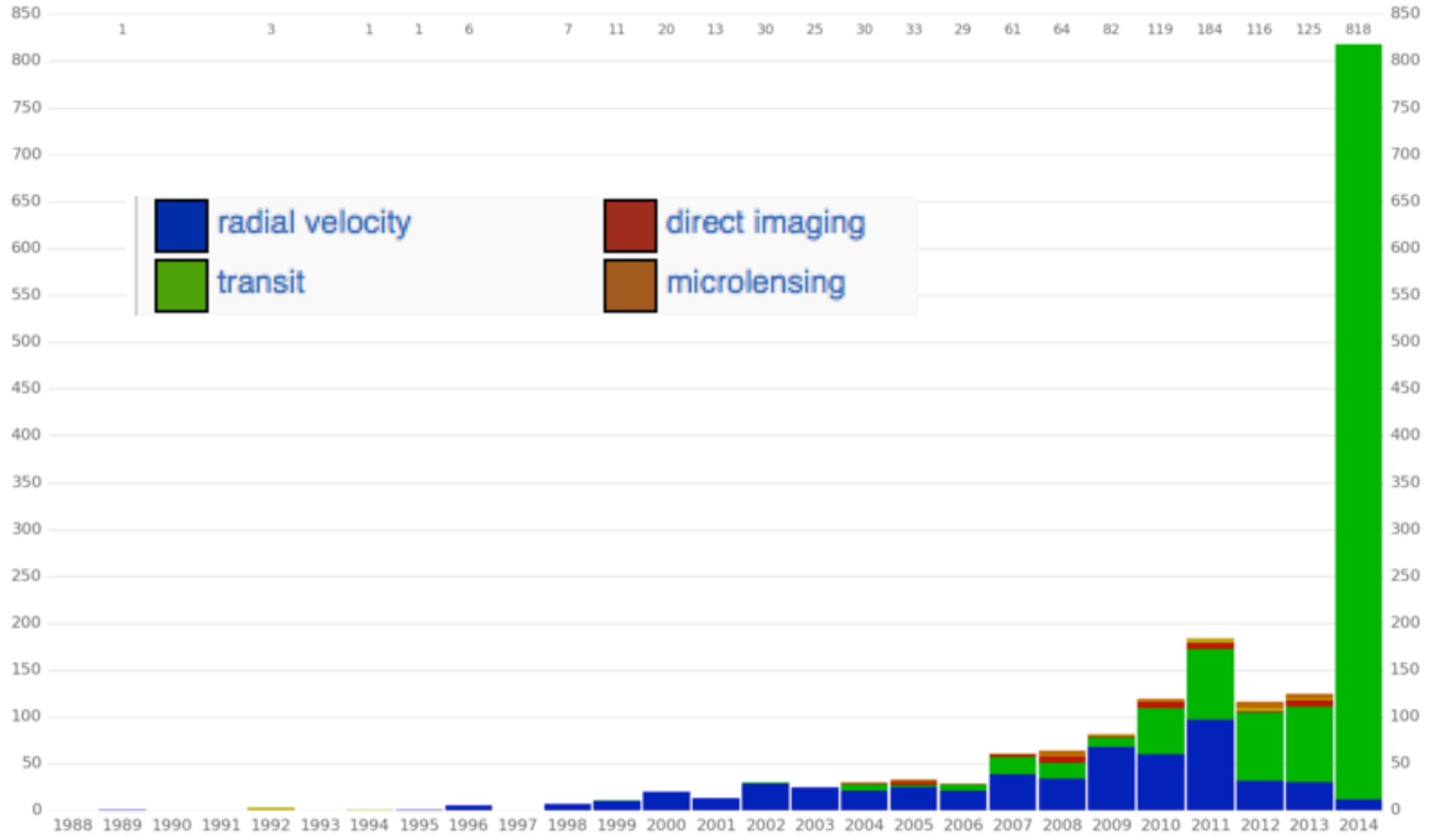
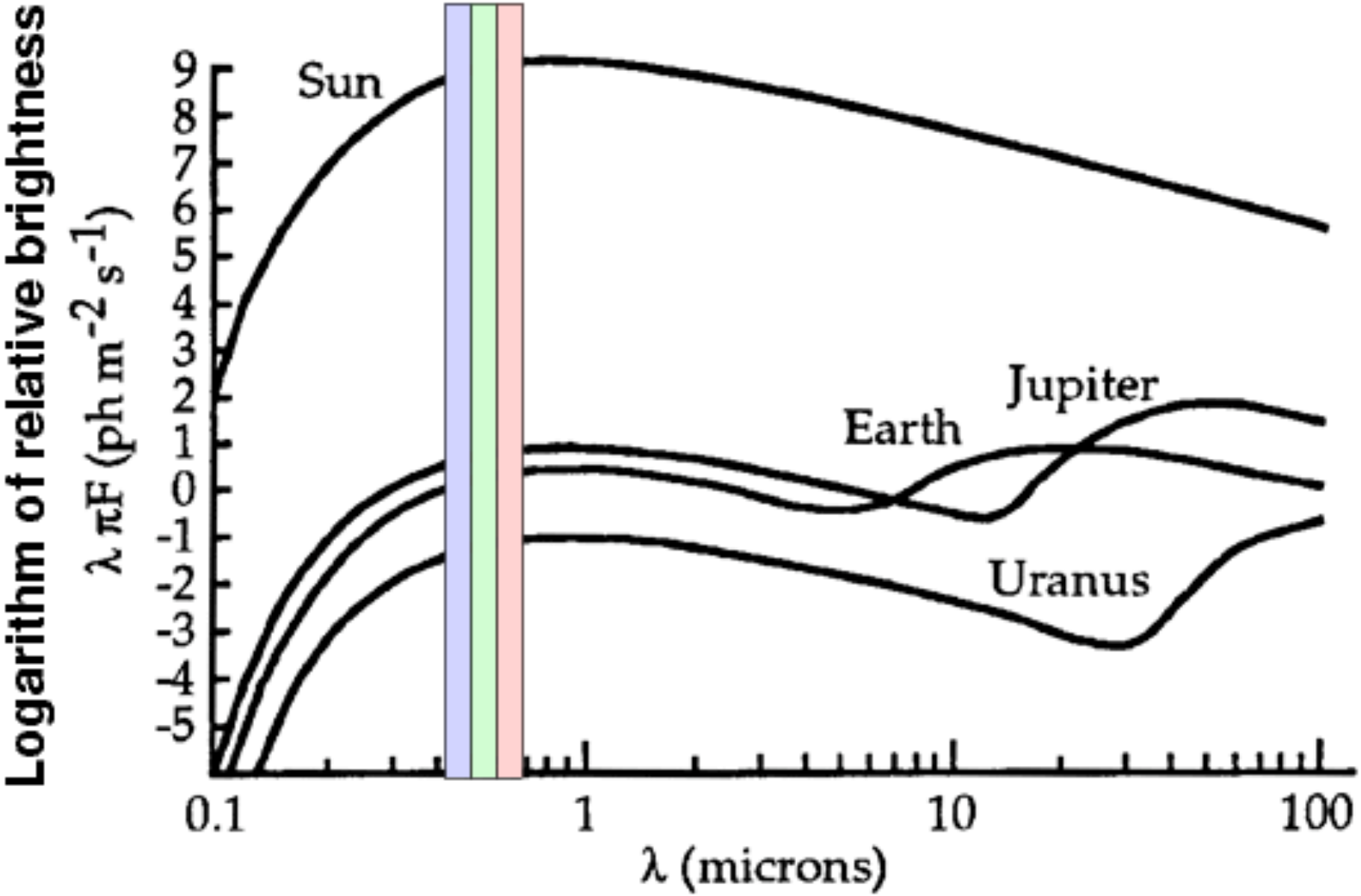
Exoplanets

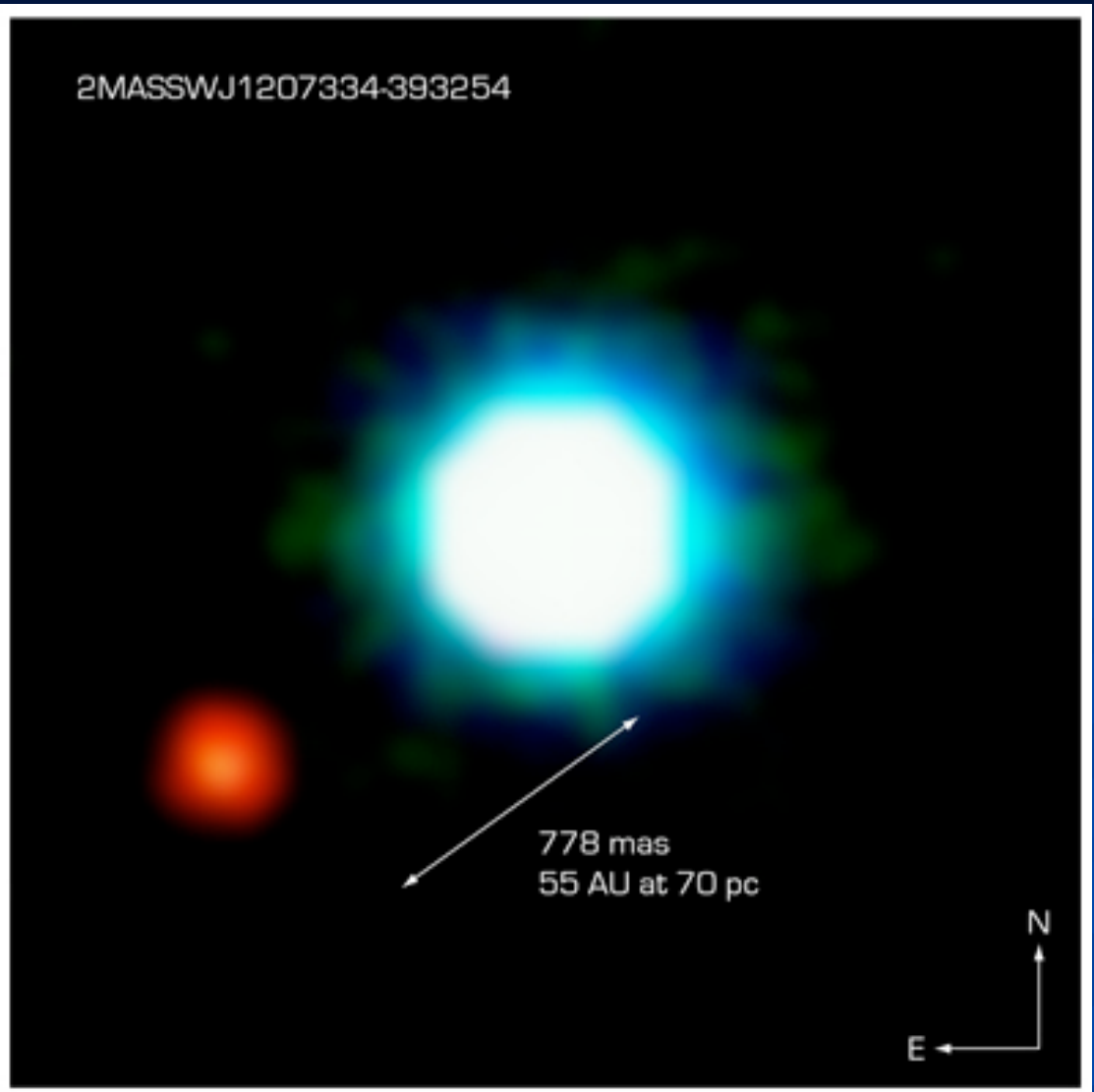
Pace of Discovery



Direct Detection – Large Contrast = Difficult



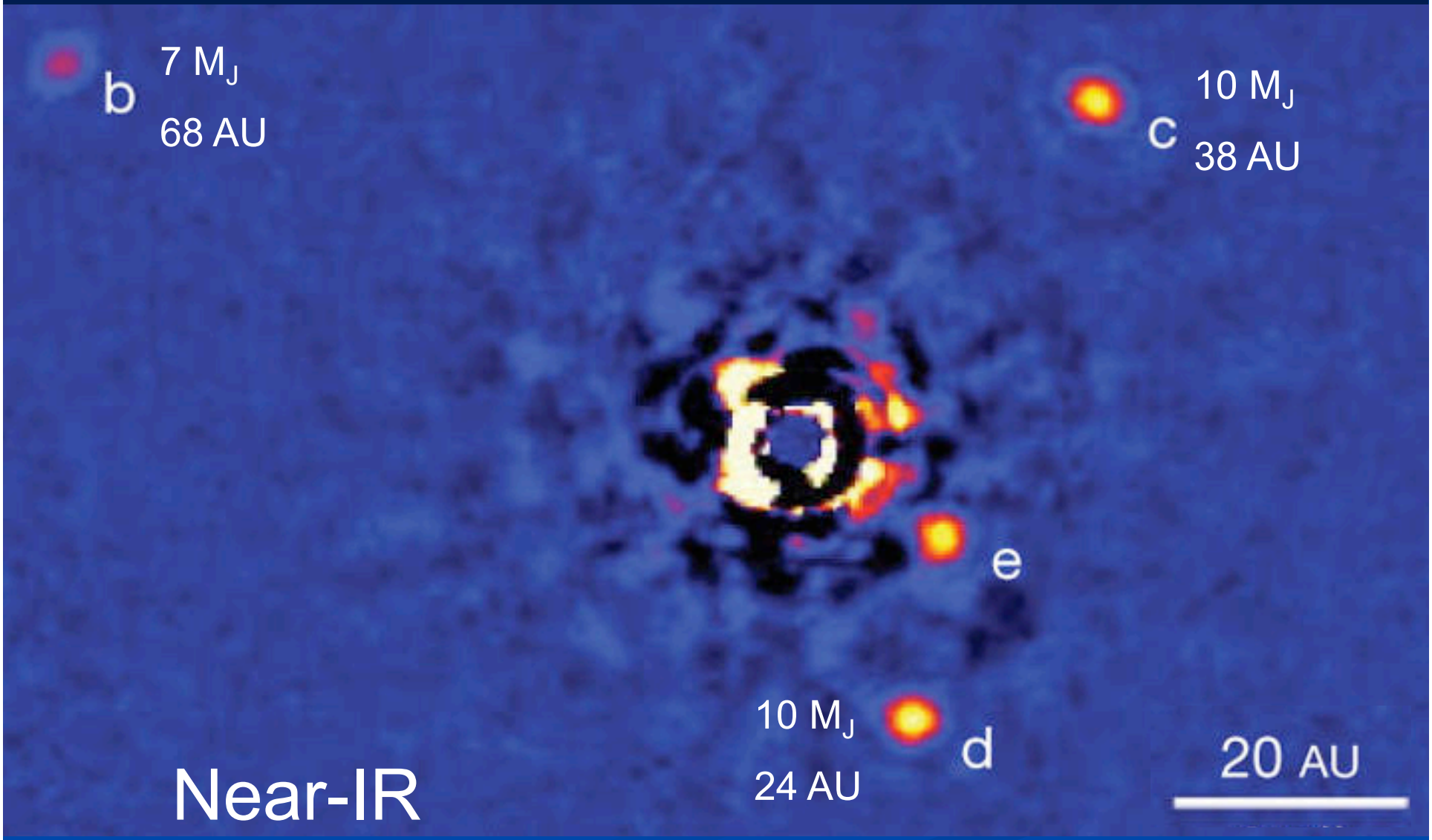
Direct Detection? - Need to Confirm Orbit



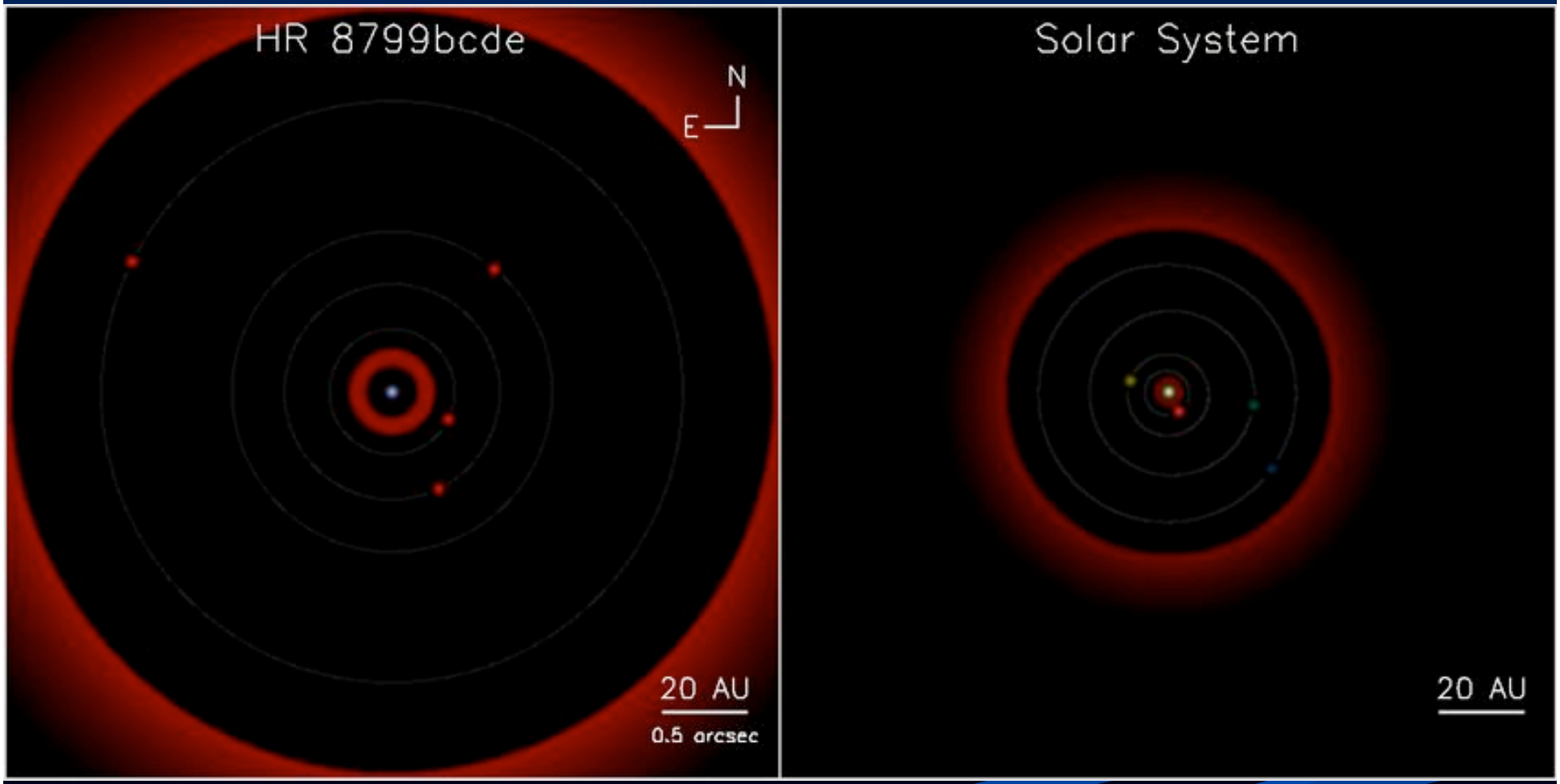
NACO Image of the Brown Dwarf Object 2M1207 and GPCC

ESO PR Photo 26a/04 (10 September 2004)

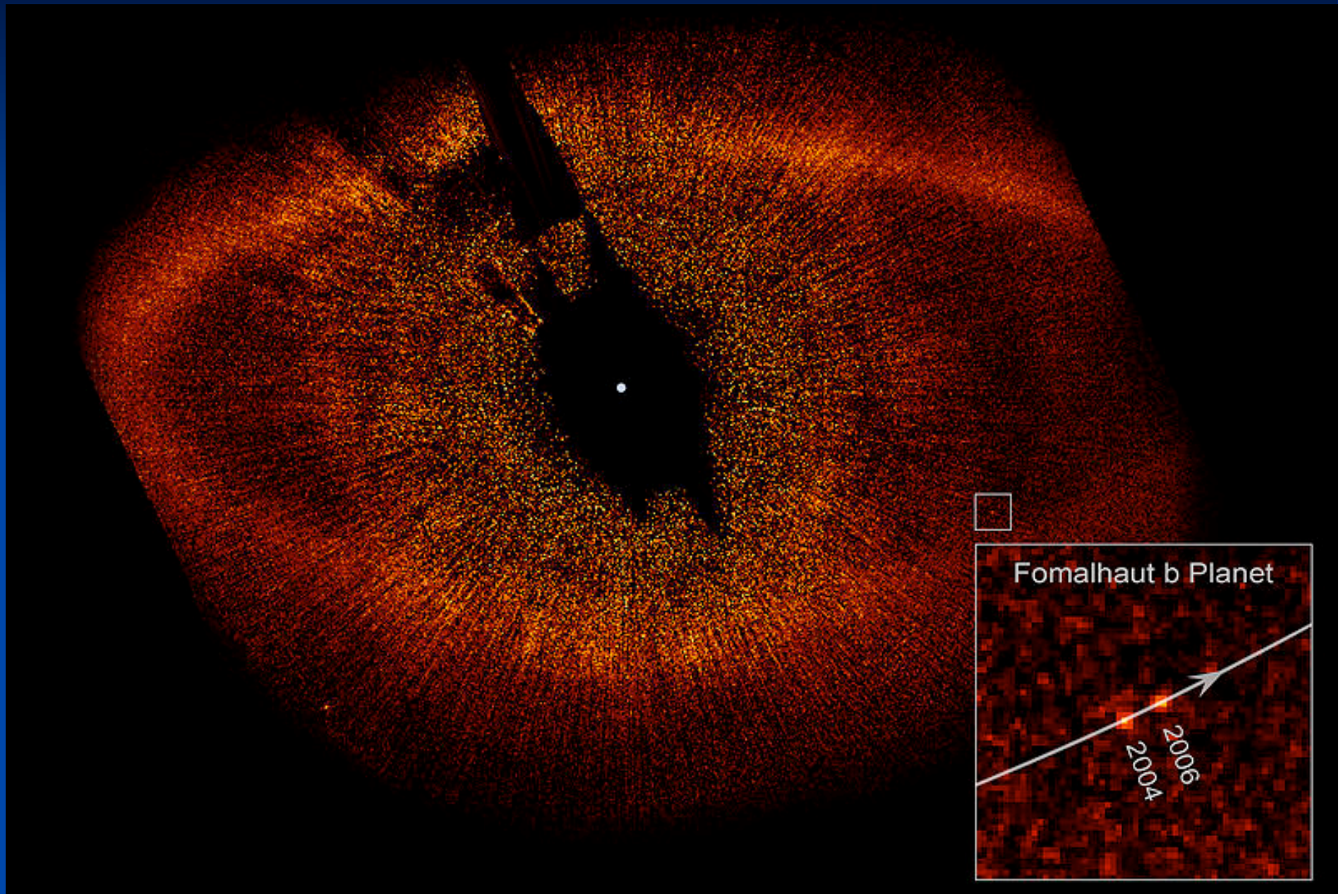
HR 8799



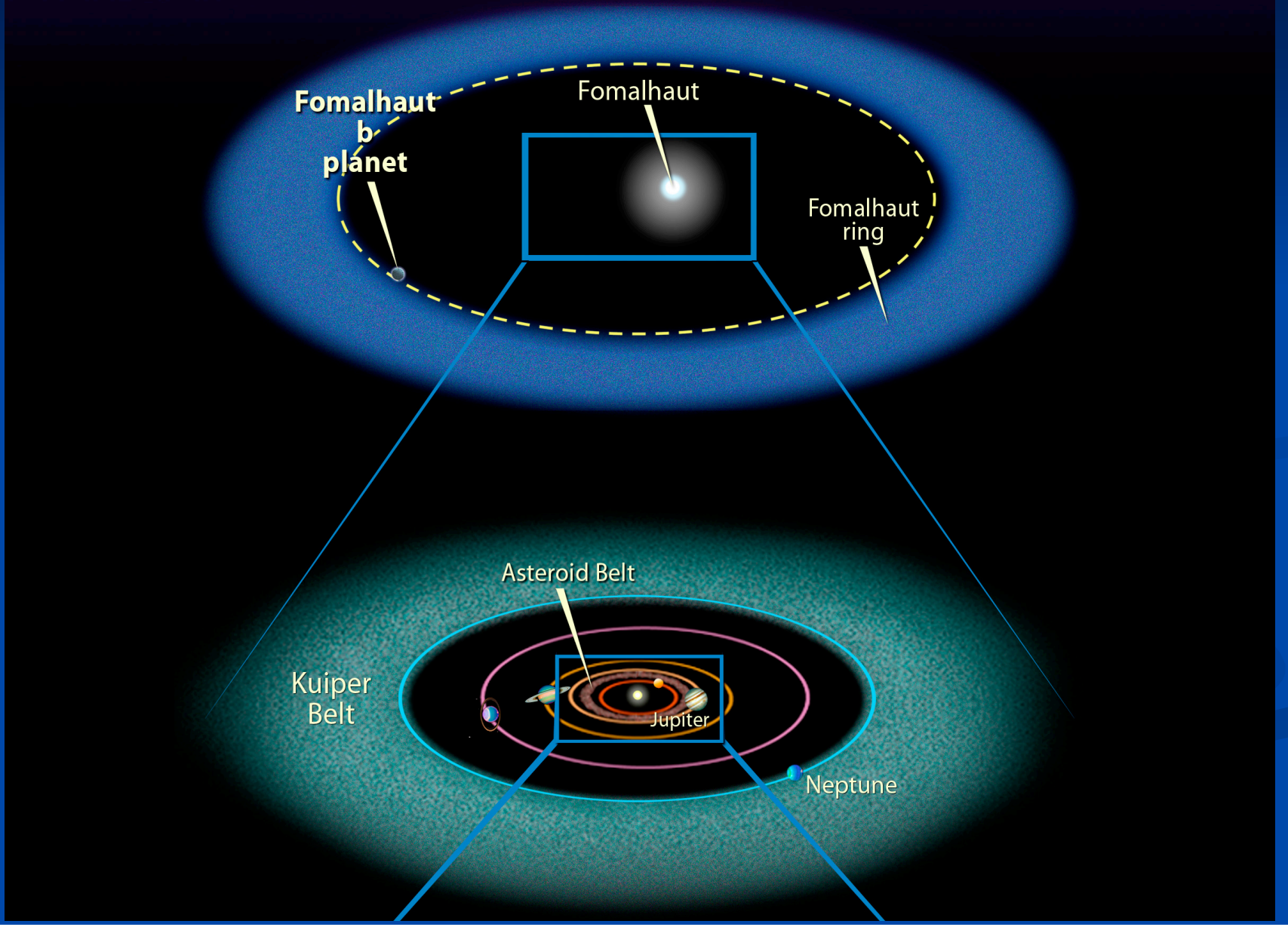
HR8799 vs. Solar System



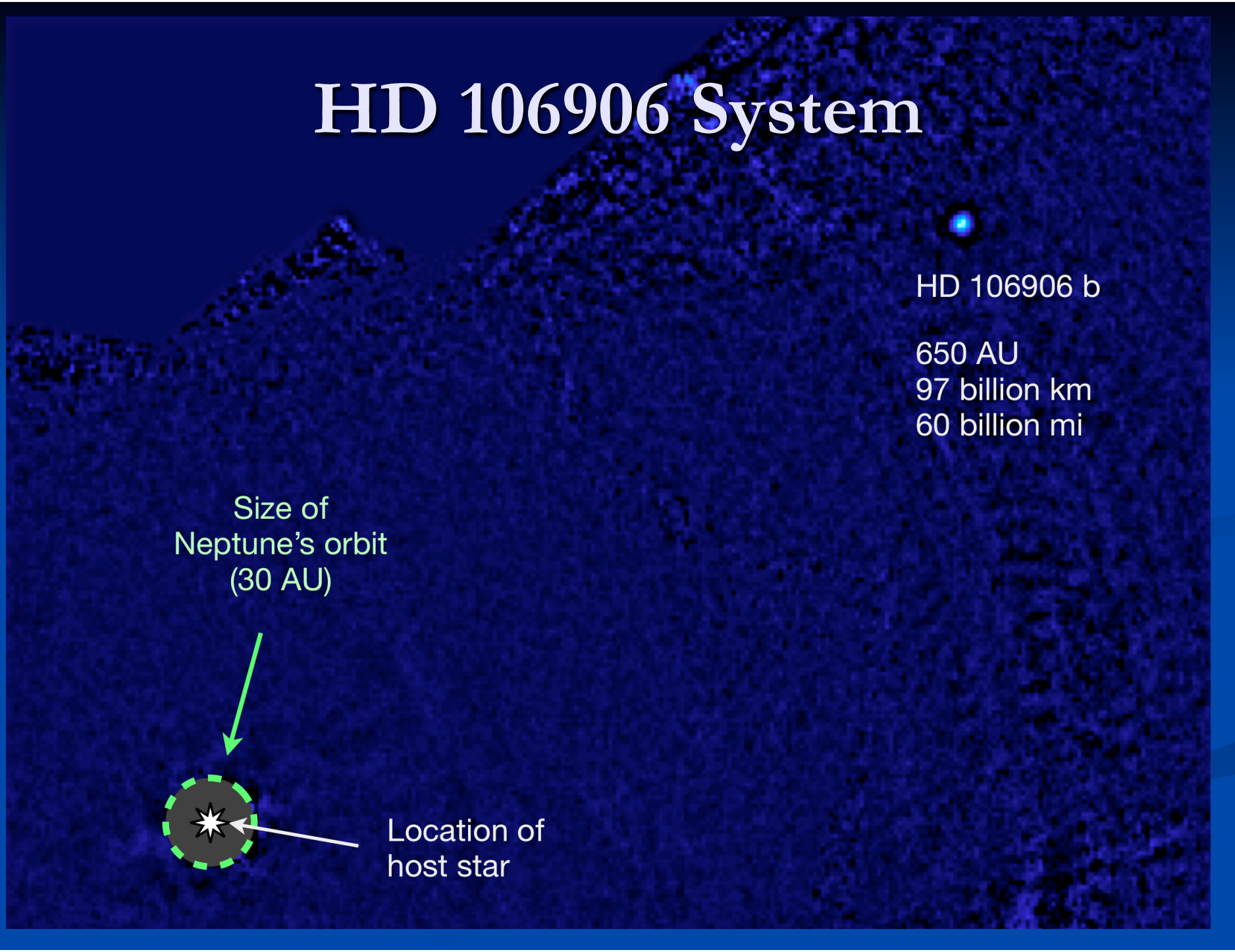
Formalhaut B - ??



Comparison of Fomalhaut System and Solar System



HD 106906 System



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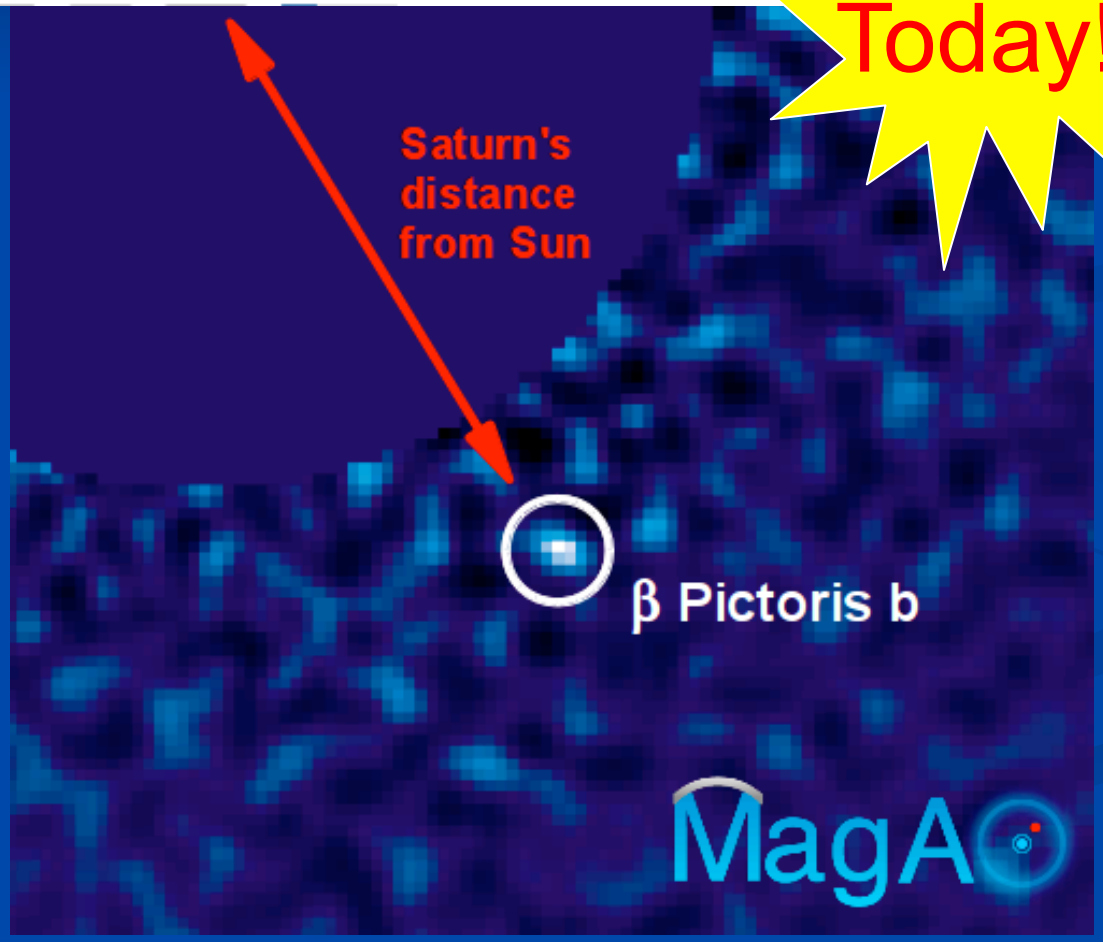
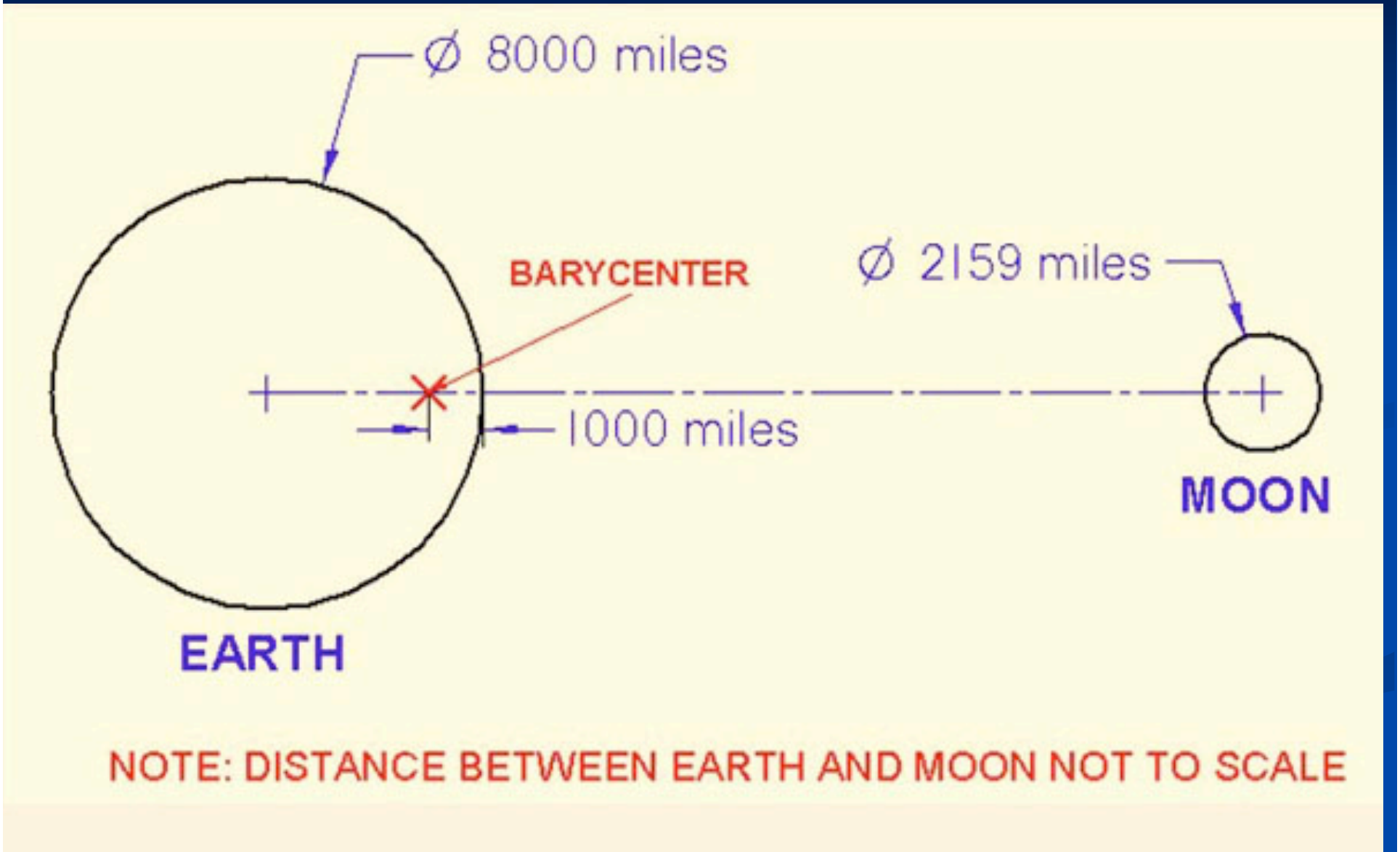
A Small Step Toward Discovering Habitable Earths

By Daniel Stolte, University Communications | March 4, 2014



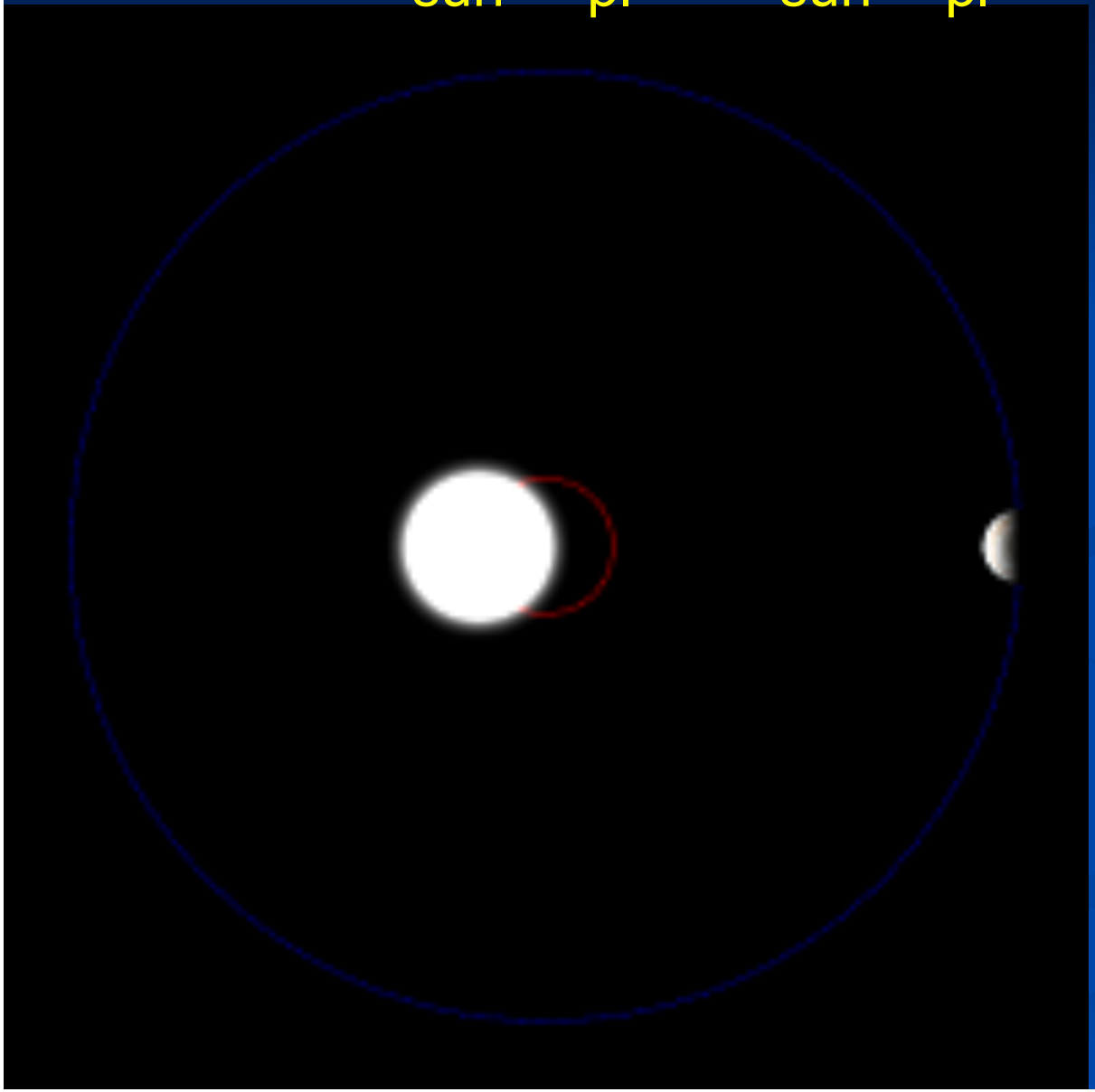
Today!

Center of Mass = “Barycenter”



Radial Velocity Technique

$V_{sun}/V_{pl} = d_{sun}/d_{pl} = M_{pl}/M_{sun}$



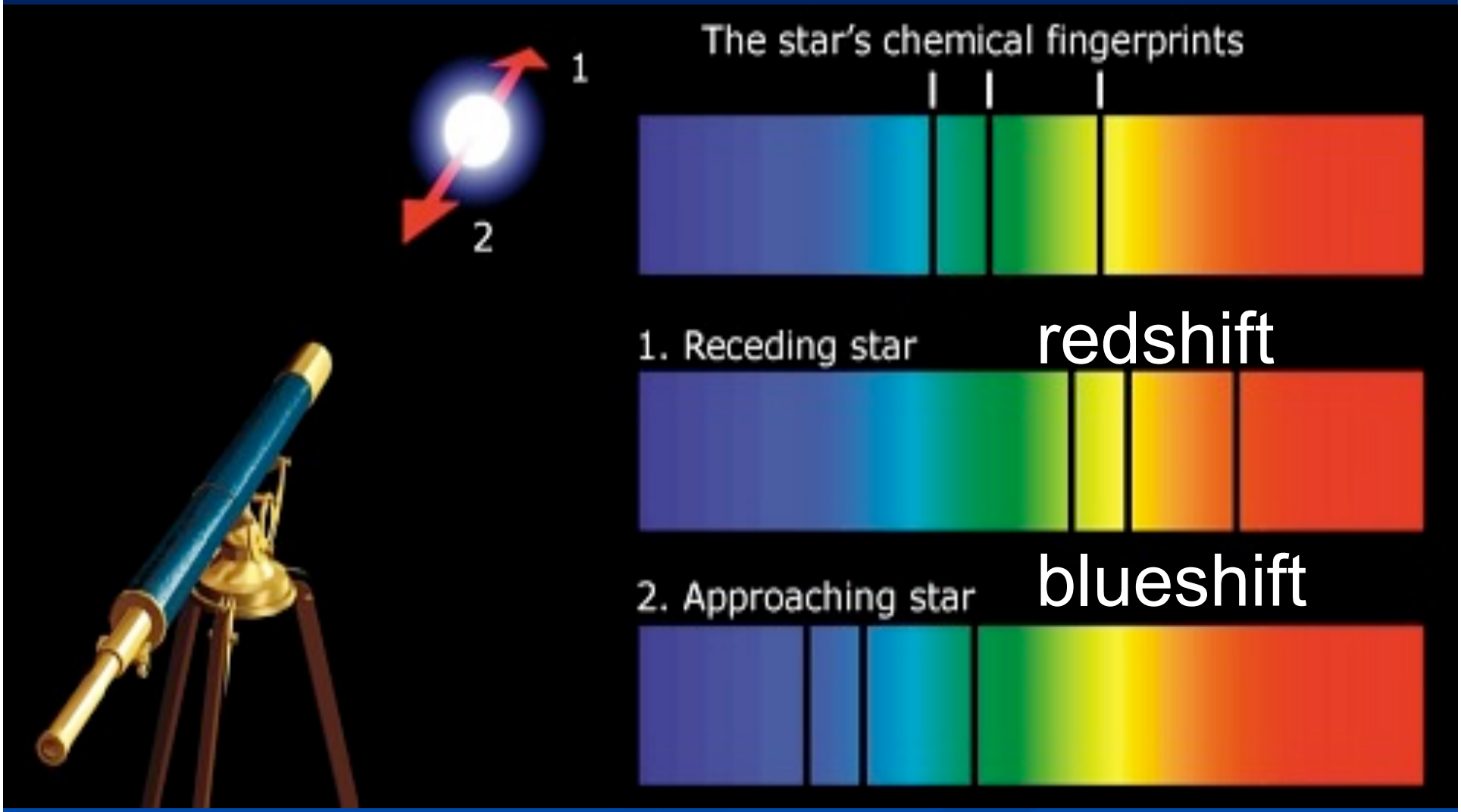
Sun's reflex motion due to:

Jupiter ~13 m/s

Earth ~ 9 cm/s

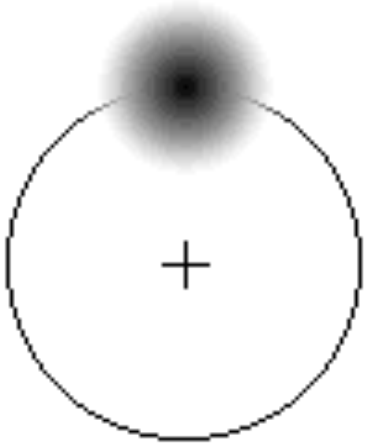
Motion with respect to center-of-mass

Doppler Shift of Stellar Spectra



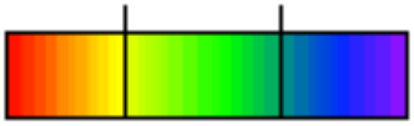
Observation of Stellar Motions Due to Presence of Extra-Solar Planet

Orbit of Star Around System's Center of Mass (Viewed from above)

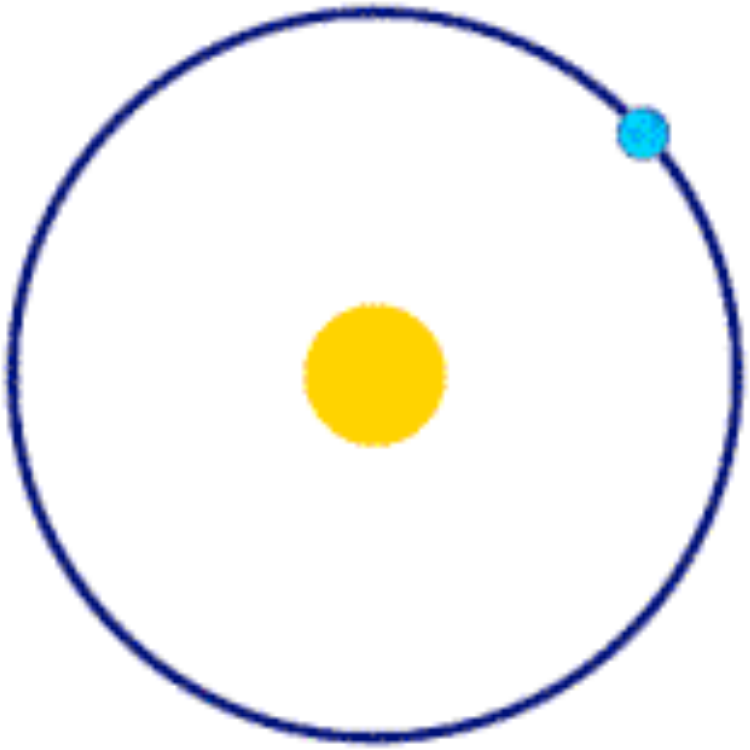


Earth

Doppler Shift (Detects movement *along* line of sight)



Face-on

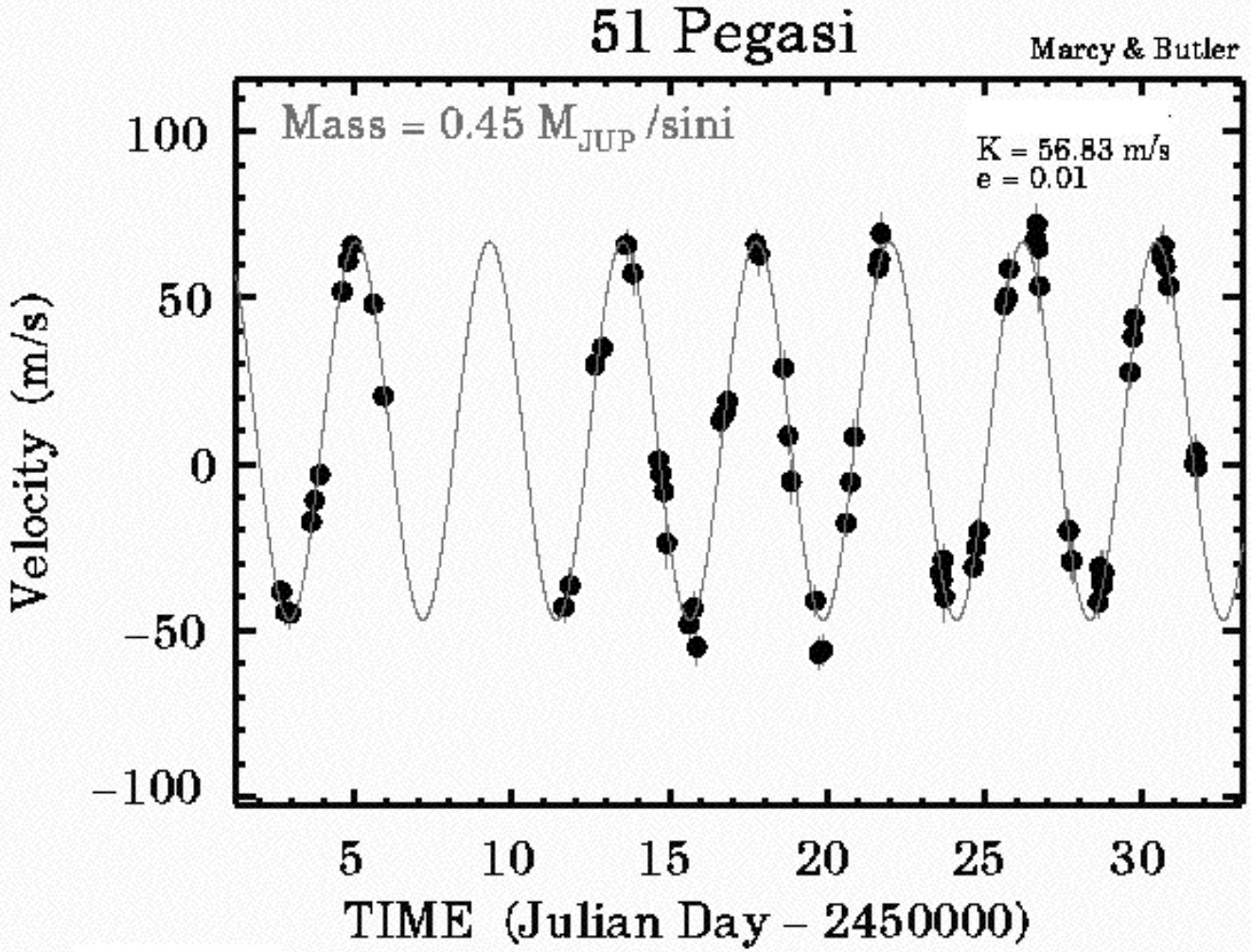


Minimum Doppler Signature

Edge-on

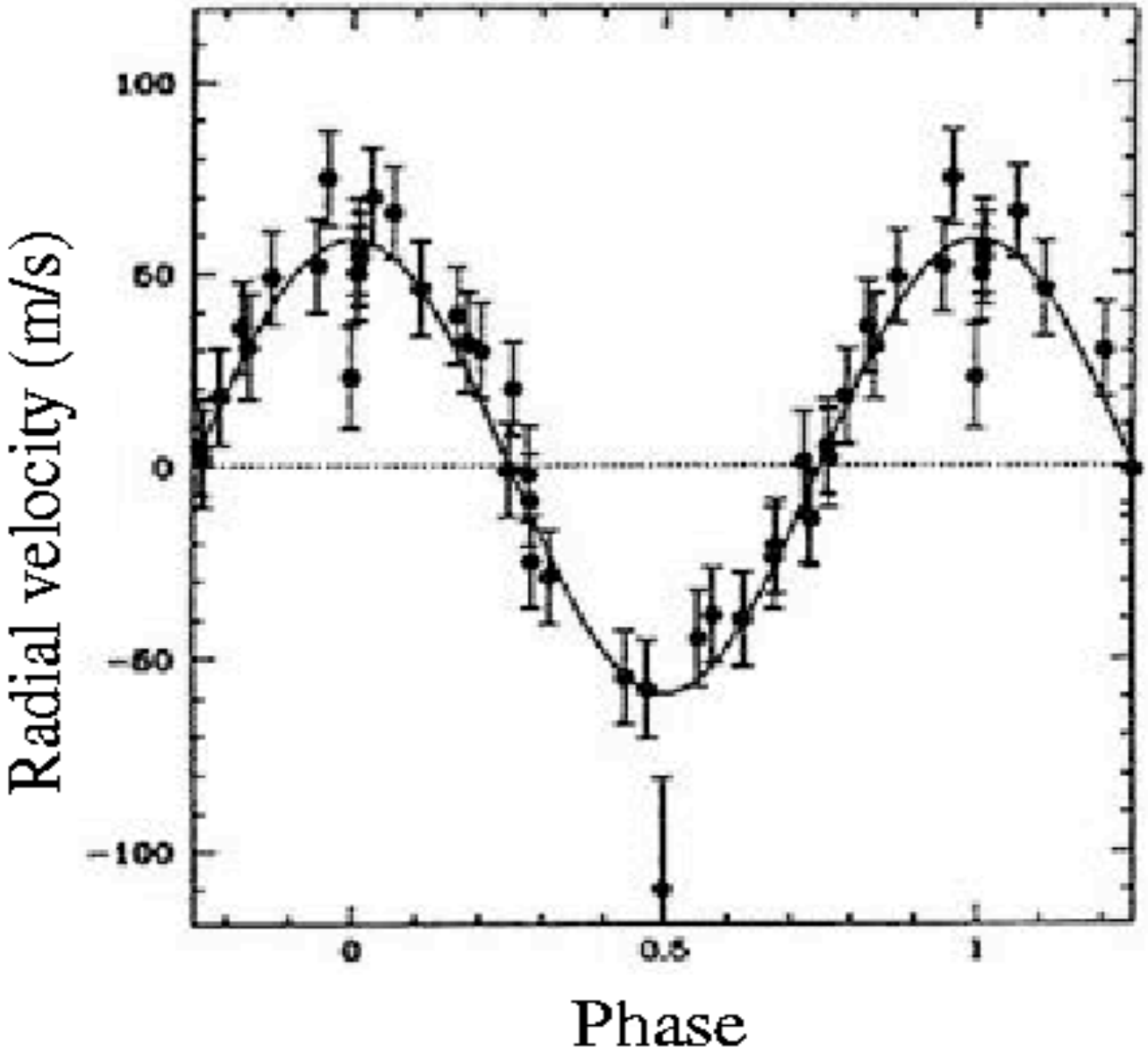
Maximum Doppler Signature

51 Peg b - 1st "RV" Exoplanet (1995)

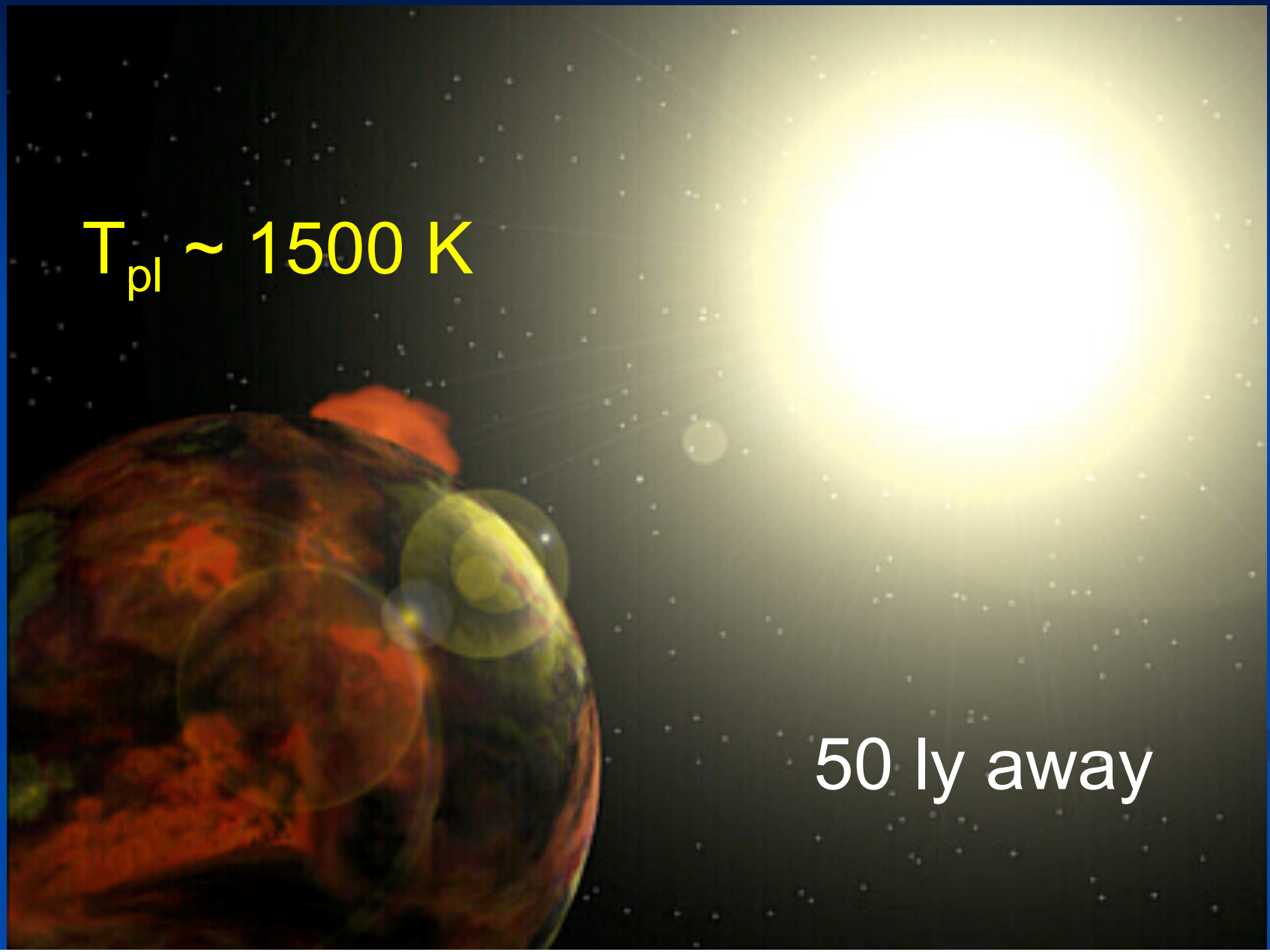


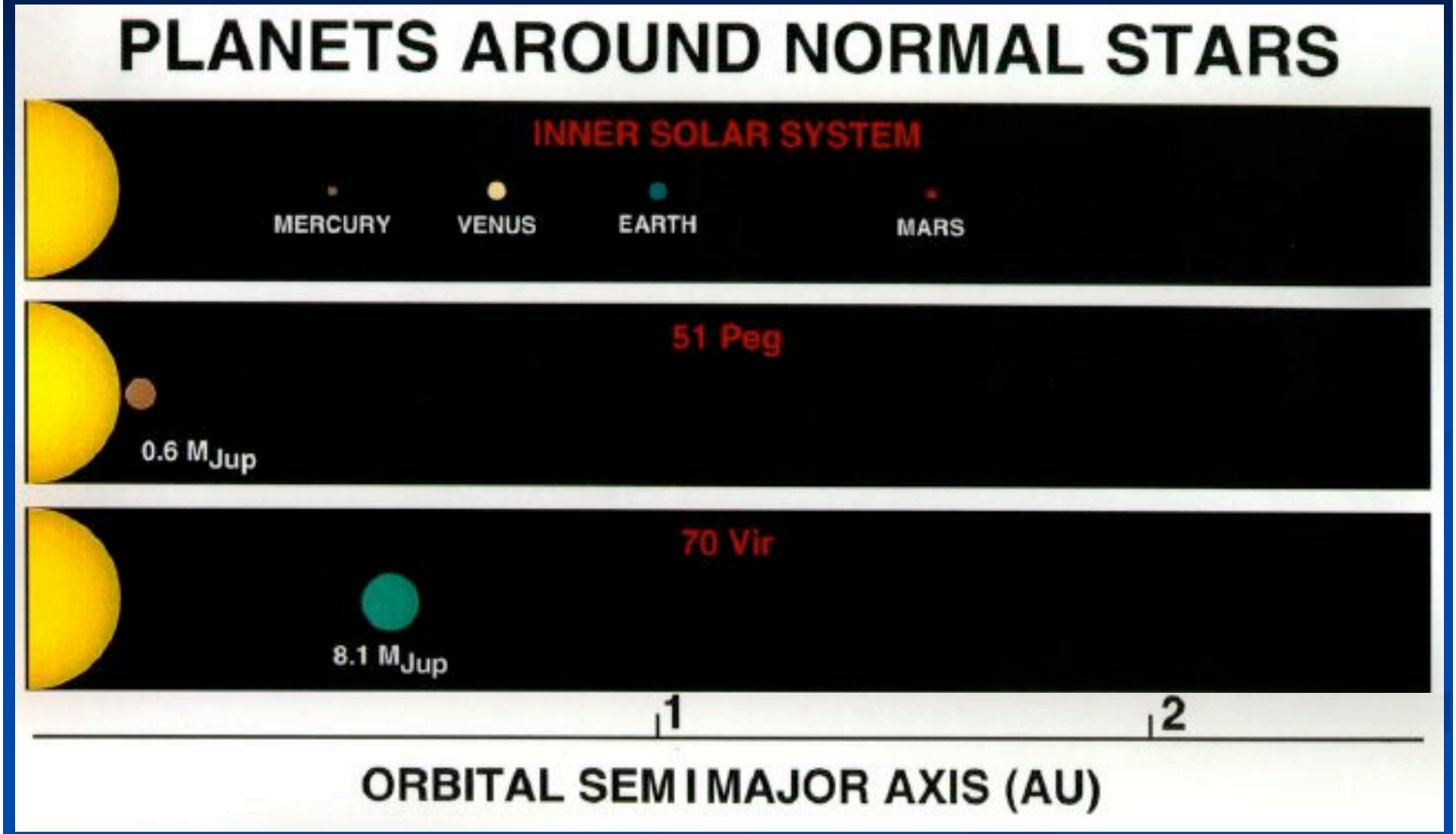
Orbits in 4.2 days!

51 Peg b – Phased RV Curve

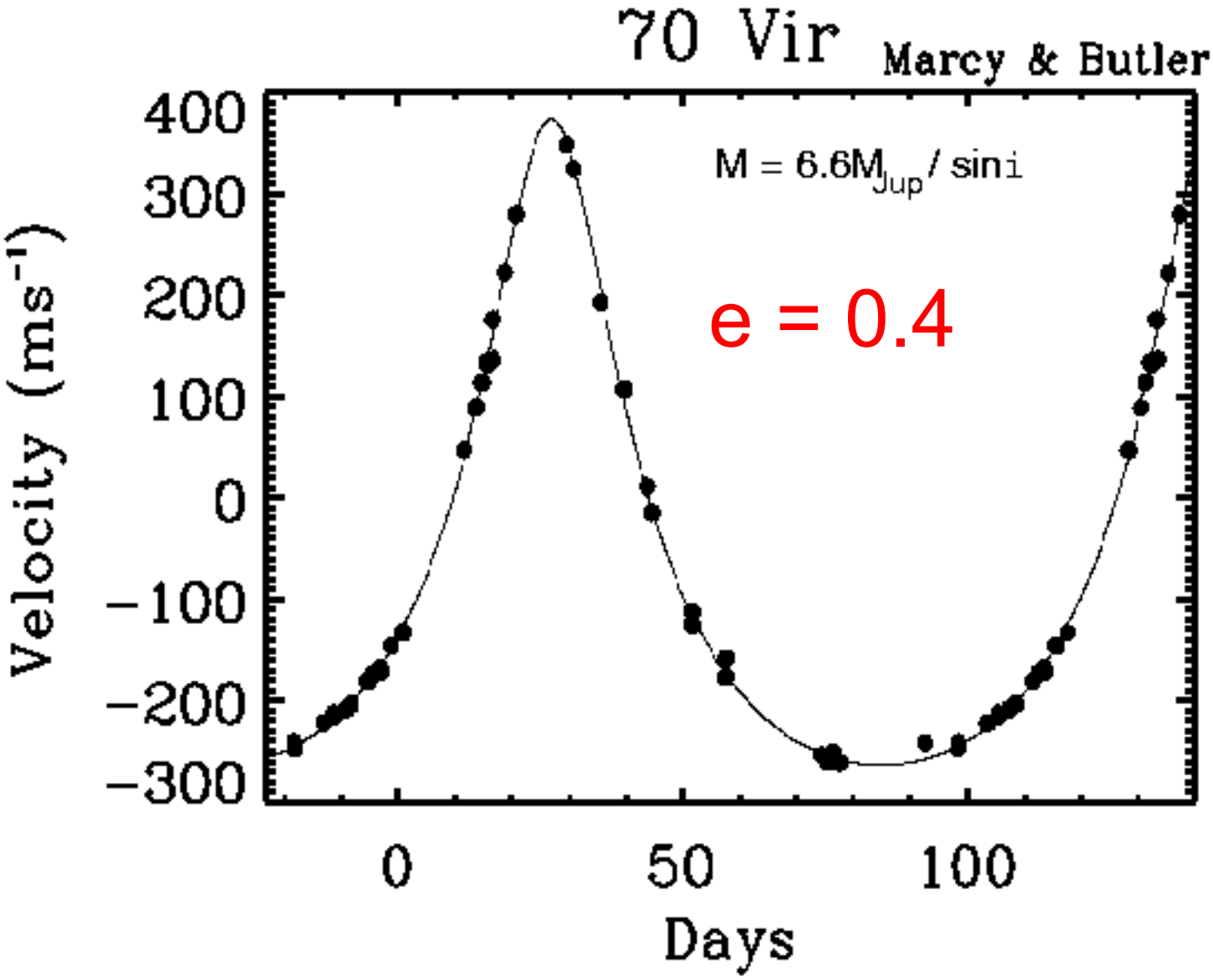


51 Peg b is a “Hot” Jupiter

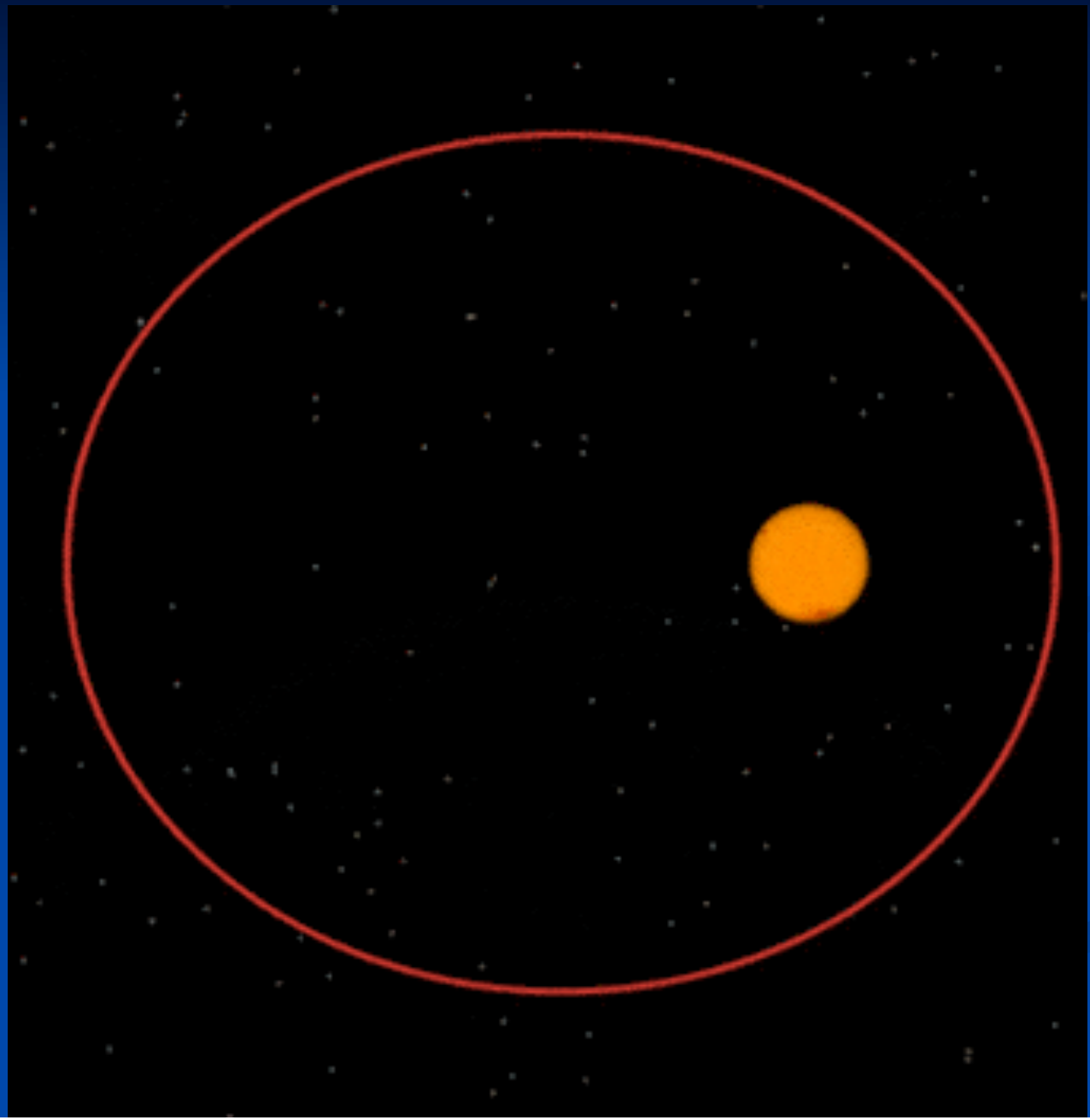


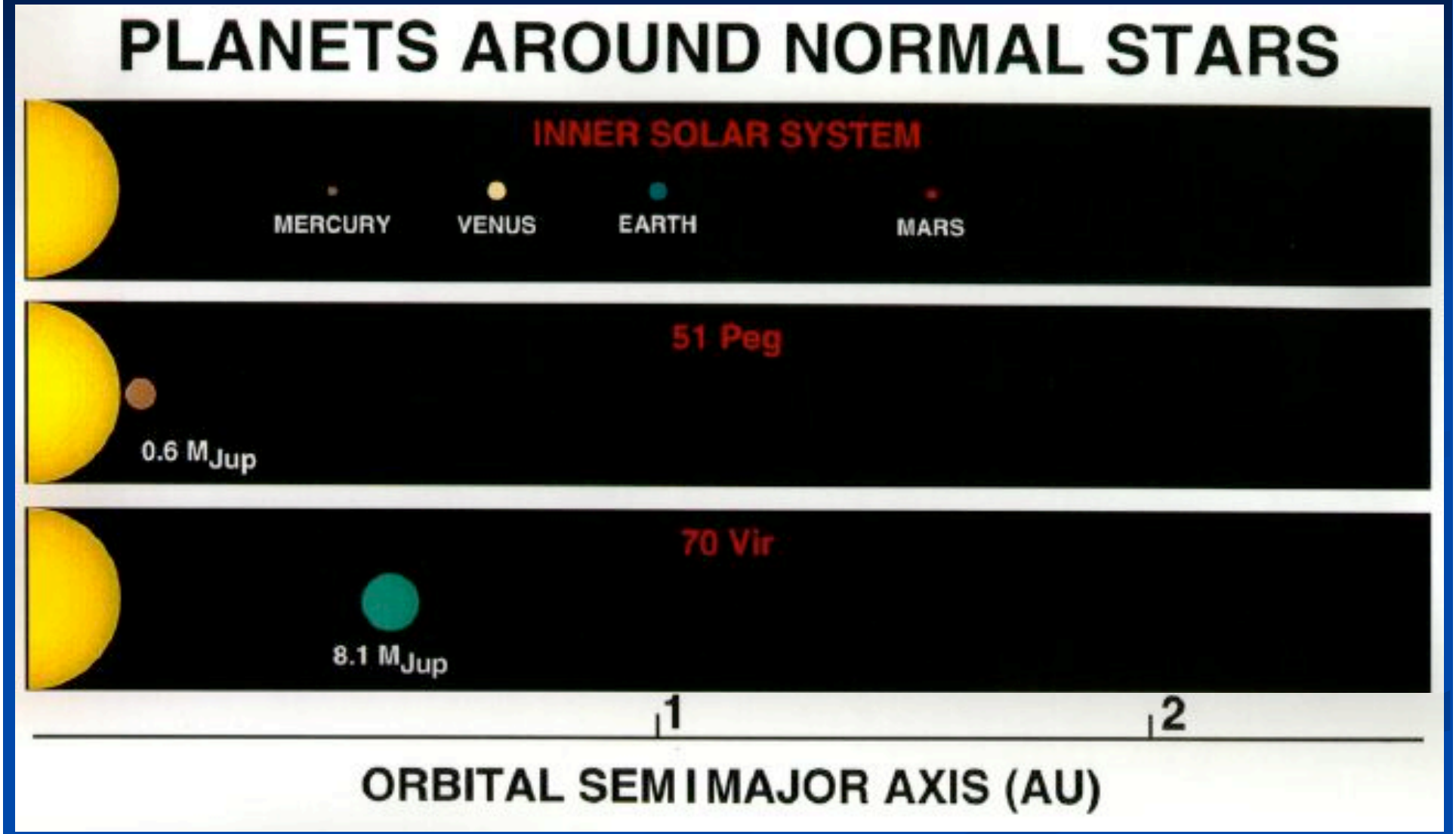

PLANETS AROUND NORMAL STARS
INNER SOLAR SYSTEM
MERCURY
VENUS
EARTH
MARS
51 Peg
0.6 M Jup
70 Vir
8.1 M Jup
1
2
ORBITAL SEMI MAJOR AXIS (AU)

70 Vir b - Eccentric Orbit

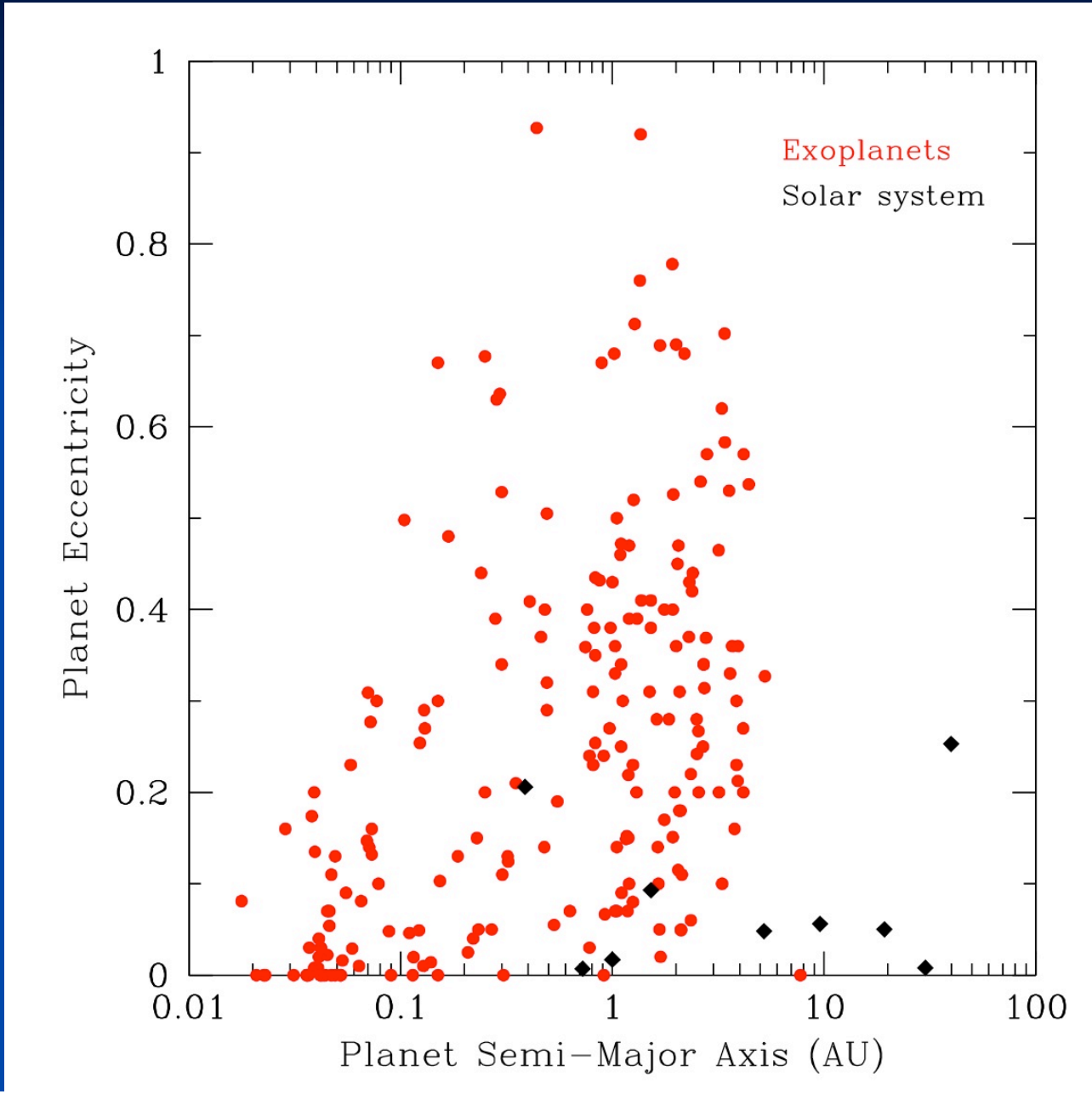


70 Vir b - Eccentric Orbit

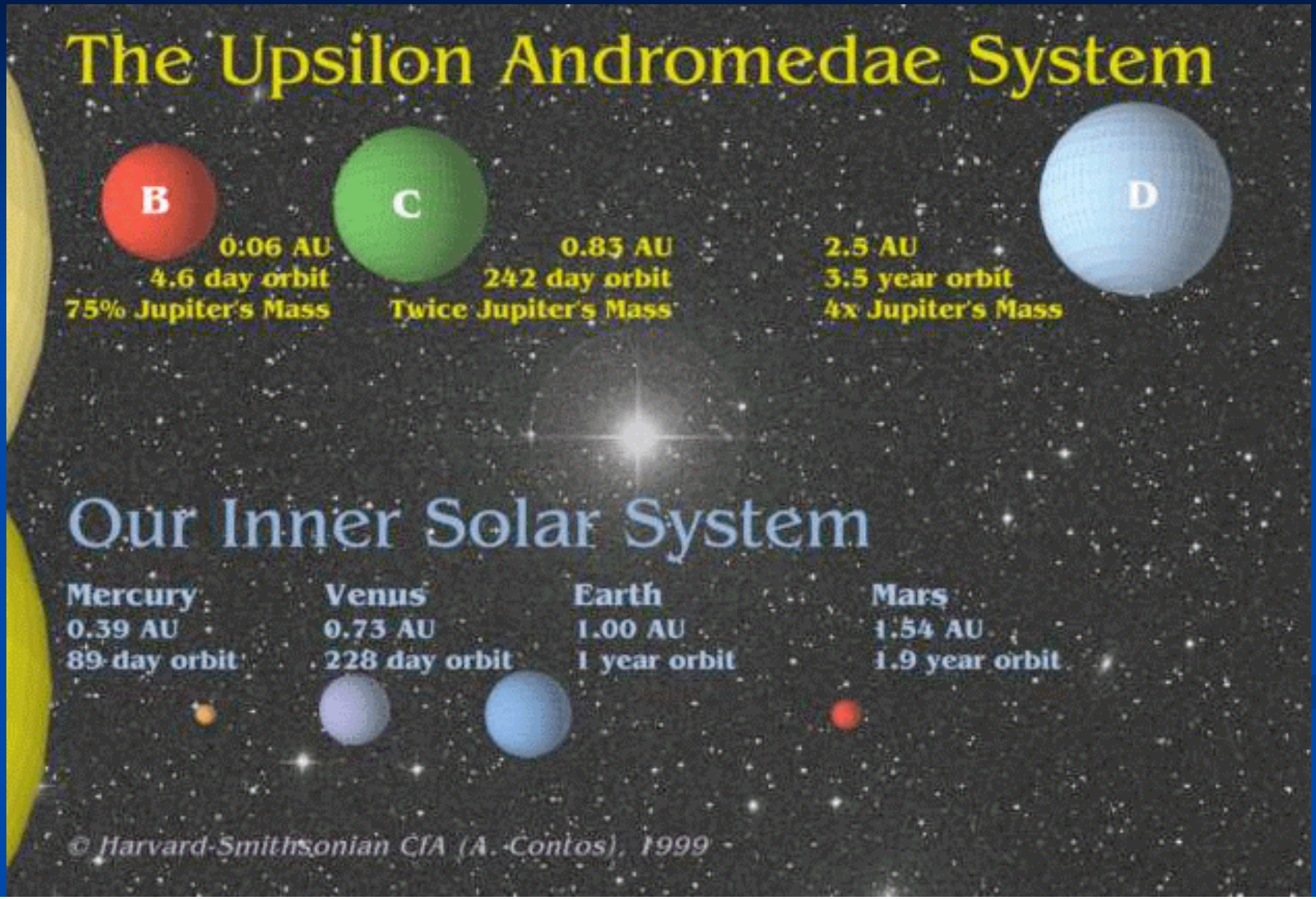


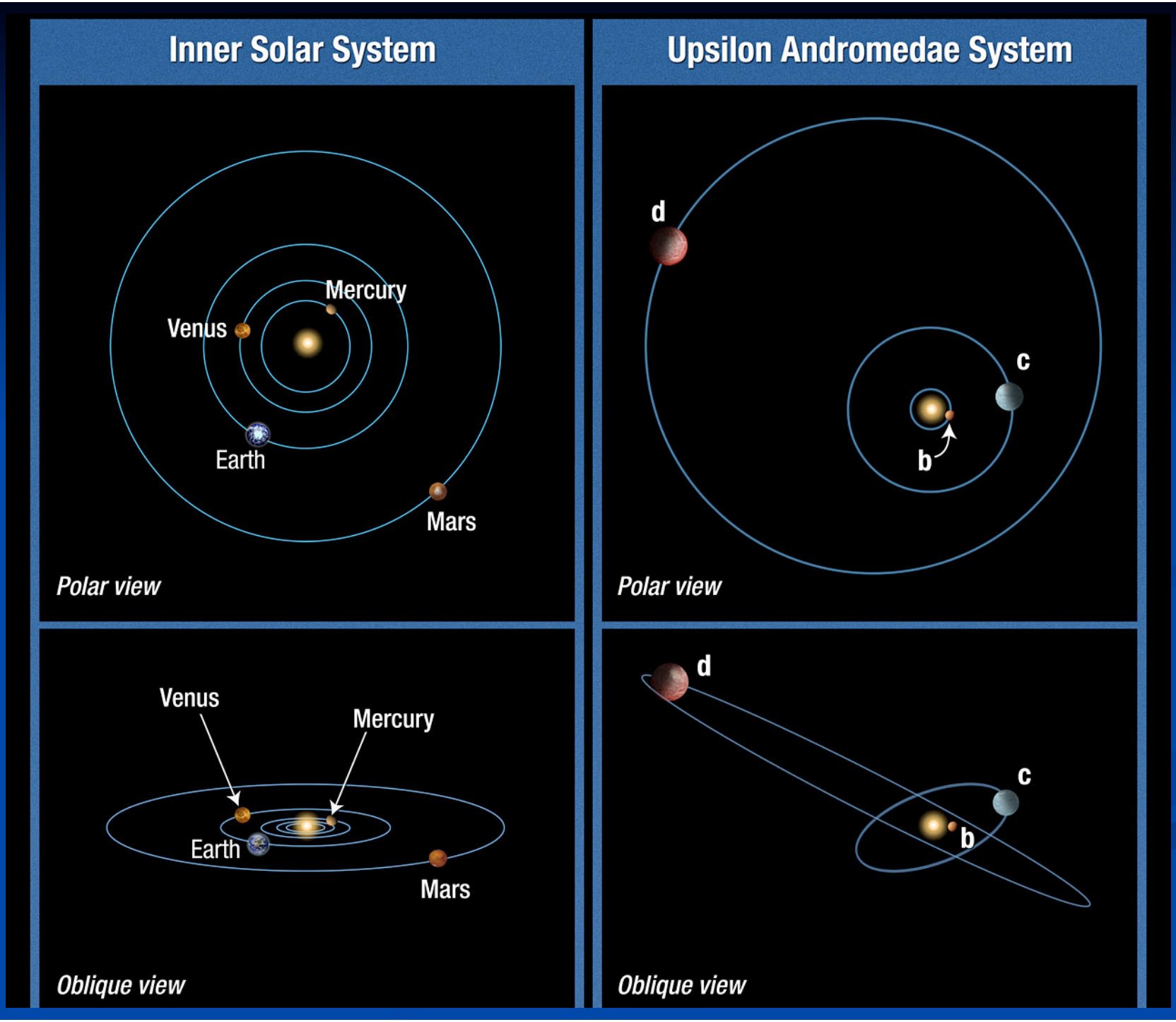

PLANETS AROUND NORMAL STARS
INNER SOLAR SYSTEM
MERCURY
VENUS
EARTH
MARS
51 Peg
0.6 M Jup
70 Vir
8.1 M Jup
1
2
ORBITAL SEMI MAJOR AXIS (AU)

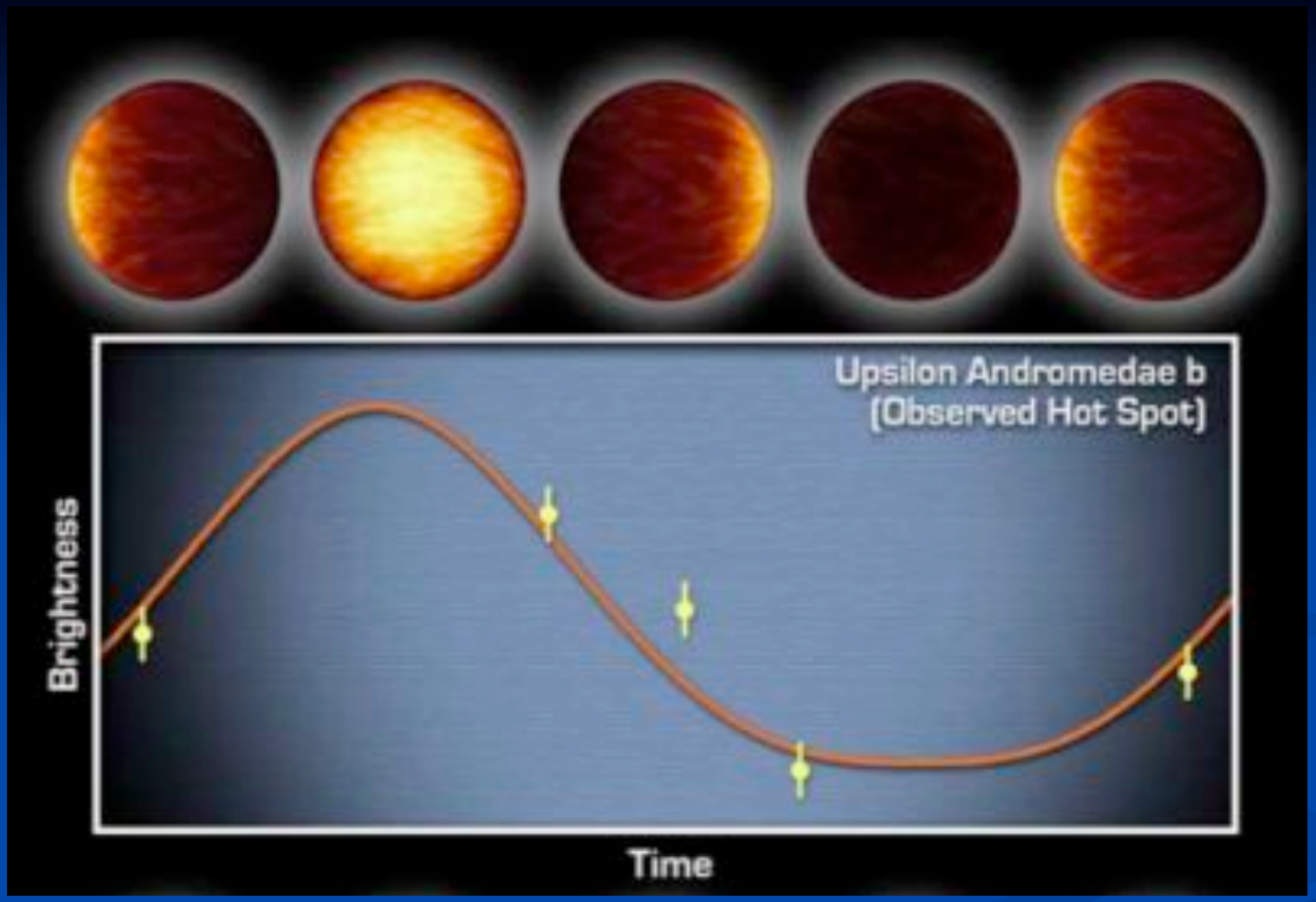
Detected Orbital Eccentricities



Multiple Planet Systems



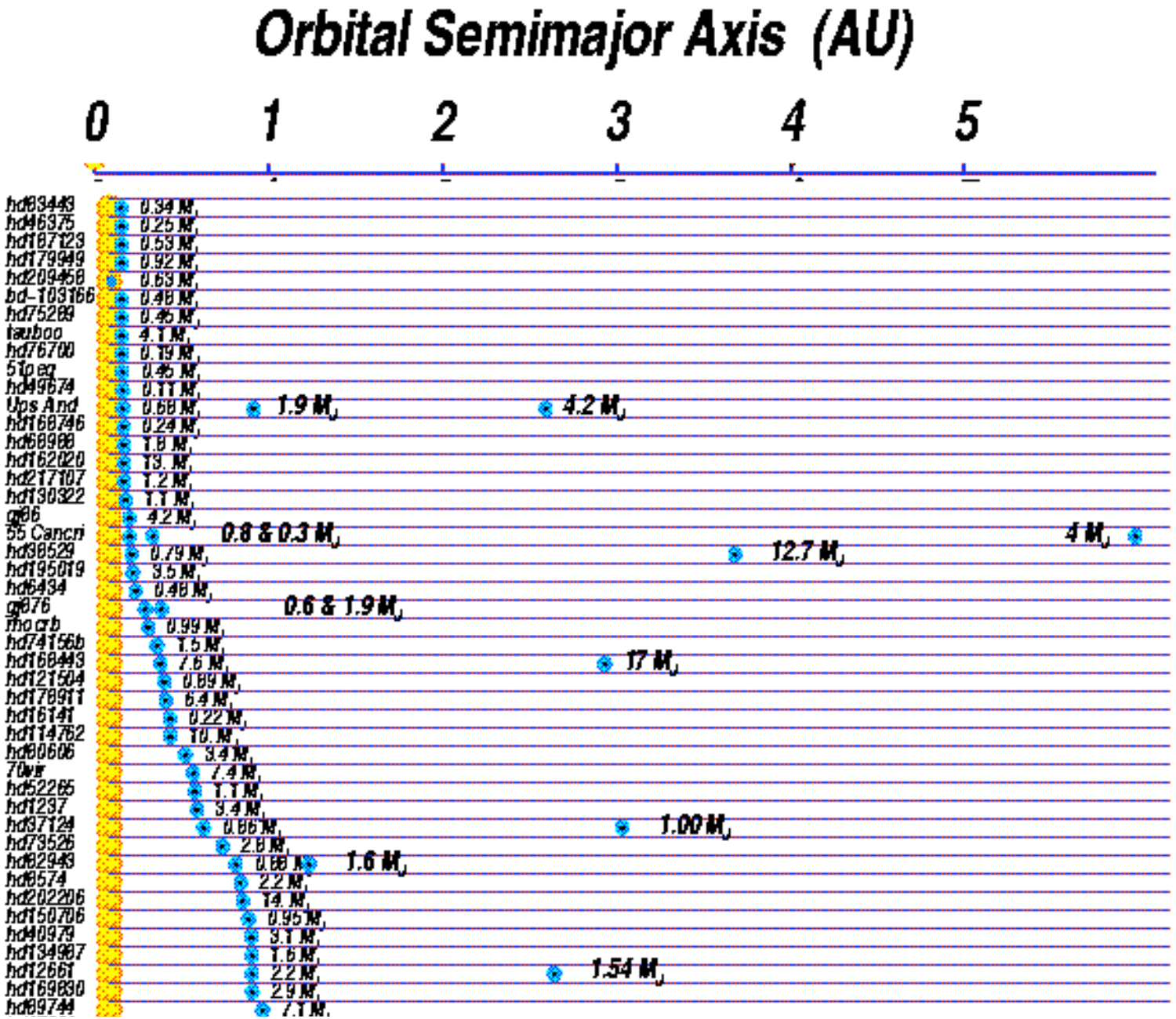

Inner Solar System
Mercury
Venus
Earth
Mars
Polar view
Venus
Mercury
Earth
Mars
Oblique view
Upsilon Andromedae System
d
c
b
Polar view
d
c
b
Oblique view



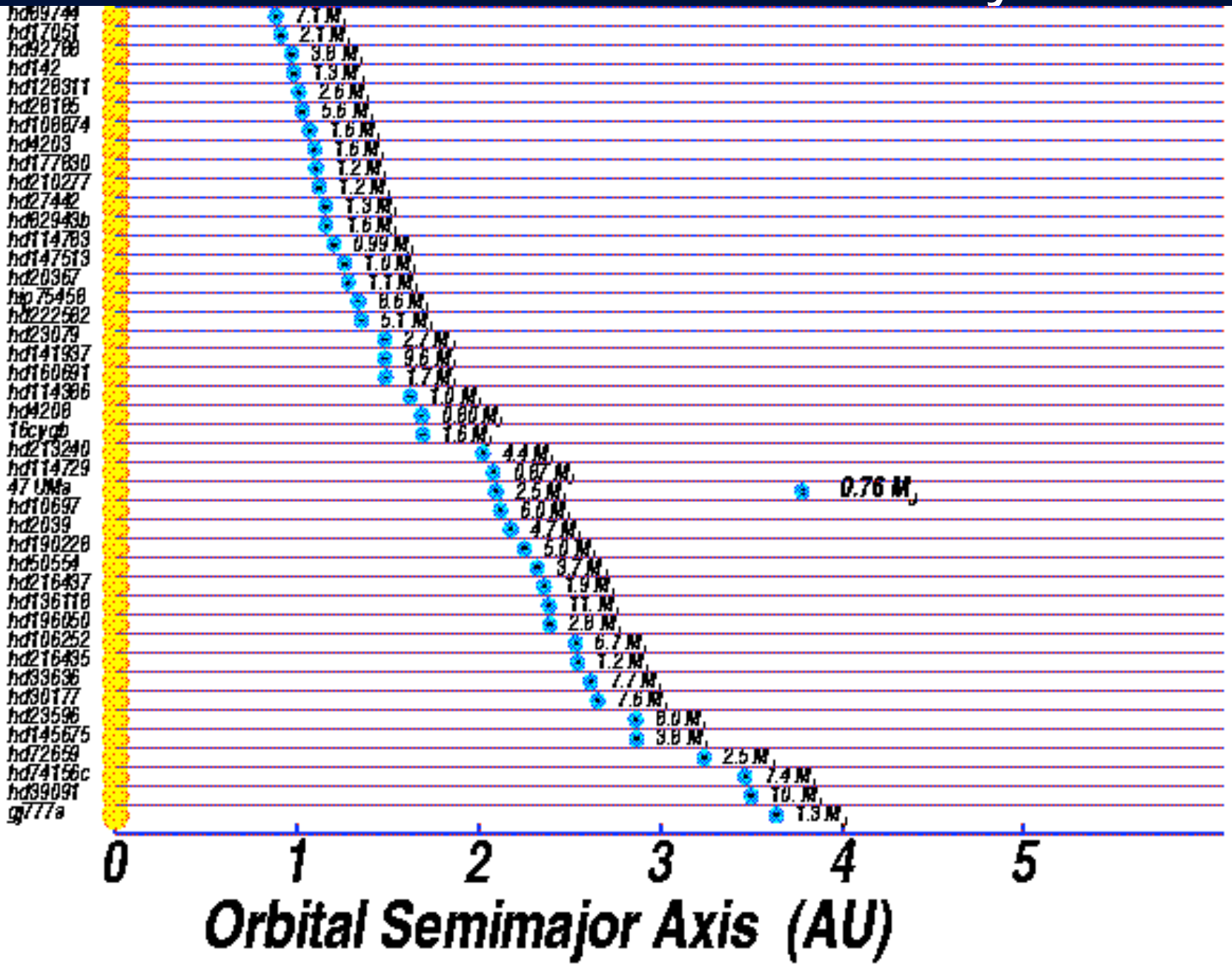
Day and Night on an Extrasolar Planet Spitzer Space Telescope • MIPS

NASA / JPL-Caltech / J. Harrington (Univ. of Central Florida), B. Hansen (UCLA) ssc2006-18a

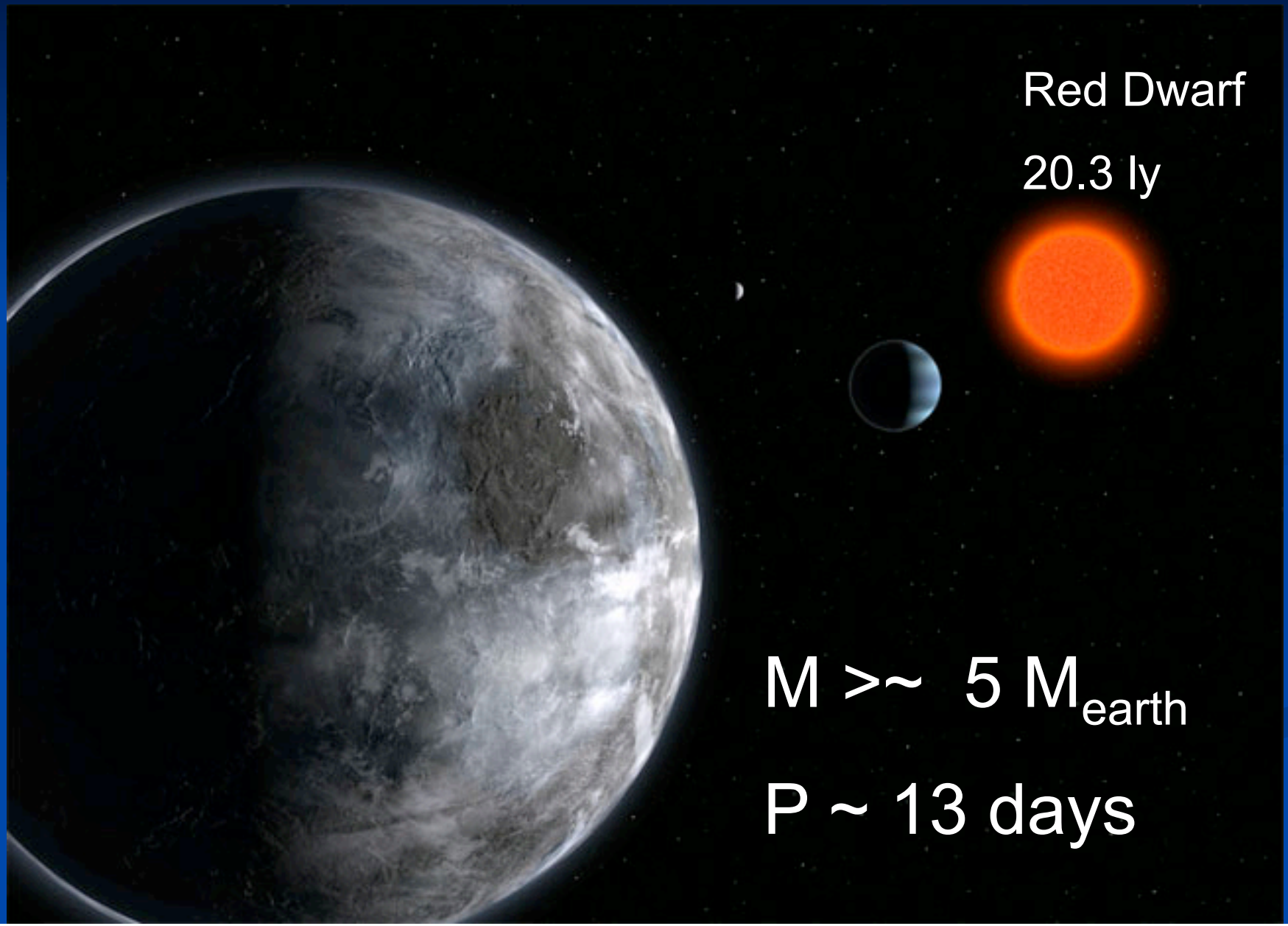
Some RV-Detected Solar Systems



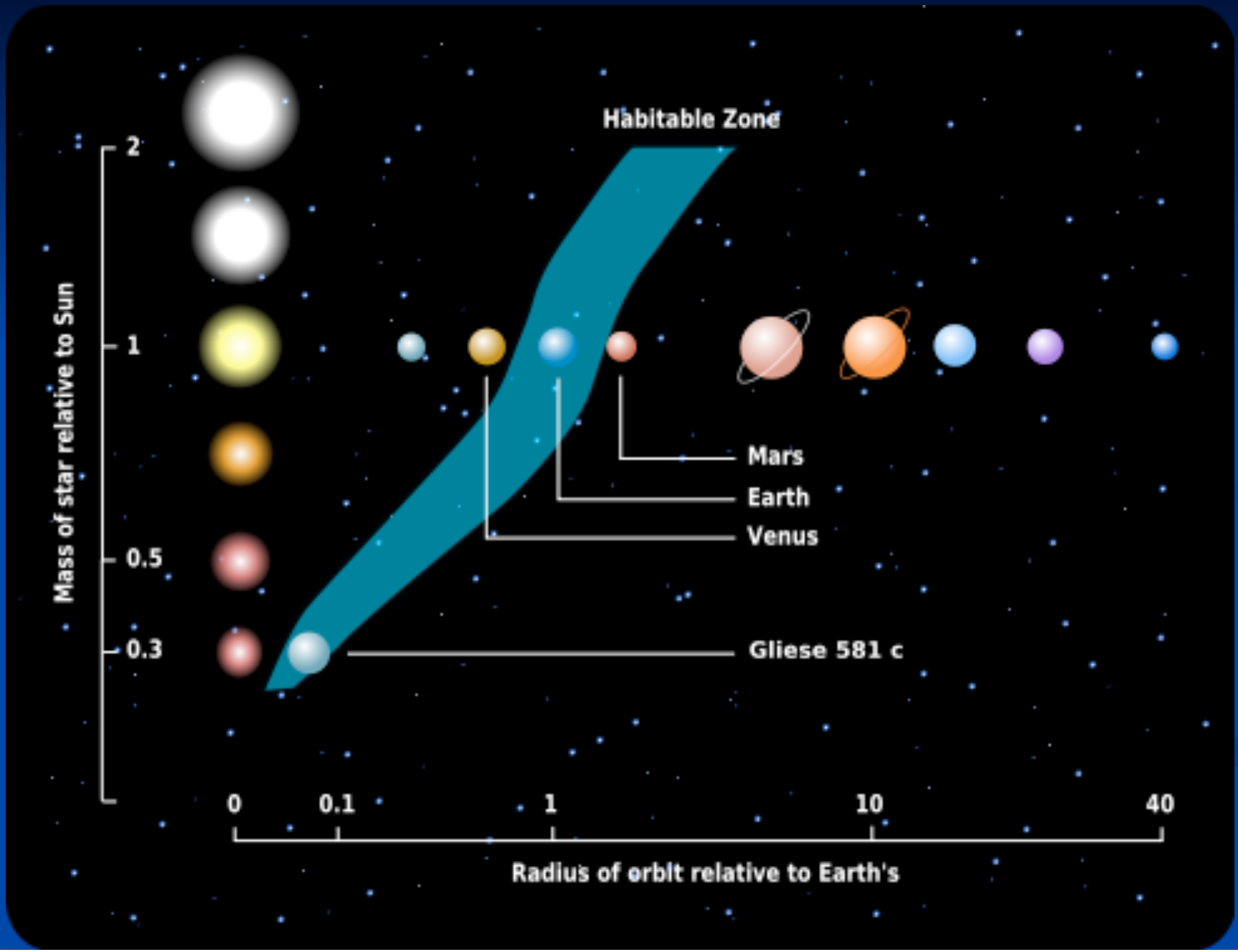
Some RV-Detected Solar Systems

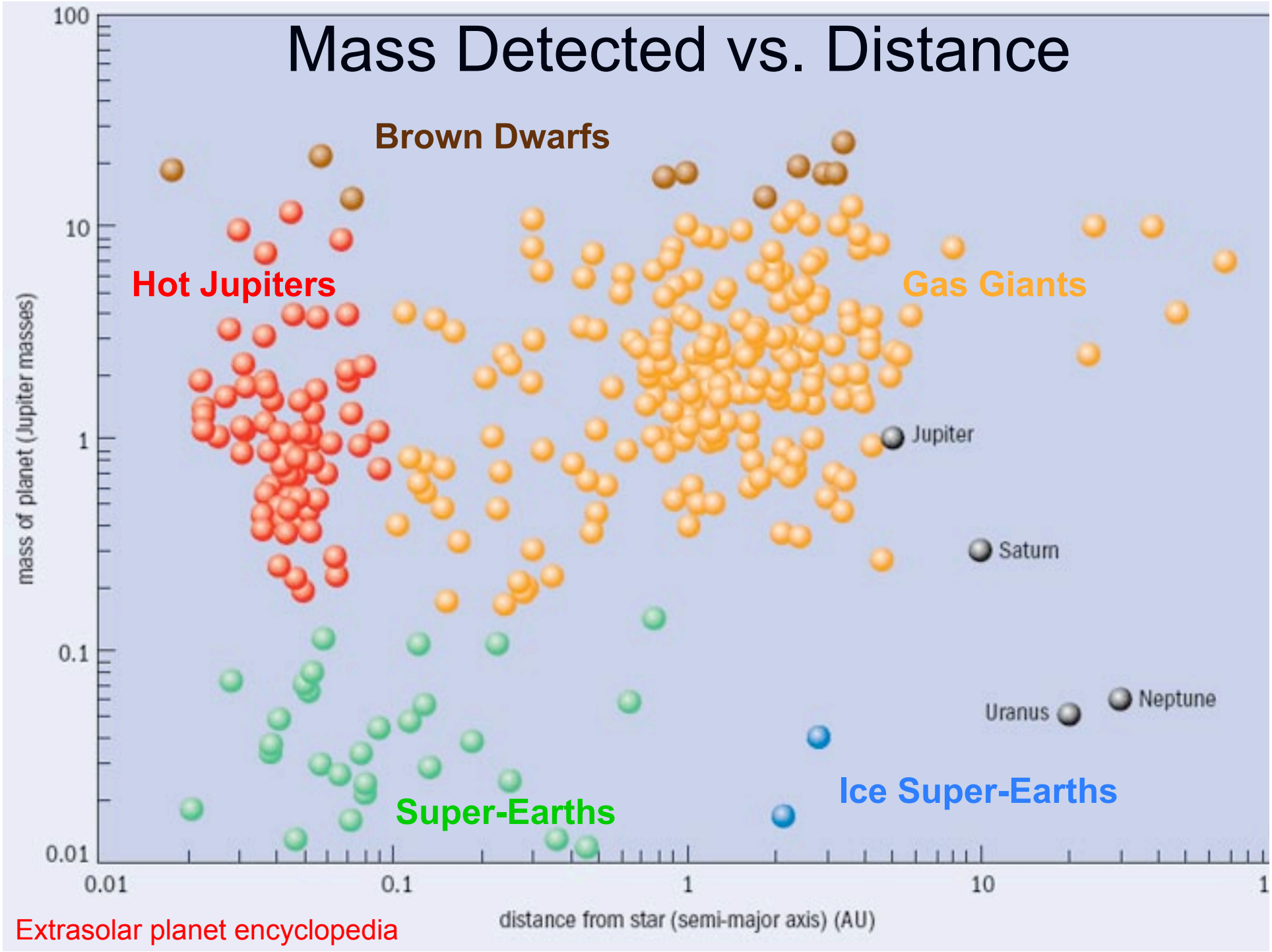


Gliese 581c - A “Super-Earth”



Gliese 581c – In the Habitable Zone?




Mass Detected vs. Distance
Brown Dwarfs
Hot Jupiters
Gas Giants
Jupiter
Saturn
Uranus
Neptune
Ice Super-Earths
Super-Earths
100
10
1
0.1
0.01
mass of planet (Jupiter masses)
0.01
0.1
1
10
1
distance from star (semi-major axis) (AU)
Extrasolar planet encyclopedia