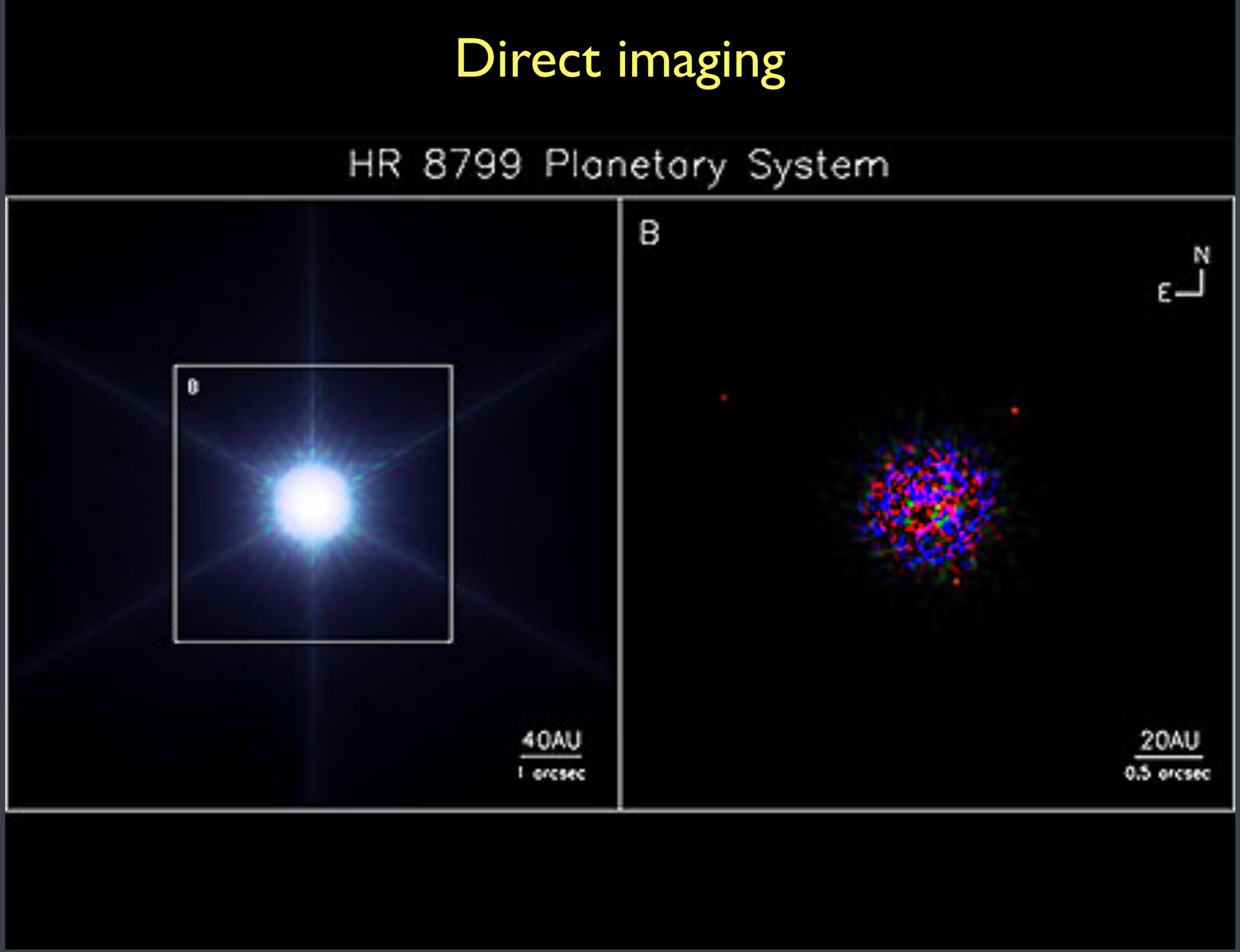
How common are other planetary systems?

What properties do they have?

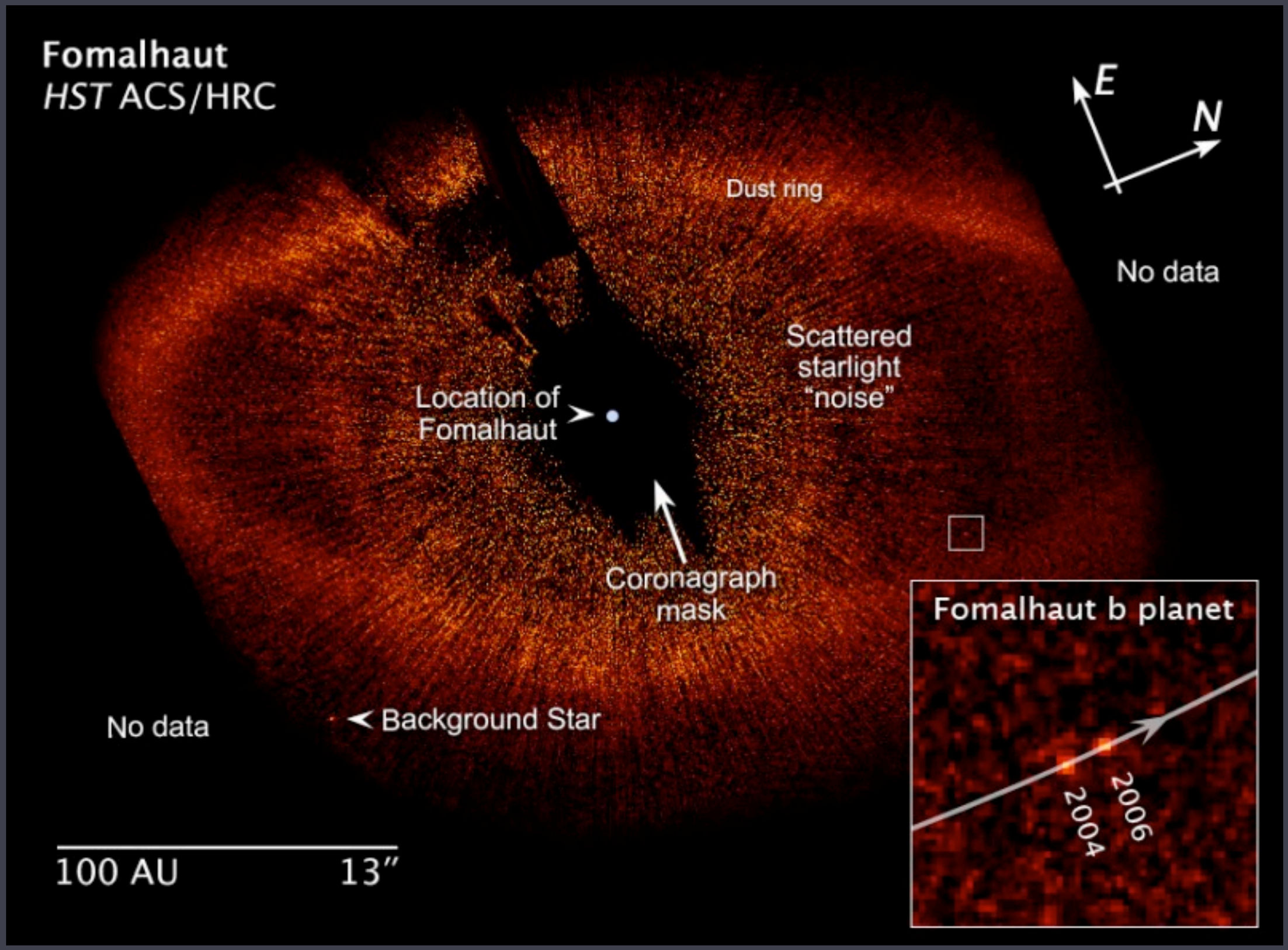
How can we detect them and measure their properties?

Planets (and moons) shine by reflected sun/star-light

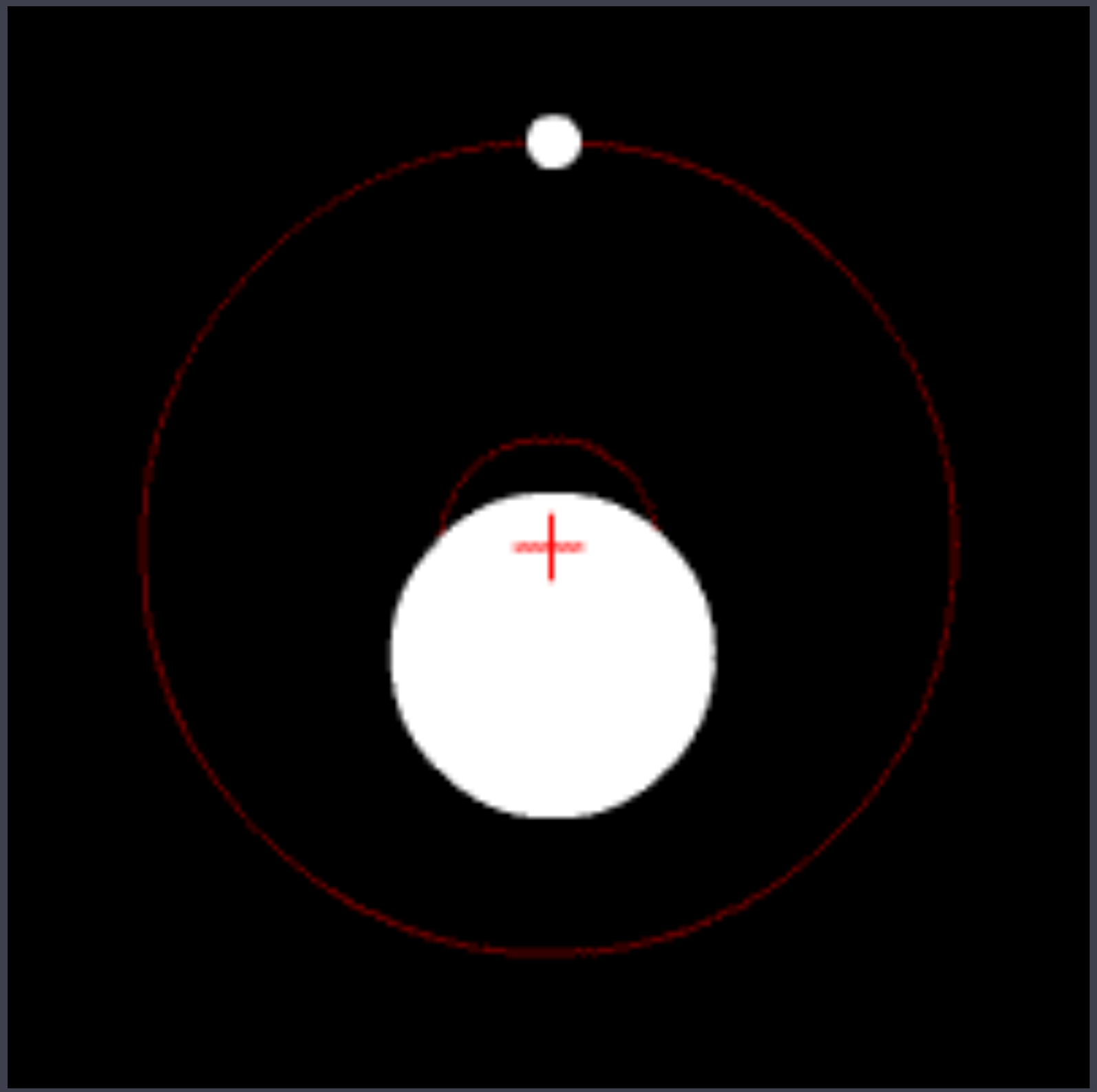
Direct imaging



Fomalhaut b - is it a planet?

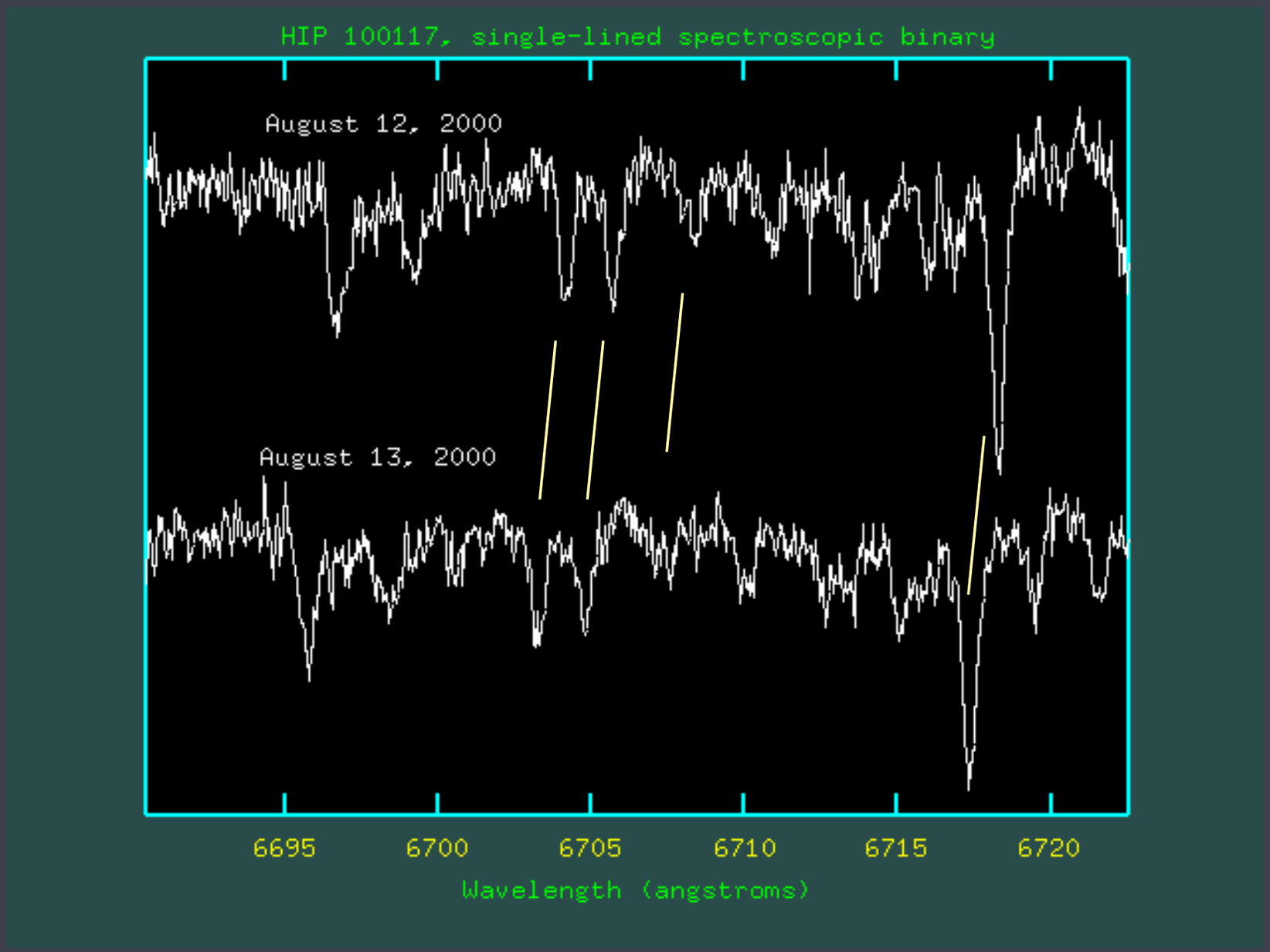


Center of mass: common orbital motion



Radial velocity method

we'll discuss this later...



Venus transiting the Sun

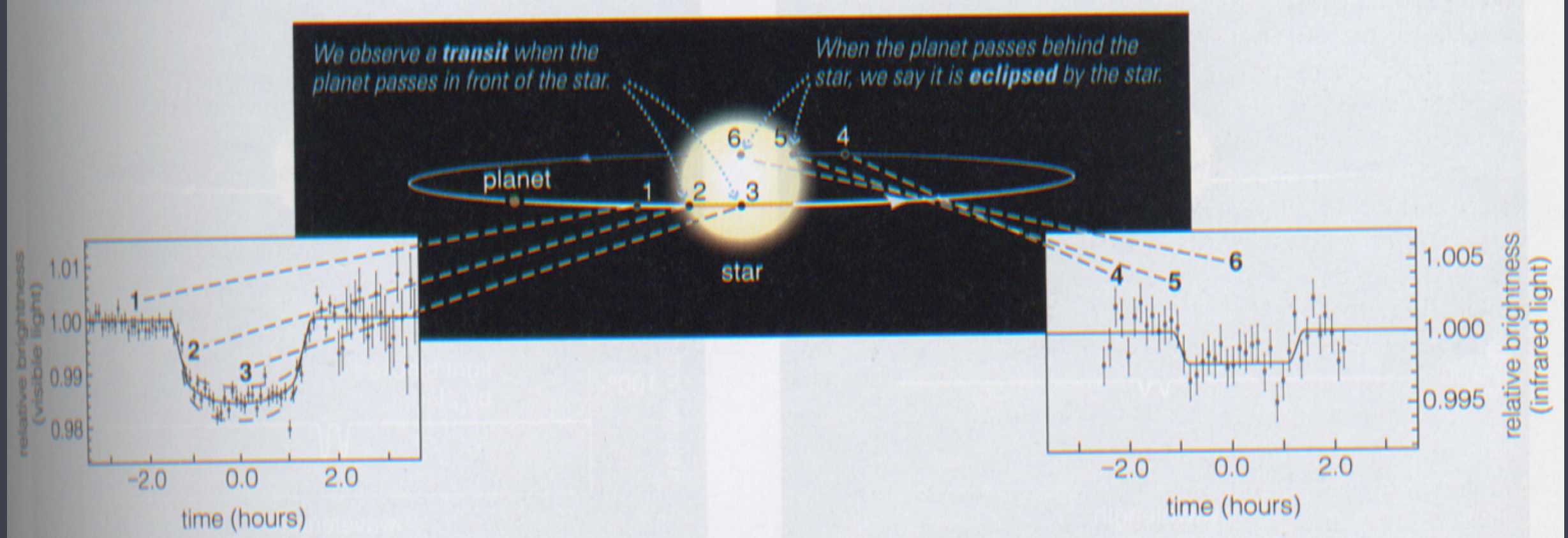
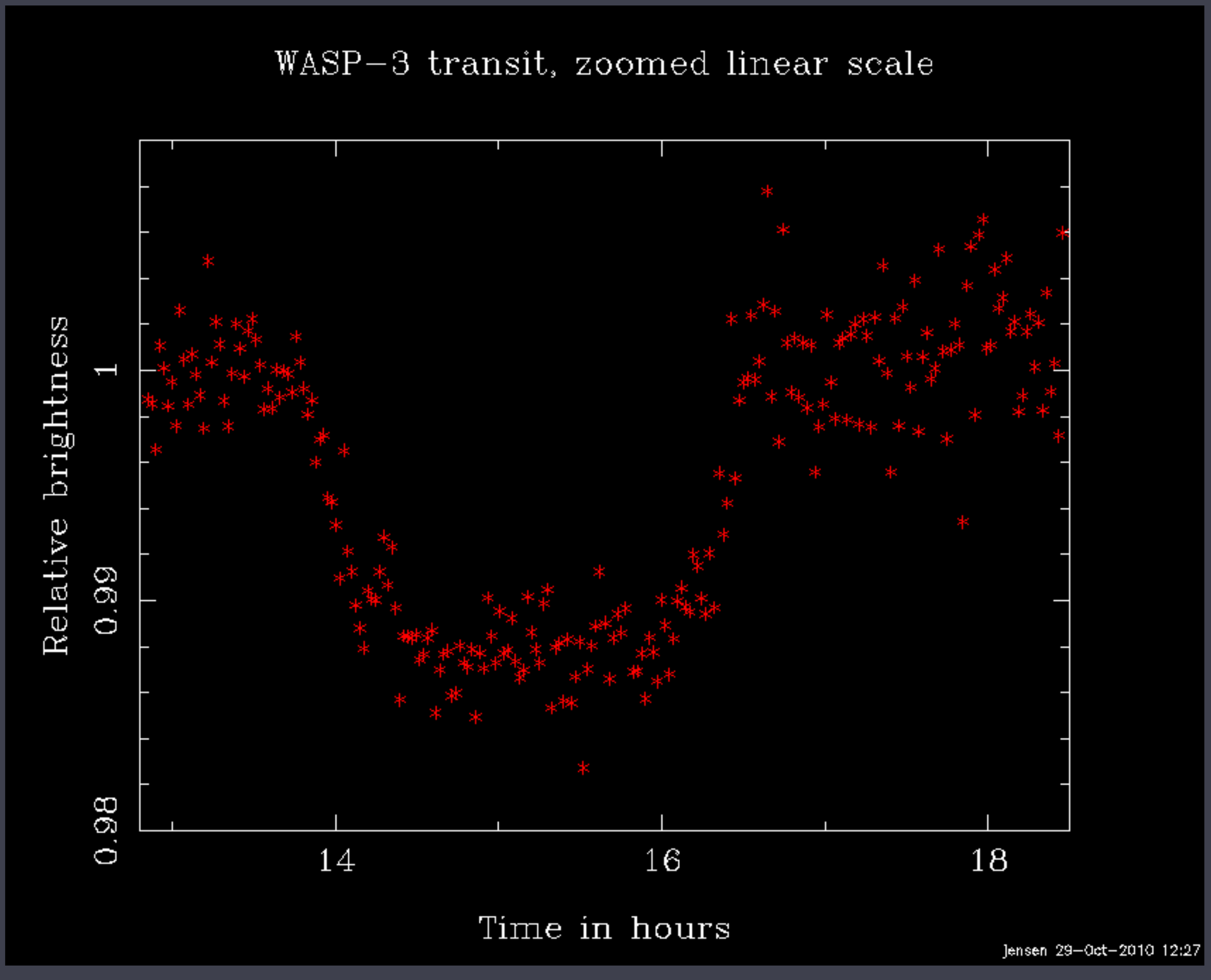
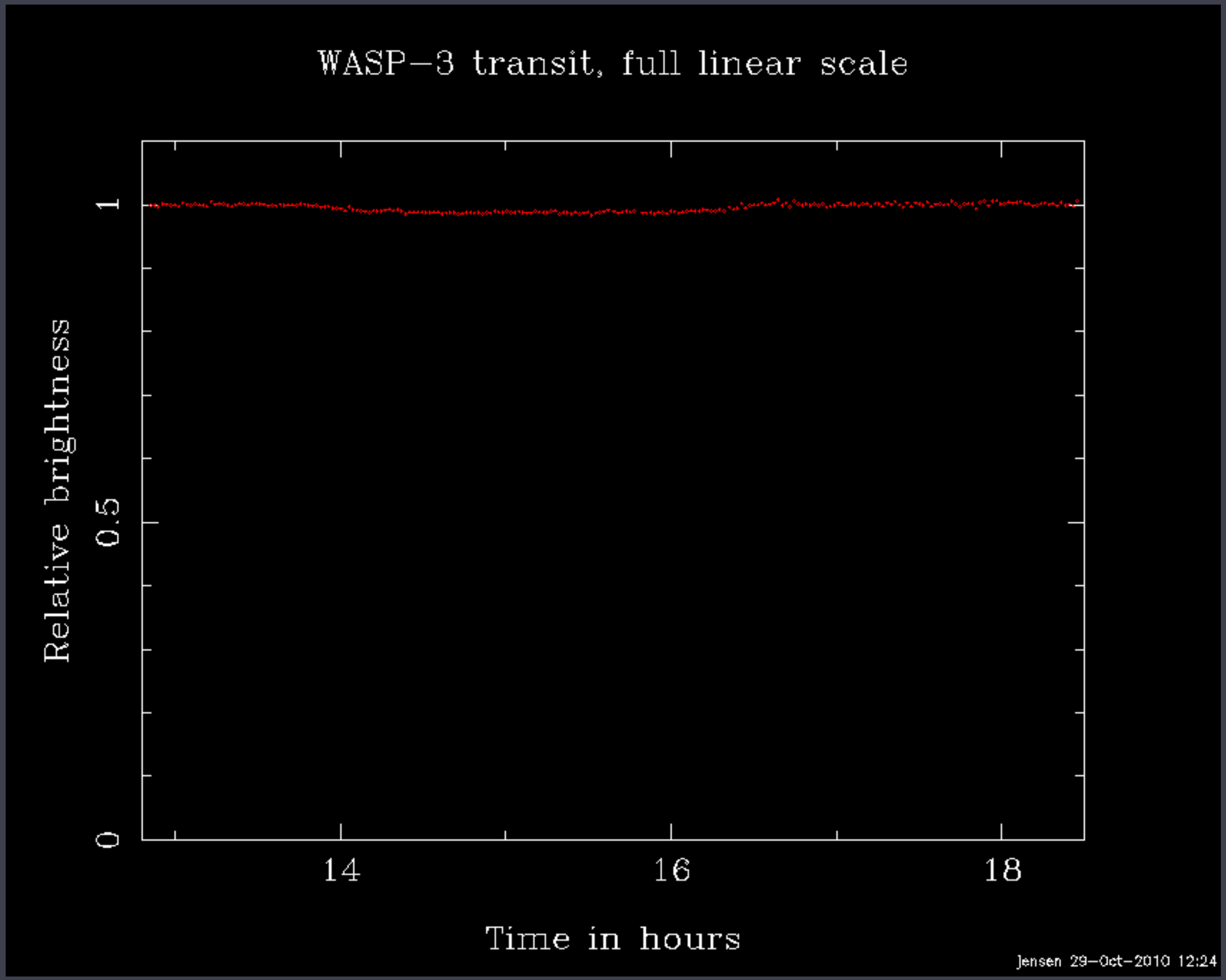
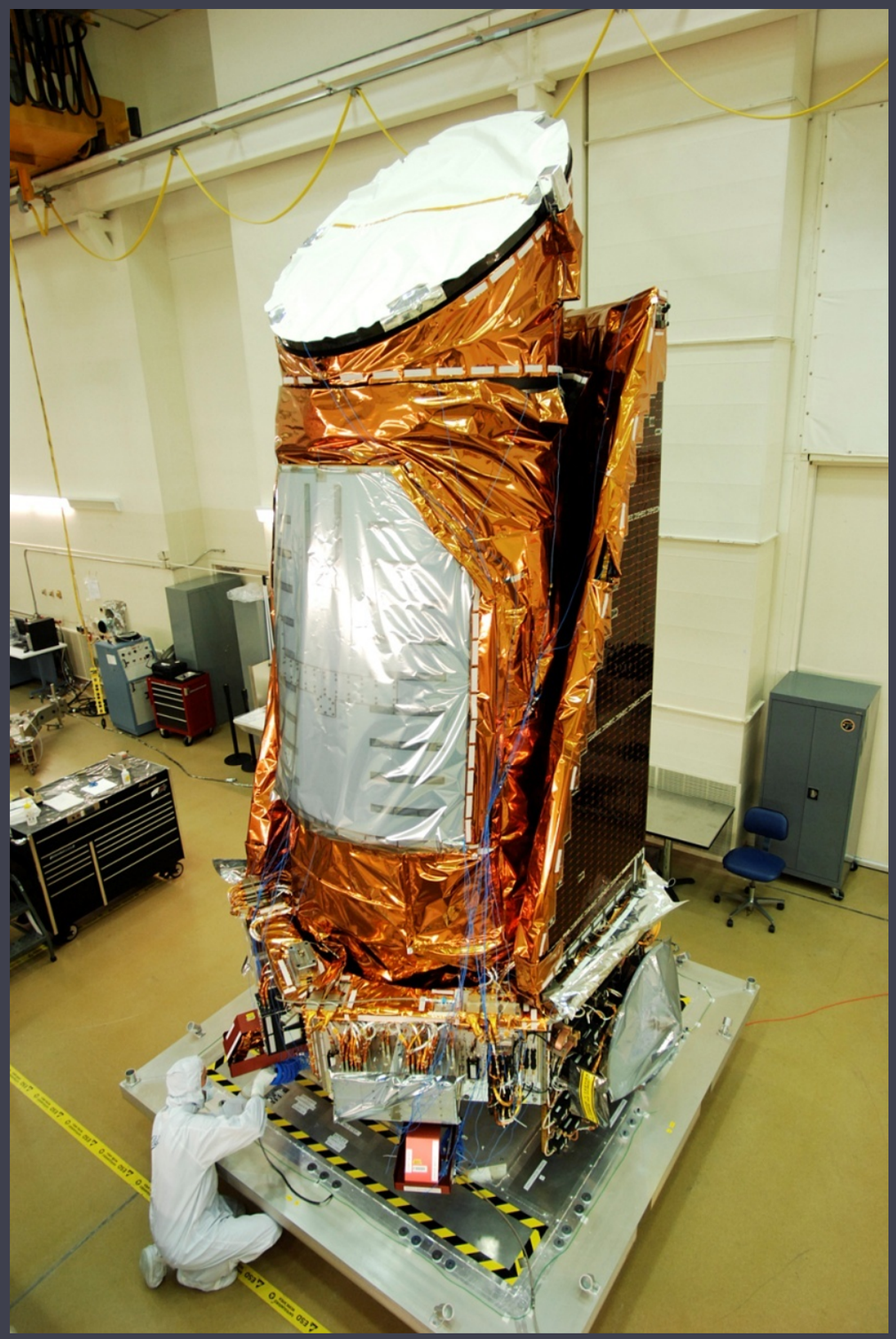


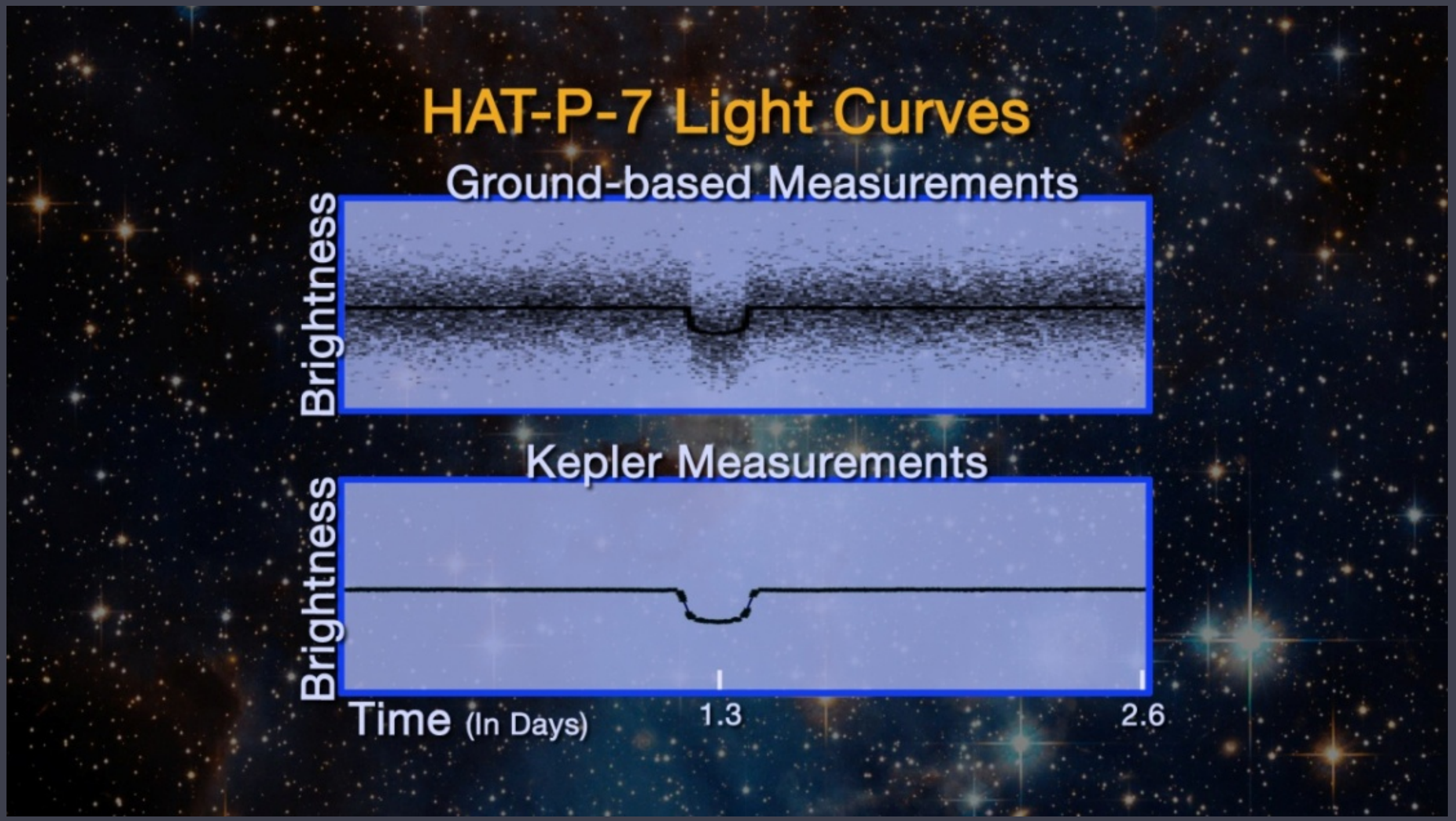
Figure 13.7 Interactive Figure The artist's conception (center) shows the planet orbiting the star HD209458. The graphs show how the star's brightness changes during transits and eclipses, which each occur once with every $3\frac{1}{2}$-day orbit. During a transit, the star's brightness drops for about 2 hours by 1.7%, which tells us how the planet's radius compares to the radius of its star. During an eclipse, the infrared signal drops by 0.25%, which tells us about the planet's thermal emission.


WASP−3 transit, zoomed linear scale
Relative brightness
1
0.99
0.98
14
16
18
Time in hours
Jensen 29−Oct−2010 12:27


WASP-3 transit, full linear scale
Relative brightness
1
0.5
0
14
16
18
Time in hours
Jensen 29-Oct-2010 12:24

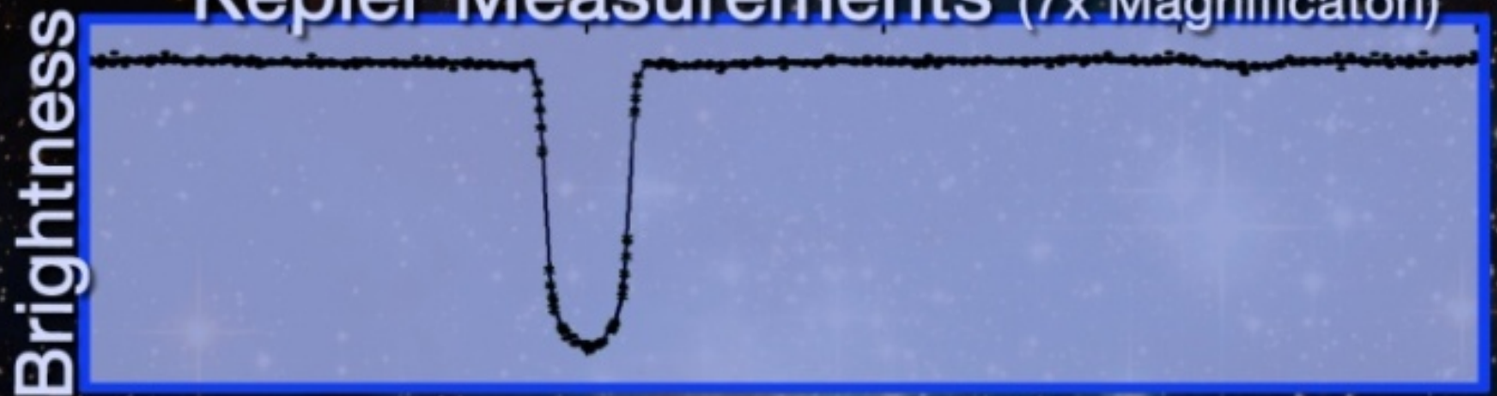
Kepler Mission (2009)



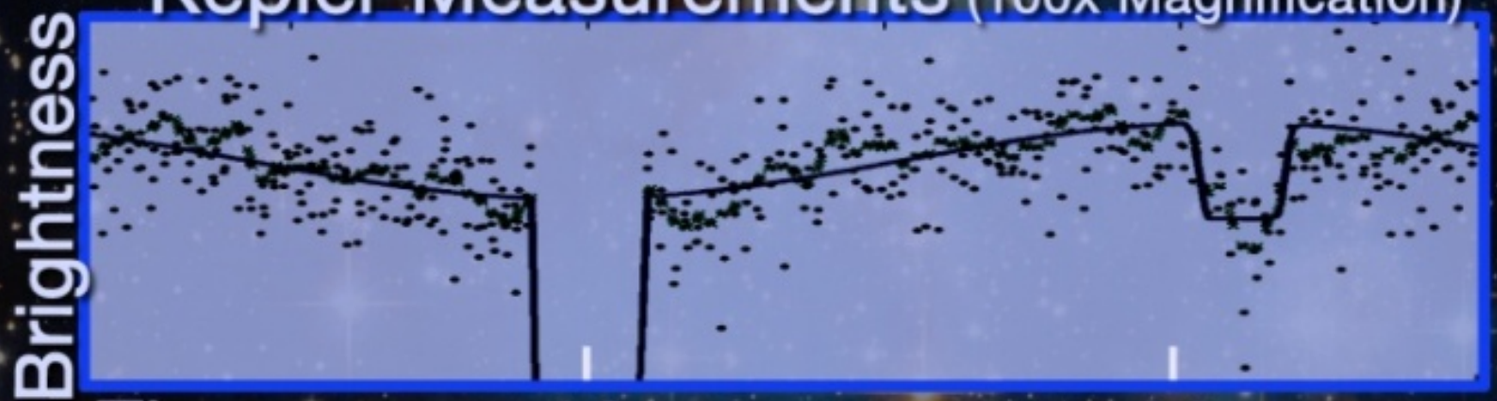

HAT-P-7 Light Curves
Ground-based Measurements
Brightness
Kepler Measurements
Brightness
Time (In Days)
1.3
2.6

HAT-P-7 Light Curves

Kepler Measurements (7x Magnificaton)

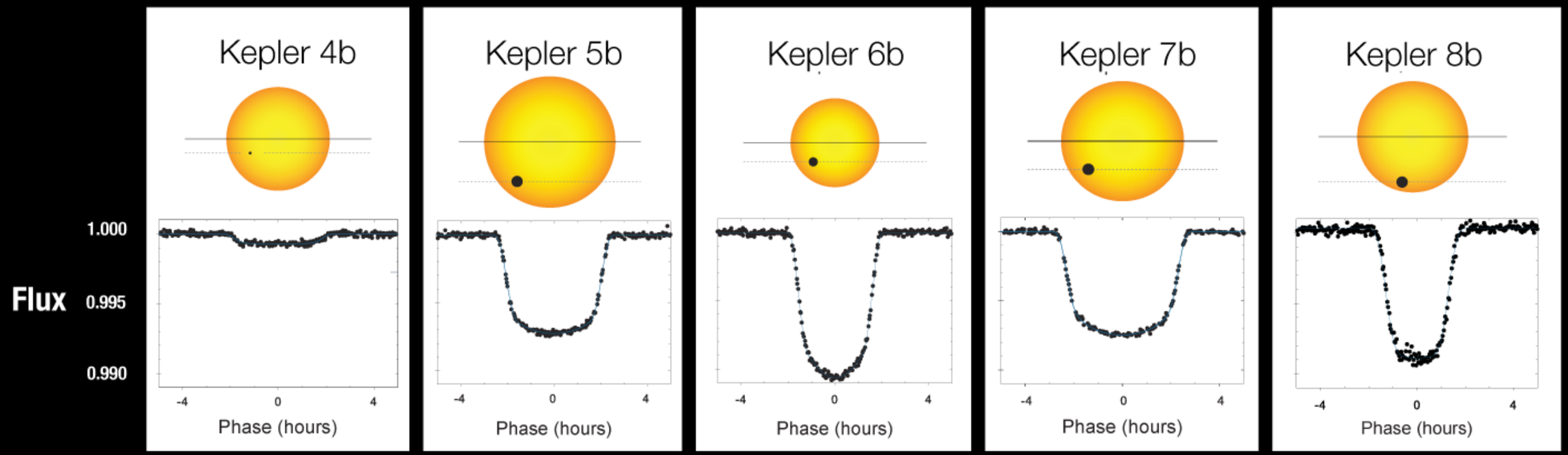


Kepler Measurements (100x Magnification)



Some early Kepler results

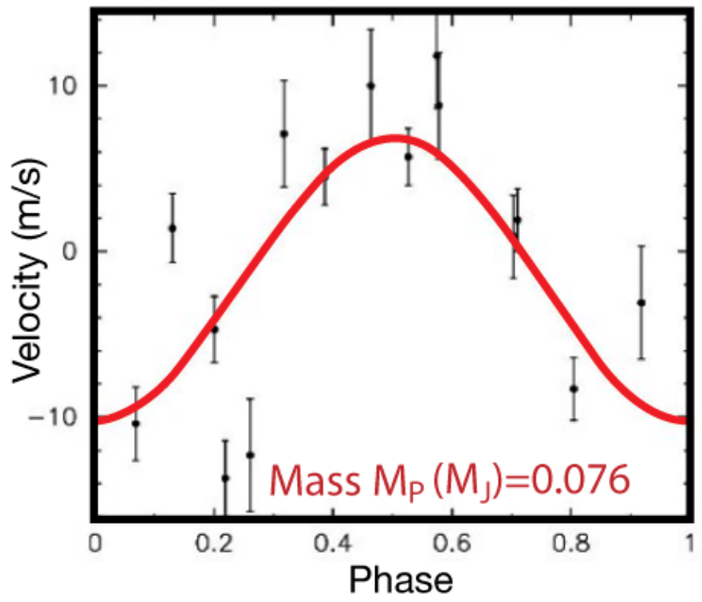
Transit Light Curves



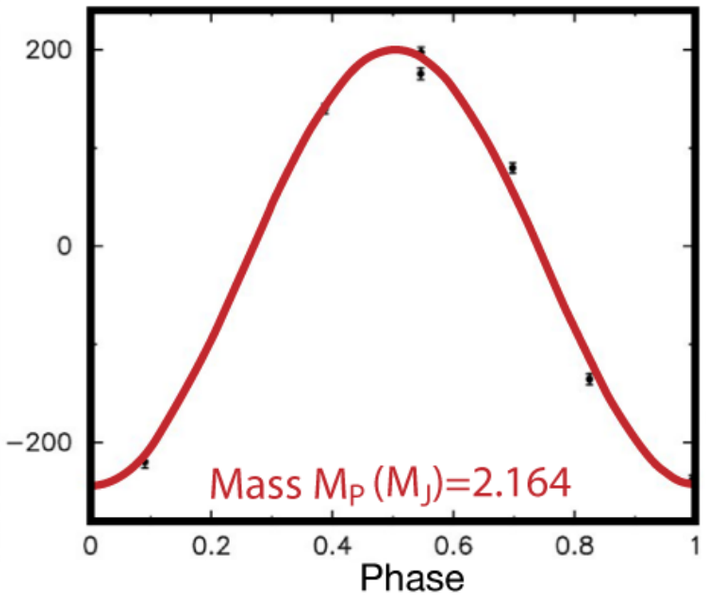
	Kepler 4b	Kepler 5b	Kepler 6b	Kepler 7b	Kepler 8b
Orbital Period (days)	*3.2 days*	*3.5 days*	*3.2 days*	*4.9 days*	*3.5 days*
Size (R_E)	*4.31*	*18.8*	*15.0*	*16.9*	*18.3*

Radial Velocity of Host Stars

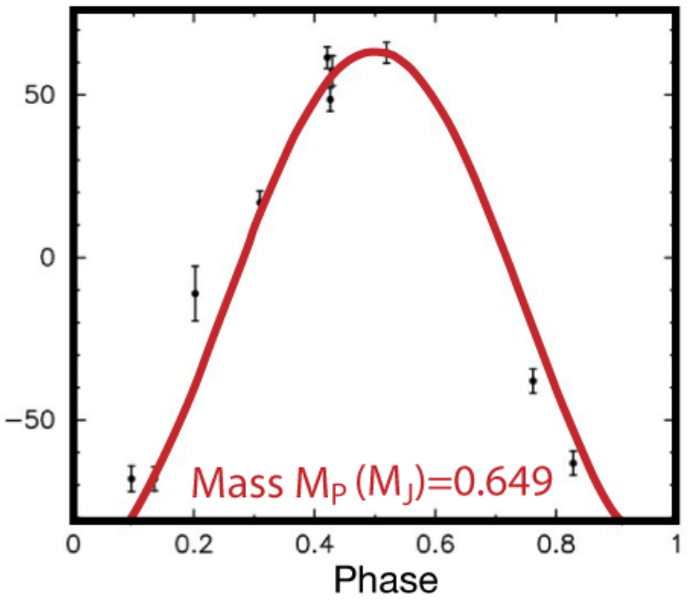
Kepler 4b



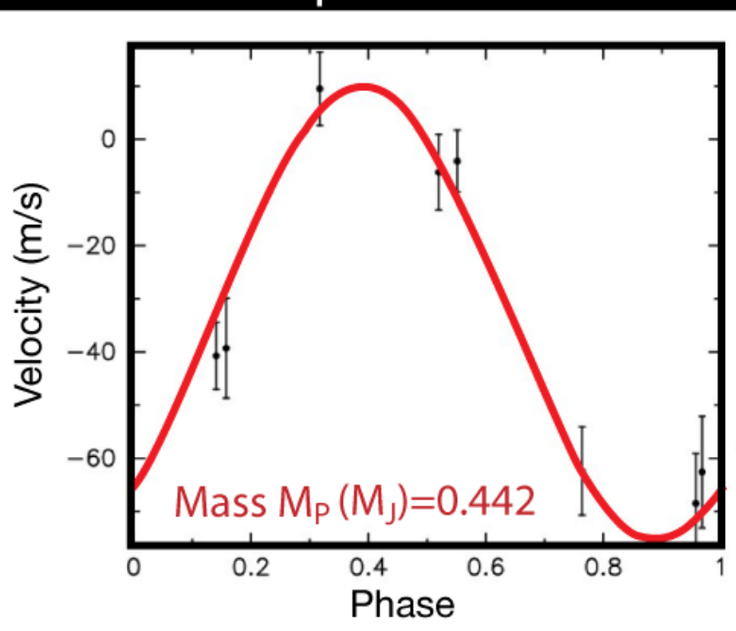
Kepler 5b



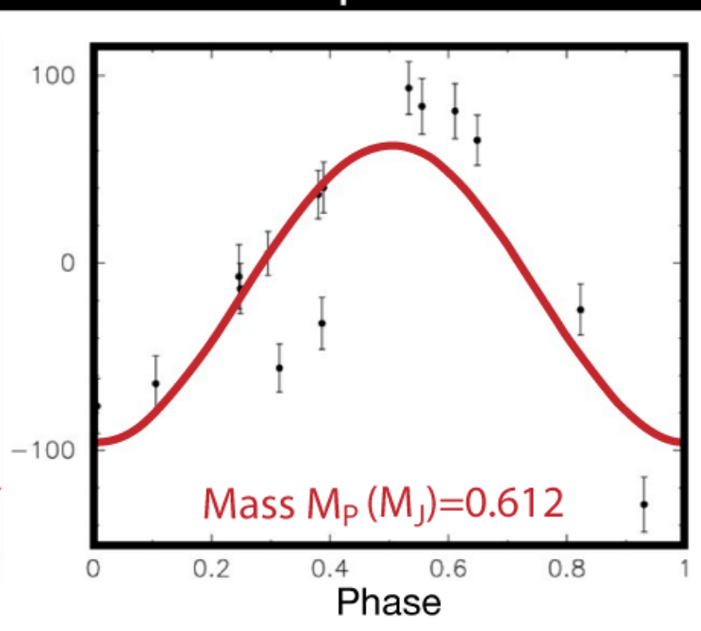
Kepler 6b



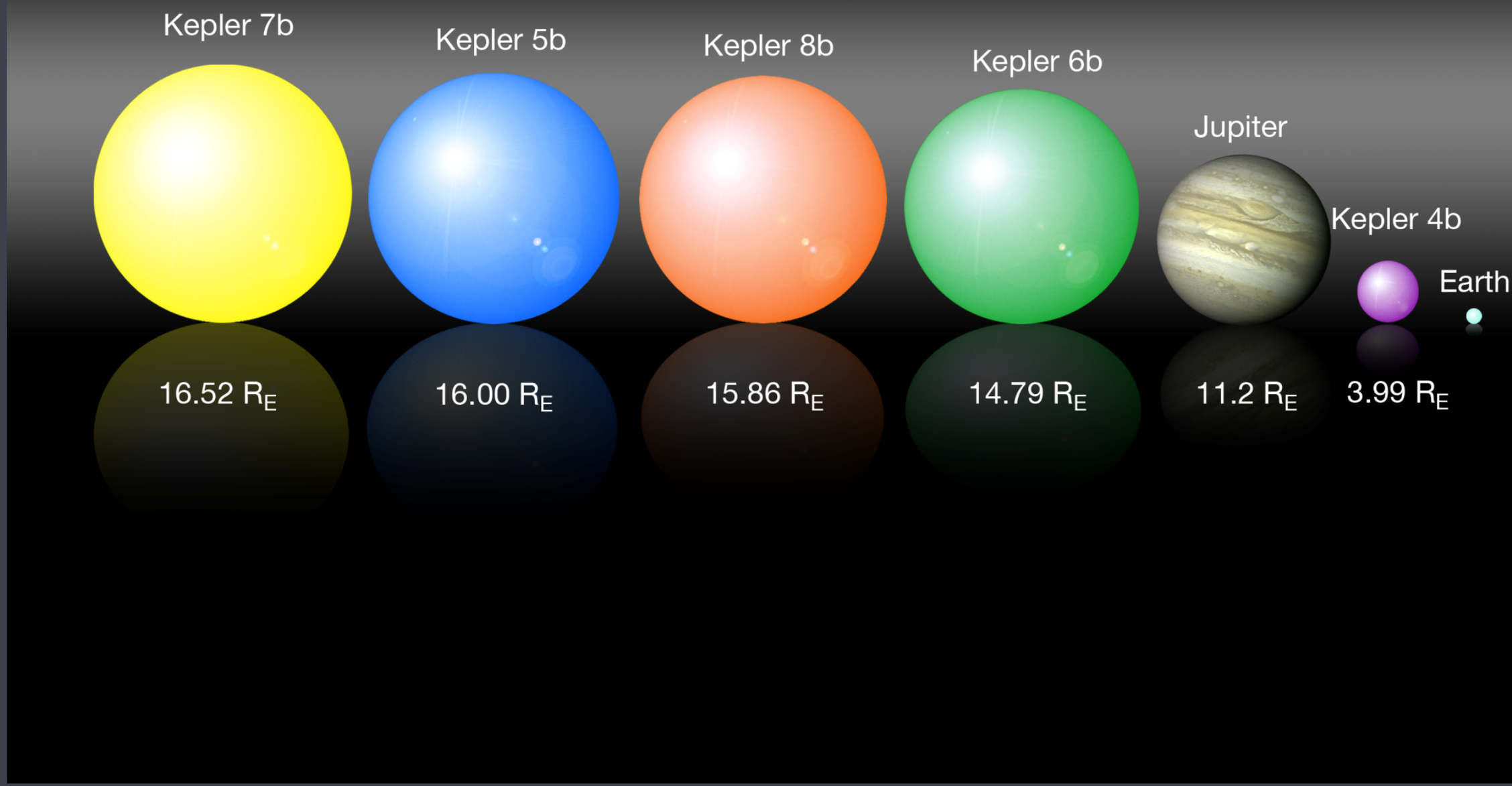
Kepler 7b



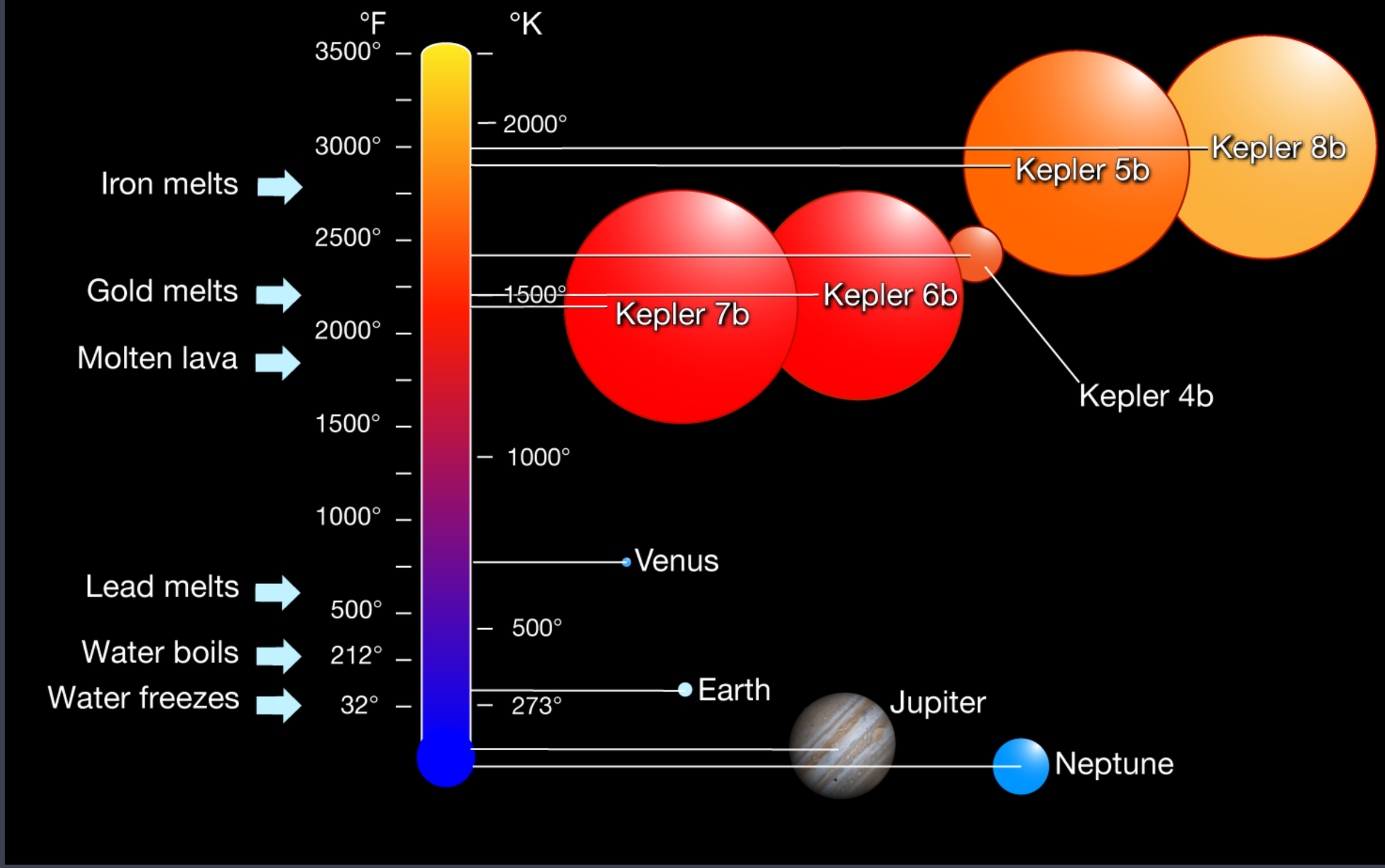
Kepler 8b



Planet Size

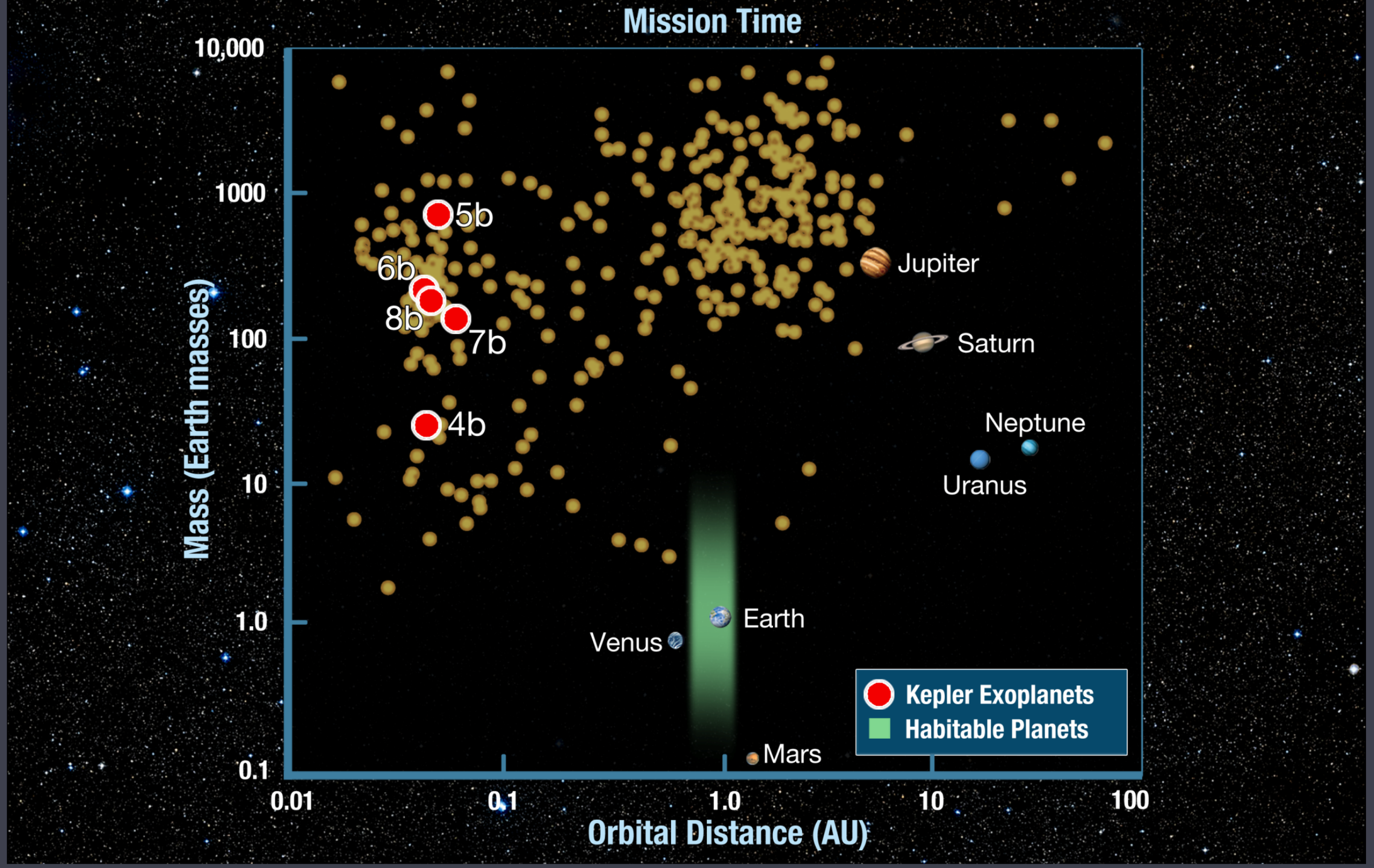

Kepler 7b
Kepler 5b
Kepler 8b
Kepler 6b
Jupiter
Kepler 4b
Earth
16.52 R_E
16.00 R_E
15.86 R_E
14.79 R_E
11.2 R_E
3.99 R_E

Planet Temperature & Size



First Five Planet Discoveries

Made with First 43 Days of Data



Variation of Planet Density with Mass