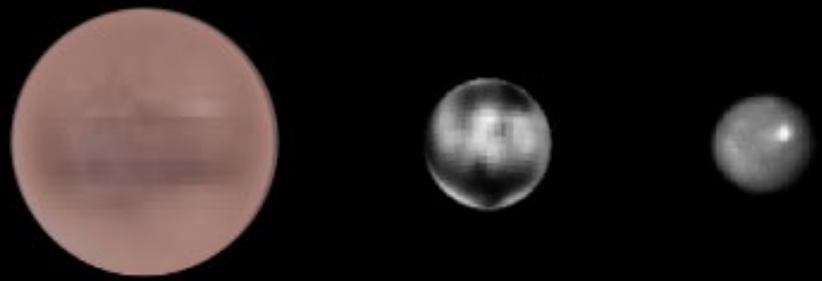
Exoplaneten

Erde und Supererden

Planeten:

Kommt es doch auf die Größe an...?



Eris (Xena) (2000) – Charon (1978) – Ceres (1801)

Planeten ...?


2003 EL61
2005 FY9
Sedna
Orcus
Quaoar
2002 TX300
2002 AW197
Varuna
Ixion
Vesta
Pallas
Hygiea

Planeten ...?

Definition Planet (IAU 2006)

(1) A planet is a celestial body that:

(a) is in orbit around the Sun,

(b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and

(c) has cleared the neighbourhood around its orbit.

(2) A "dwarf planet" is a celestial body that

(a) is in orbit around the Sun,

(b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape2,

(c) has not cleared the neighbourhood around its orbit, and

(d) is not a satellite.

(3) All other objects,except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

Exoplaneten ...?

WORKING GROUP ON EXTRASOLAR PLANETS (WGESP)

OF THE INTERNATIONAL ASTRONOMICAL UNION (2003)

1) Objects with **true masses below the limiting mass for thermonuclear fusion of deuterium** (currently calculated to be 13 Jupiter masses for objects of solar metallicity) that orbit stars or stellar remnants are "planets" (no matter how they formed). The minimum mass/size required for an extrasolar object to be considered a planet should be the same as that used in our Solar System.

2) Substellar objects with true masses **above the limiting mass for thermonuclear fusion of deuterium are "brown dwarfs"**, no matter how they formed nor where they are located.

3) Free-floating objects in young star clusters with masses below the limiting mass for thermonuclear fusion of deuterium are not "planets", but are "sub-brown dwarfs" (or whatever name is most appropriate).

Warum sollte es Exoplaneten geben?

Annahme: globale Gültigkeit der Gesetze der Physik

+ Statistik

403 Exoplaneten

in 383 Systemen

20.10.2009 Jean Schneider (CNRS-LUTH, Paris Observatory)

Wie findet man Exoplaneten?

Direkte Beobachtung

Radialgeschwindigkeitsmessung

Transits

Astrometrie

Microlensing

Pulsartiming

Direkte Beobachtung

Rechenspiel:

Berechnen Sie den von der Erde reflektierten, relativen Anteil des Lichts (visuelle Intensität) der Sonne.

$$I_{Stern}(r) = \frac{1}{4\pi r^2}$$

Erdradius ~ 6400 km

Abstand r zur Sonne ~ 149 600 000 km

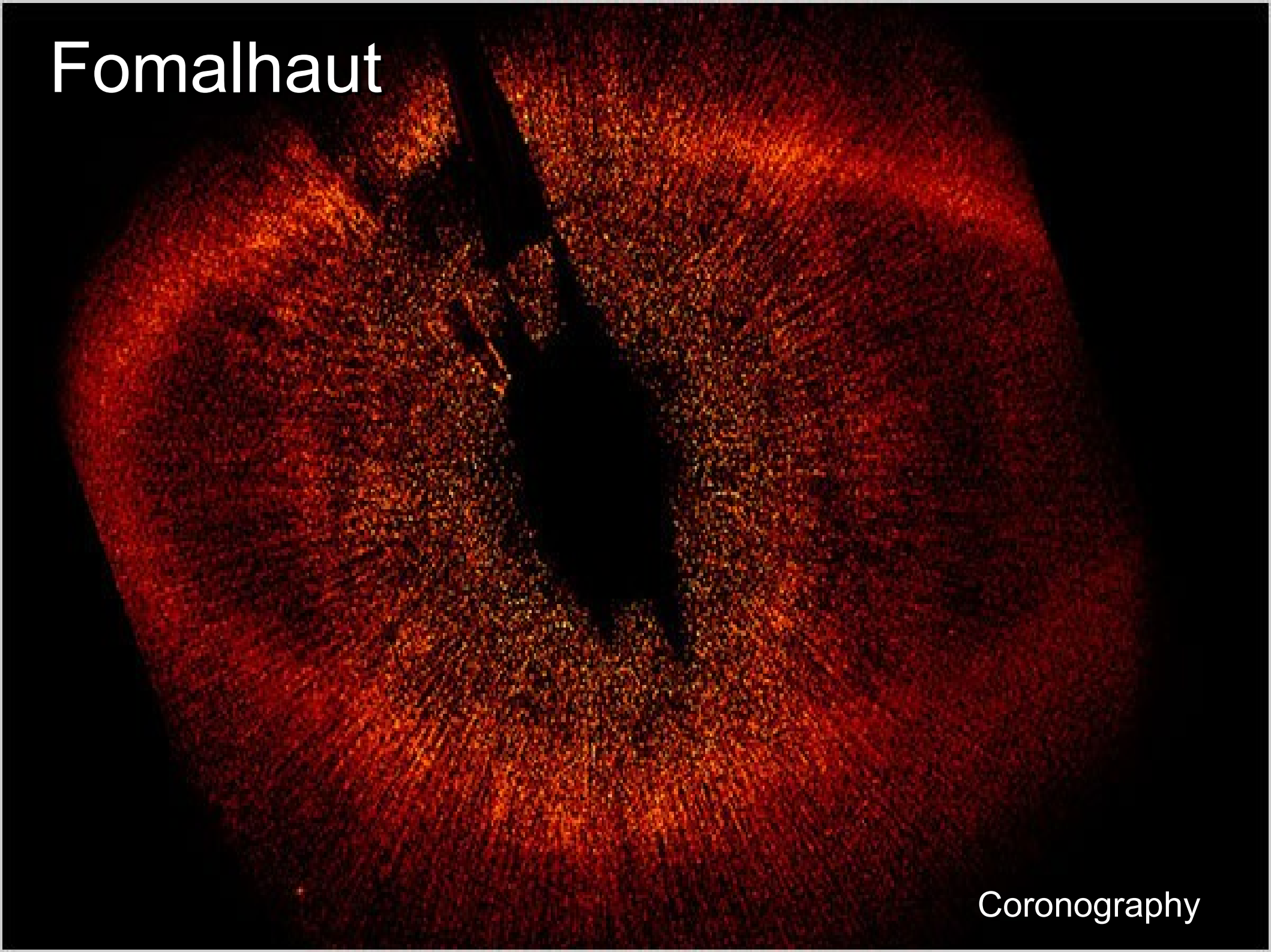
Direkte Beobachtung

Kontrastverhältnis Erde/Sonne ~ 10^{-11} !!!

1 Photon ~ 1 Blatt Papier (0.1mm)

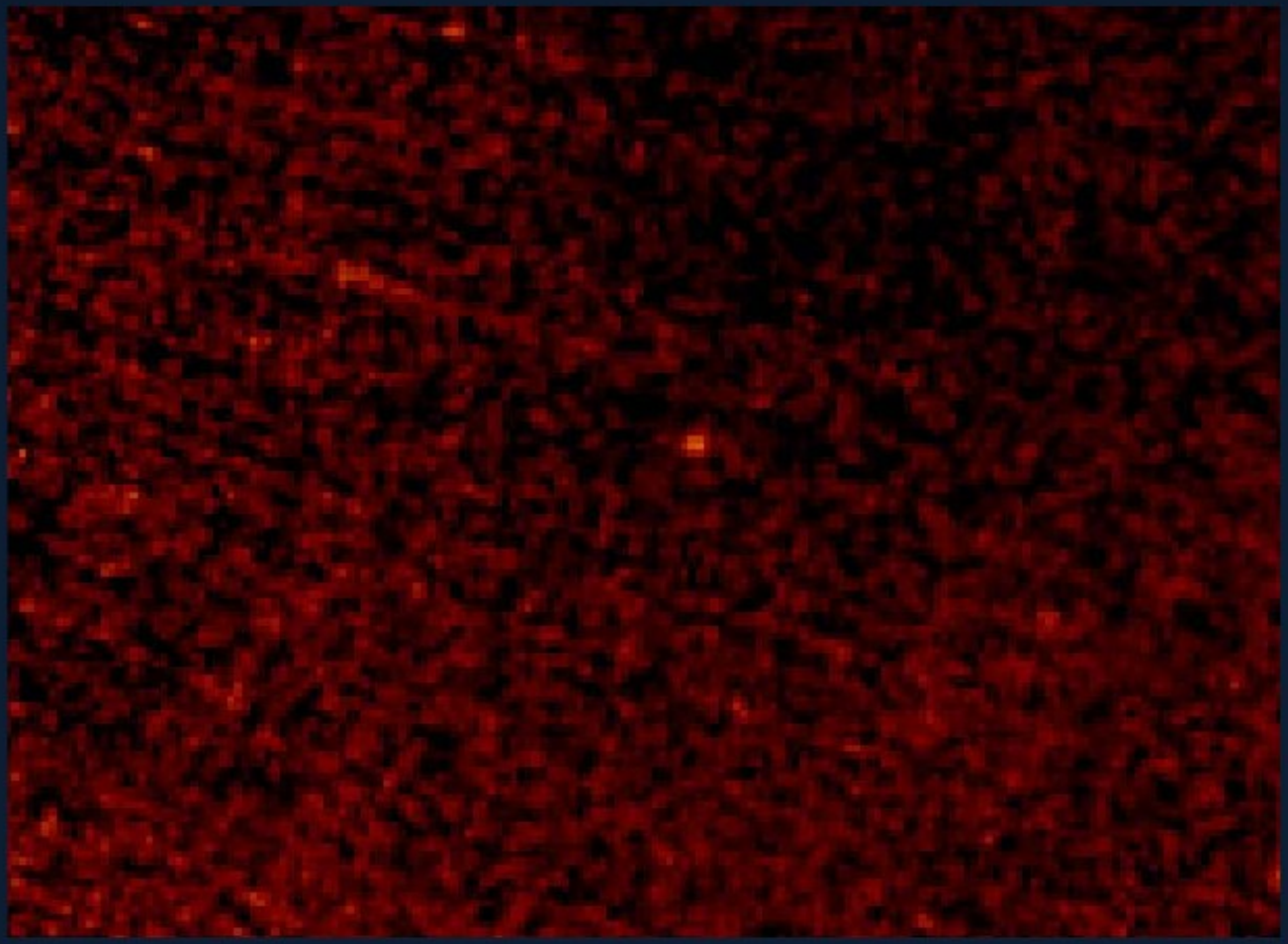
10 km hoher Papierstoß um

1 Blatt zu finden

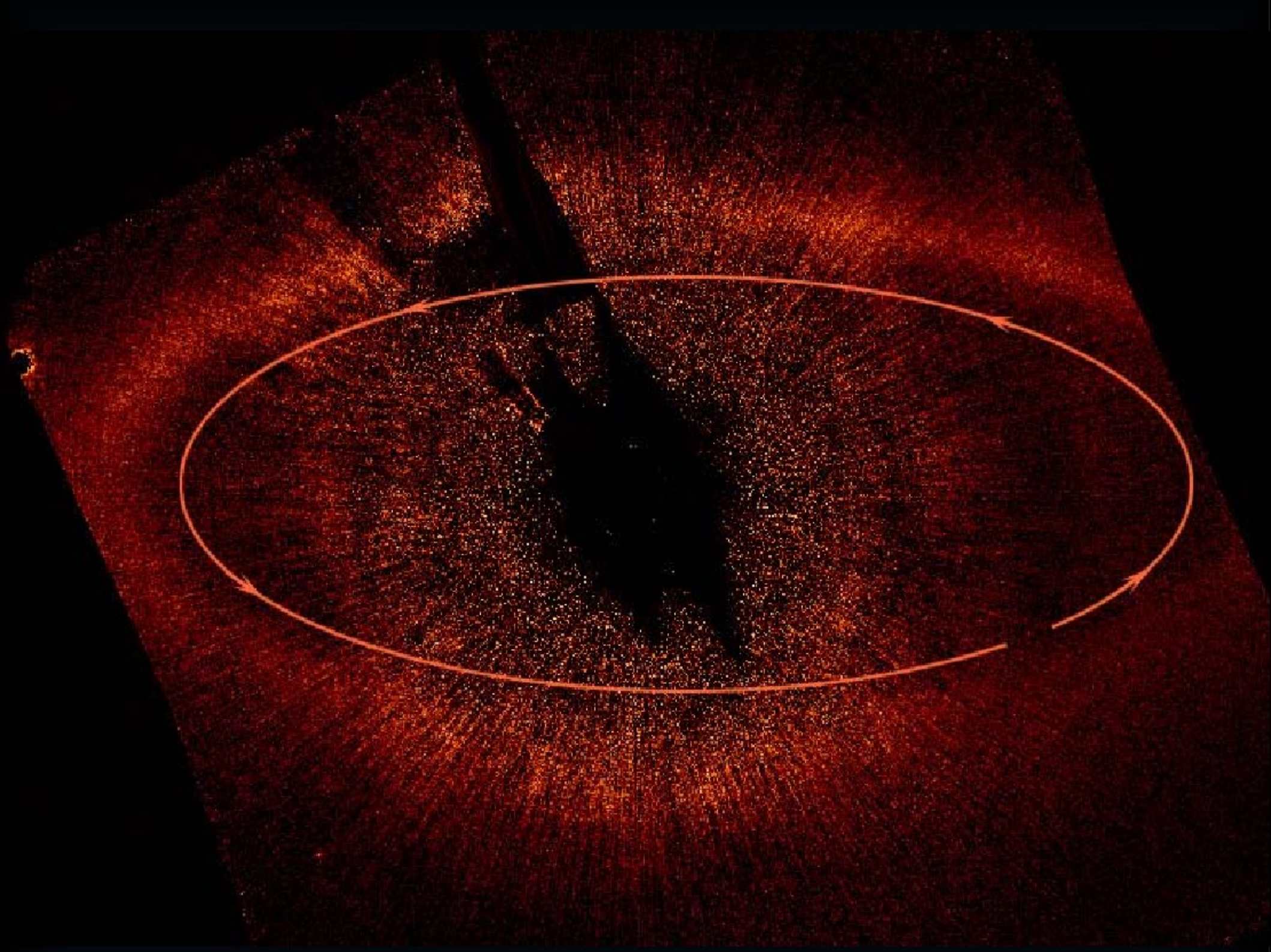

Fomalhaut
Coronography

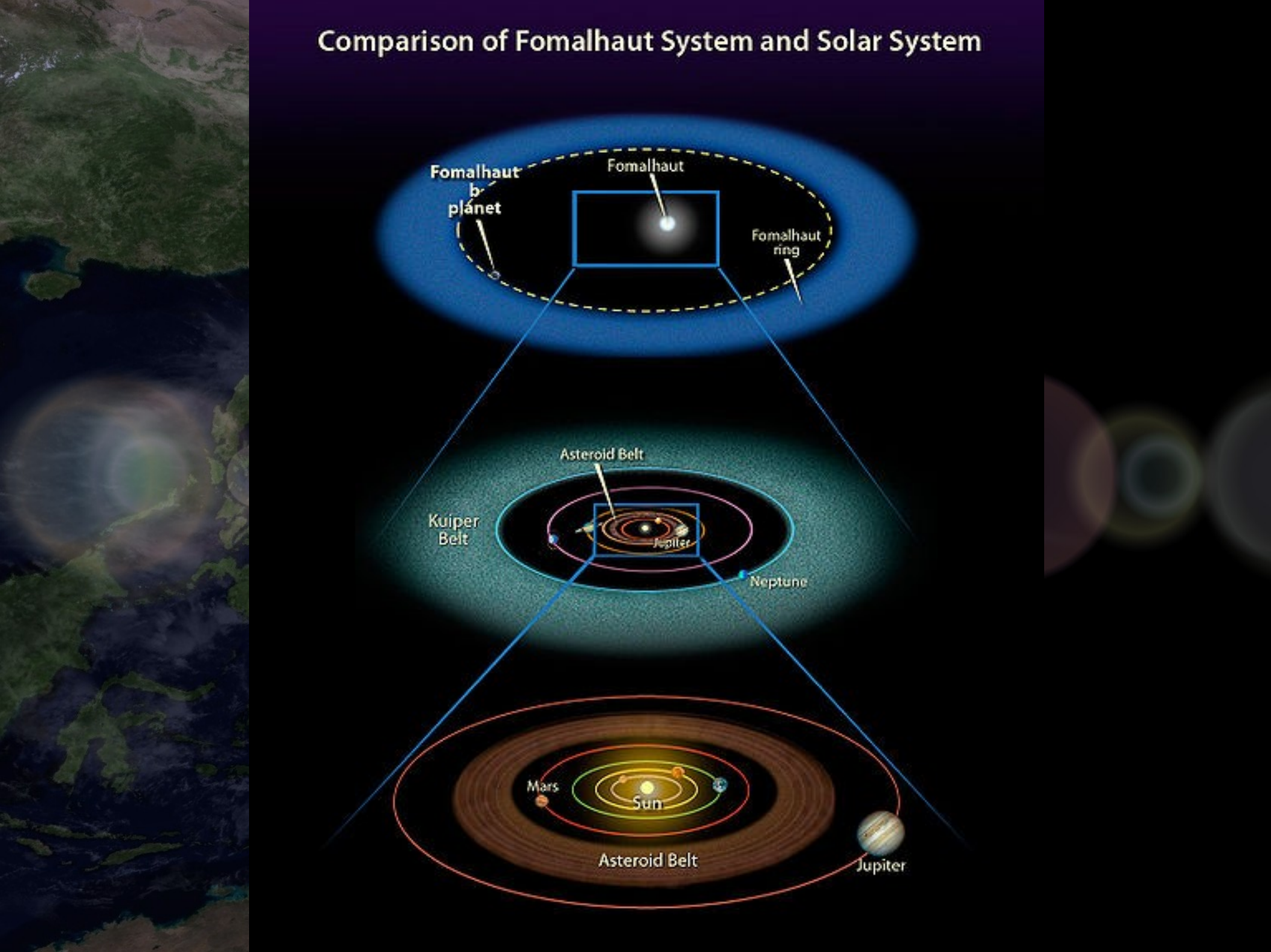
Fomalhaut b

2006



Paul Kalas (University of California, Berkeley)



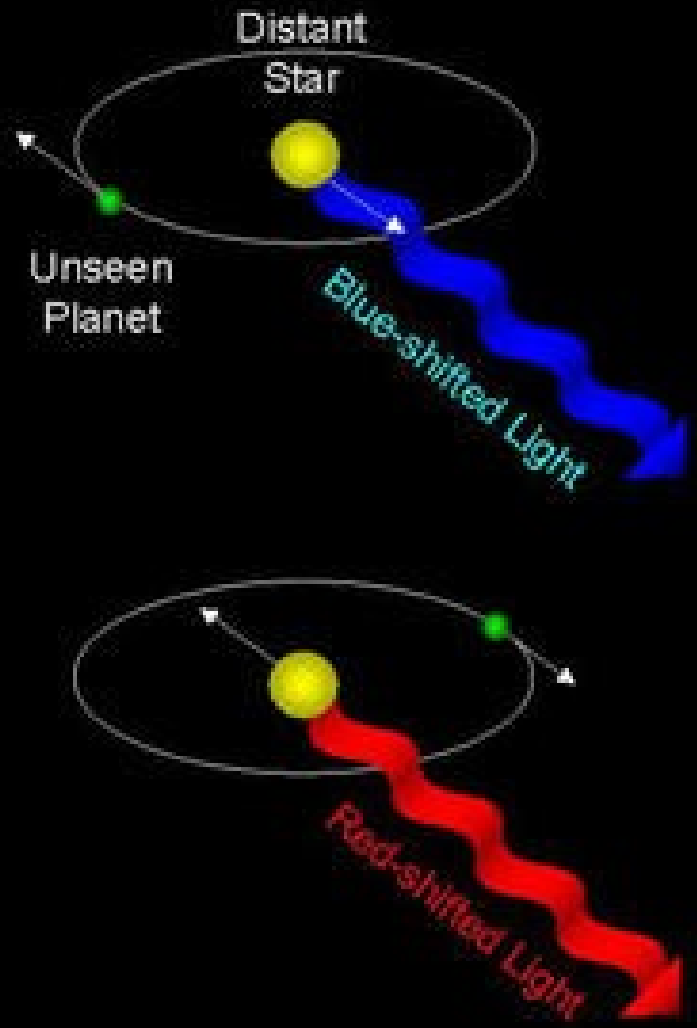

Comparison of Fomalhaut System and Solar System
Fomalhaut b planet
Fomalhaut
Fomalhaut ring
Asteroid Belt
Kuiper Belt
Jupiter
Neptune
Mars
Sun
Asteroid Belt
Jupiter

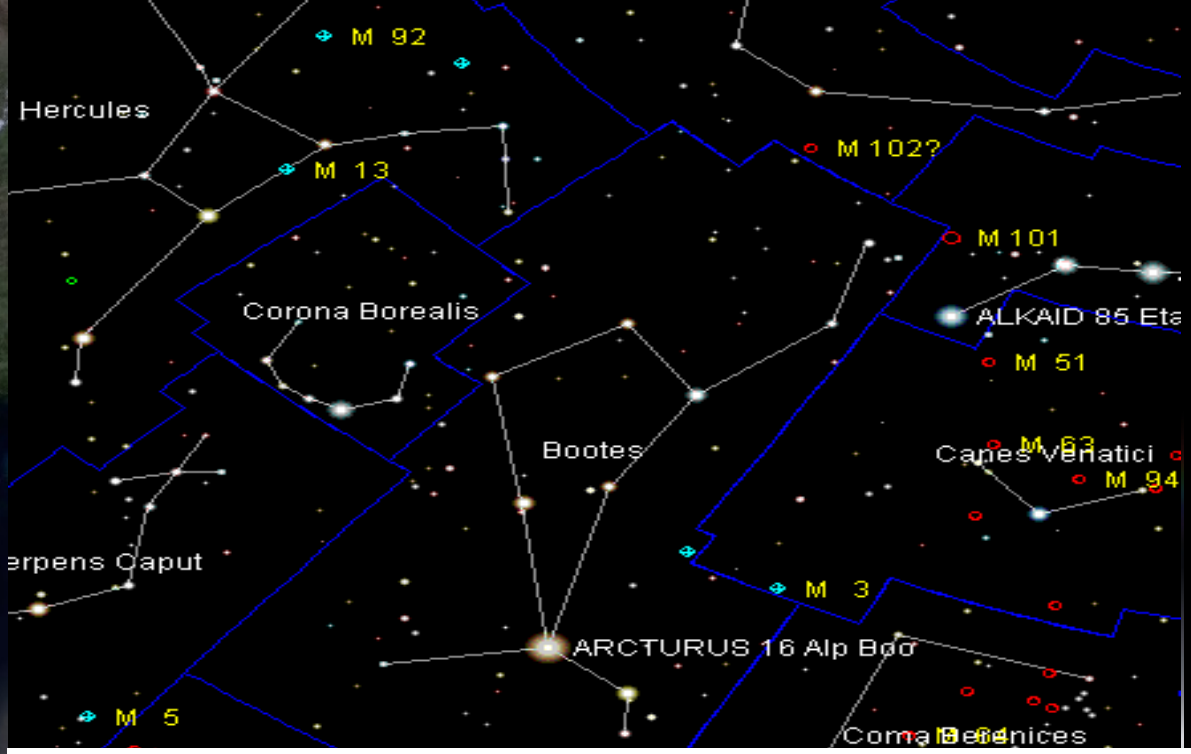
Radialgeschwindigkeitsmethode (Radial velocity – RV)

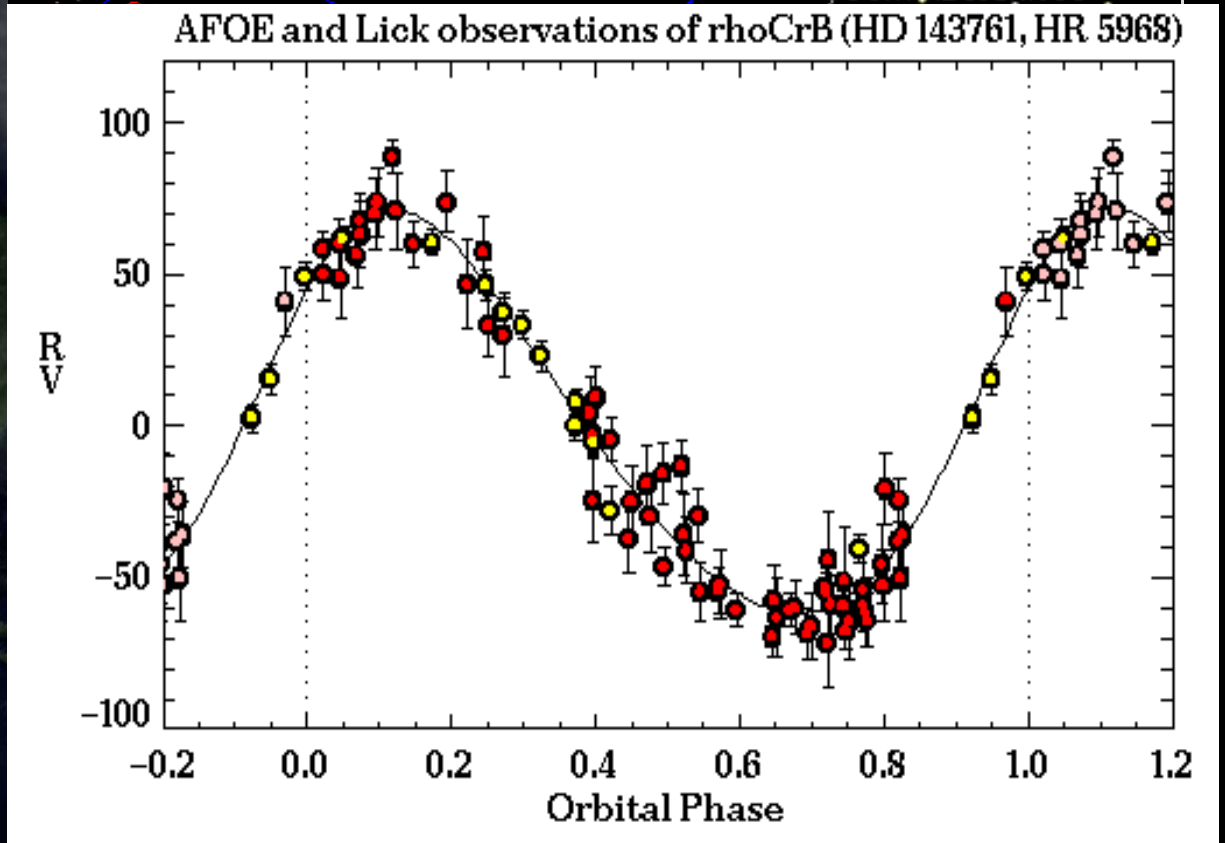
Planet und Stern bewegen sich um gemeinsamen Massenmittelpunkt

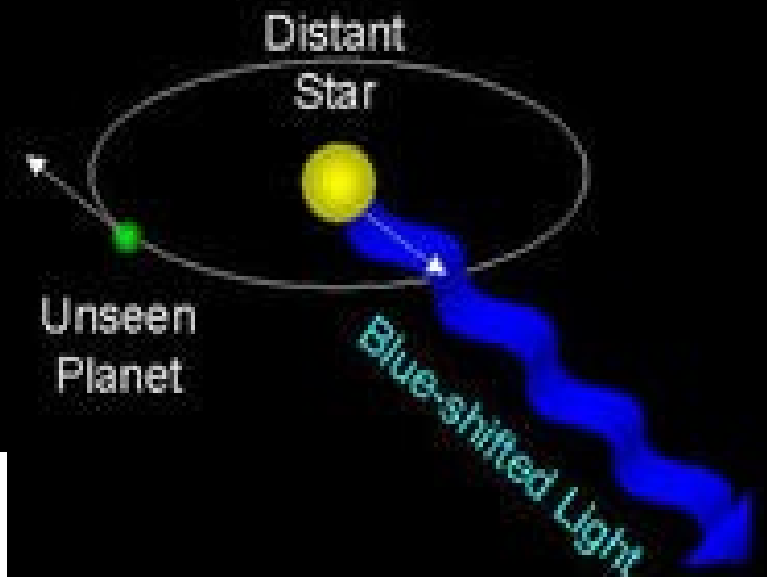
Stern bewegt sich **vor und zurück**

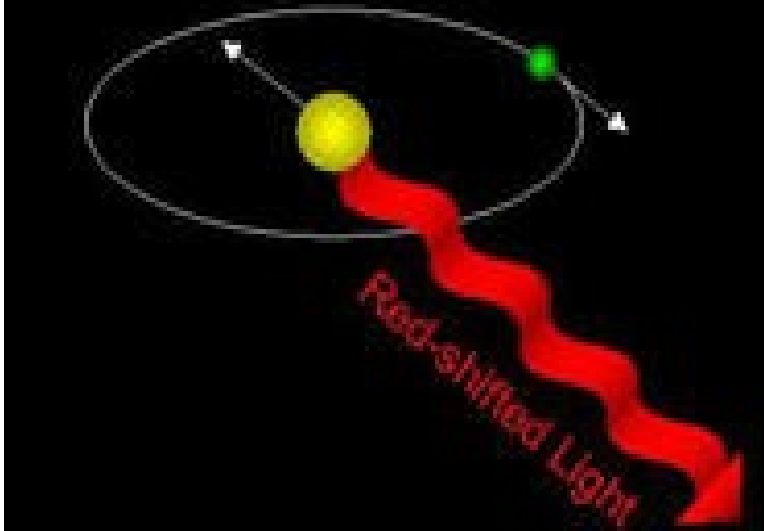
wenn Planet massereich und nah → Stern wackelt stärker

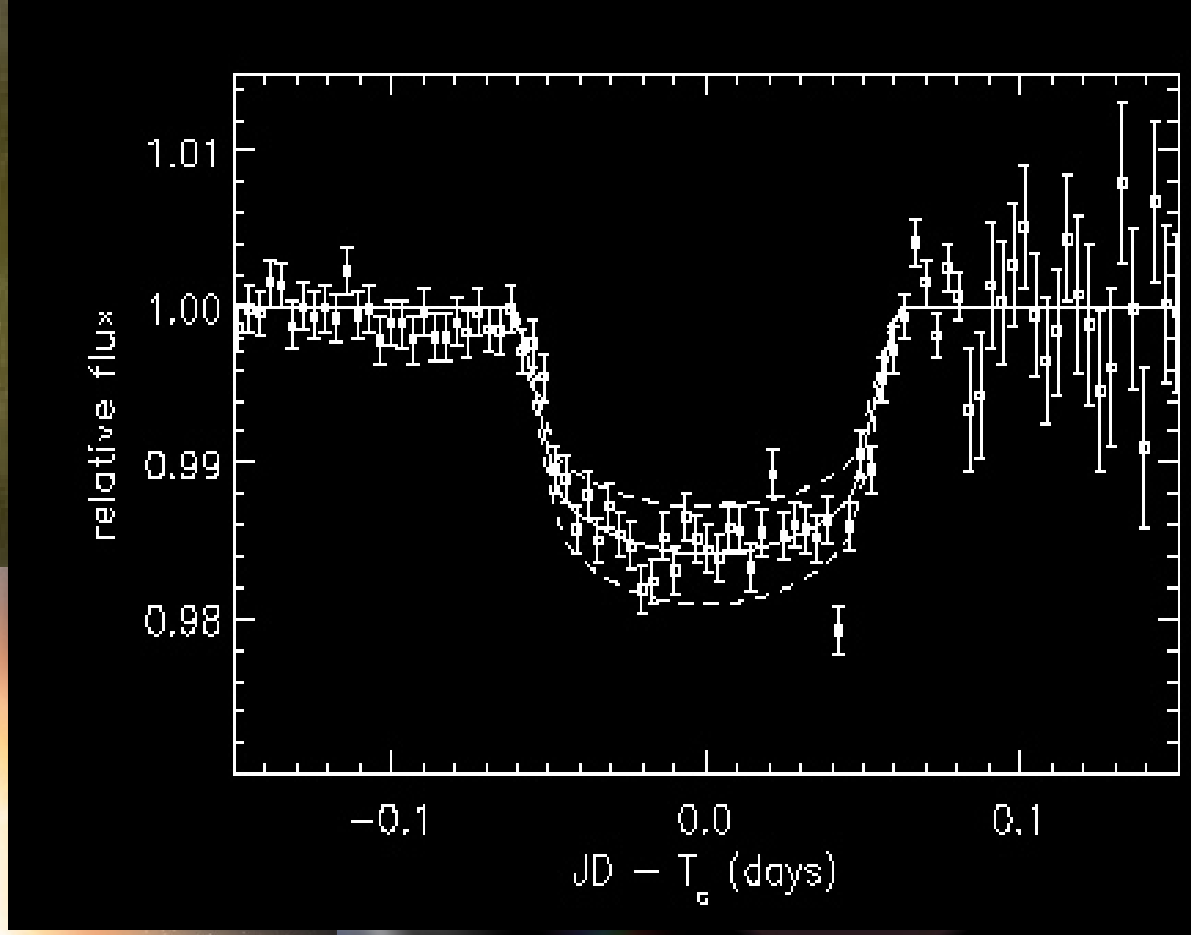



M 92
Hercules
M 13
M 102?
M 101
Corona Borealis
ALKAID 85 Eta
M 51
Bootes
Canes Venatici
M 94
M 3
ARCTURUS 16 Alp Boo
M 5


AFOE and Lick observations of rhoCrB (HD 143761, HR 5968)
RV
100
50
0
−50
−100
−0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Orbital Phase

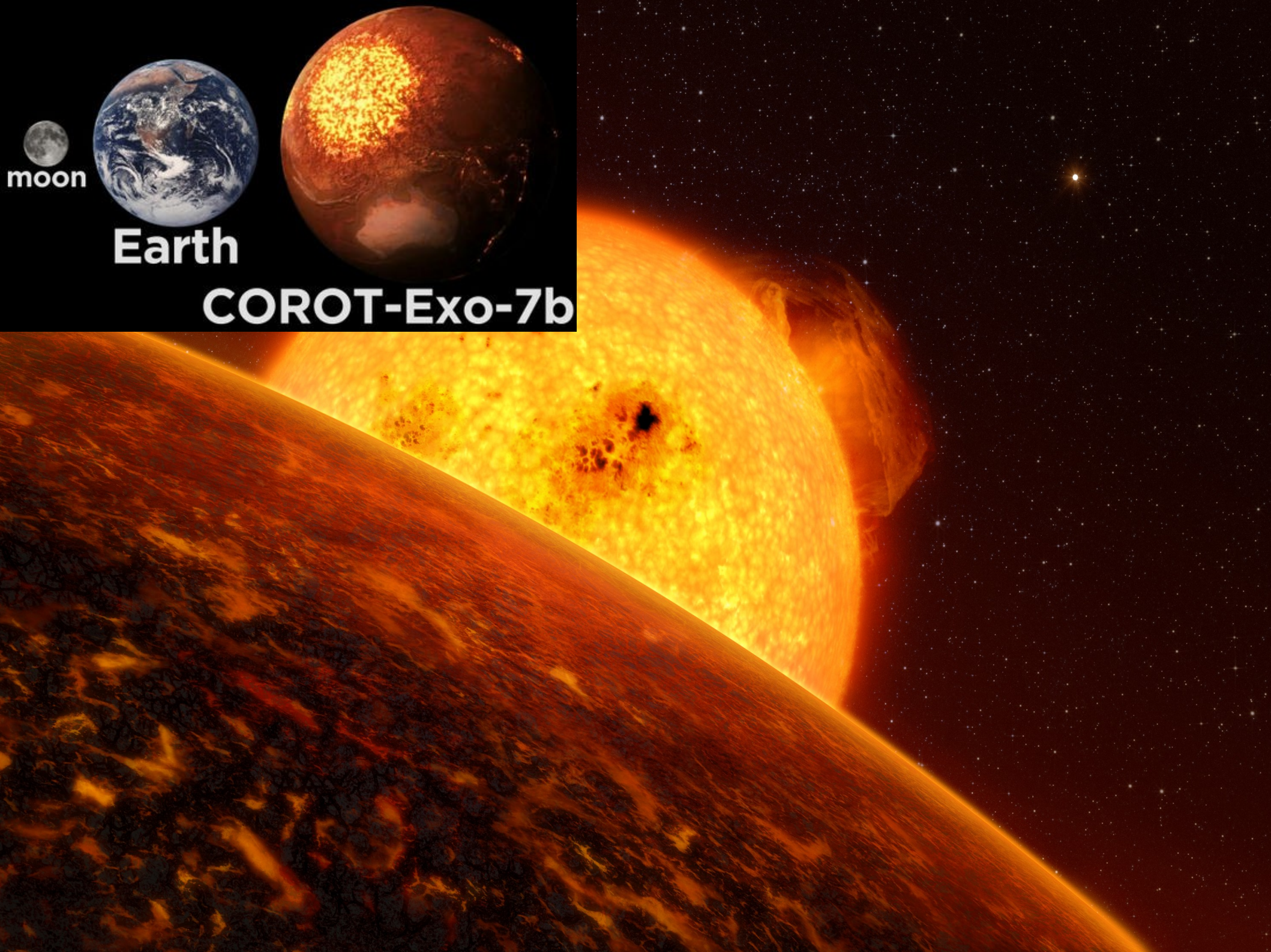

Distant
Star
Unseen
Planet
Blue-shifted Light

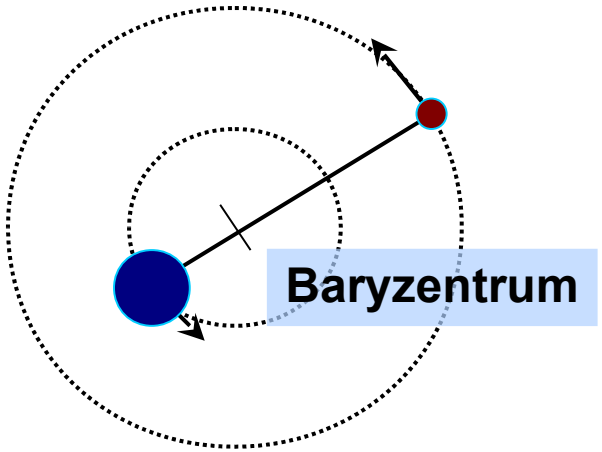

Red-shifted Light

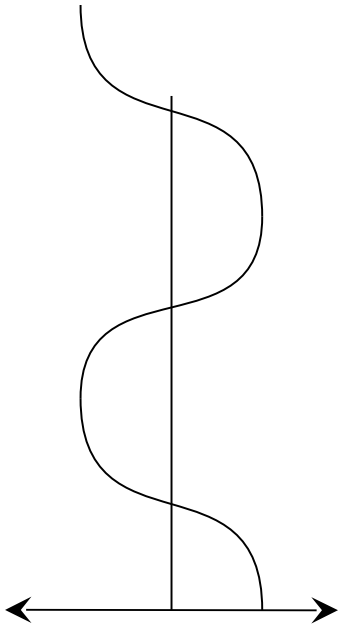


Transits

(CoRot)


moon
Earth
COROT-Exo-7b





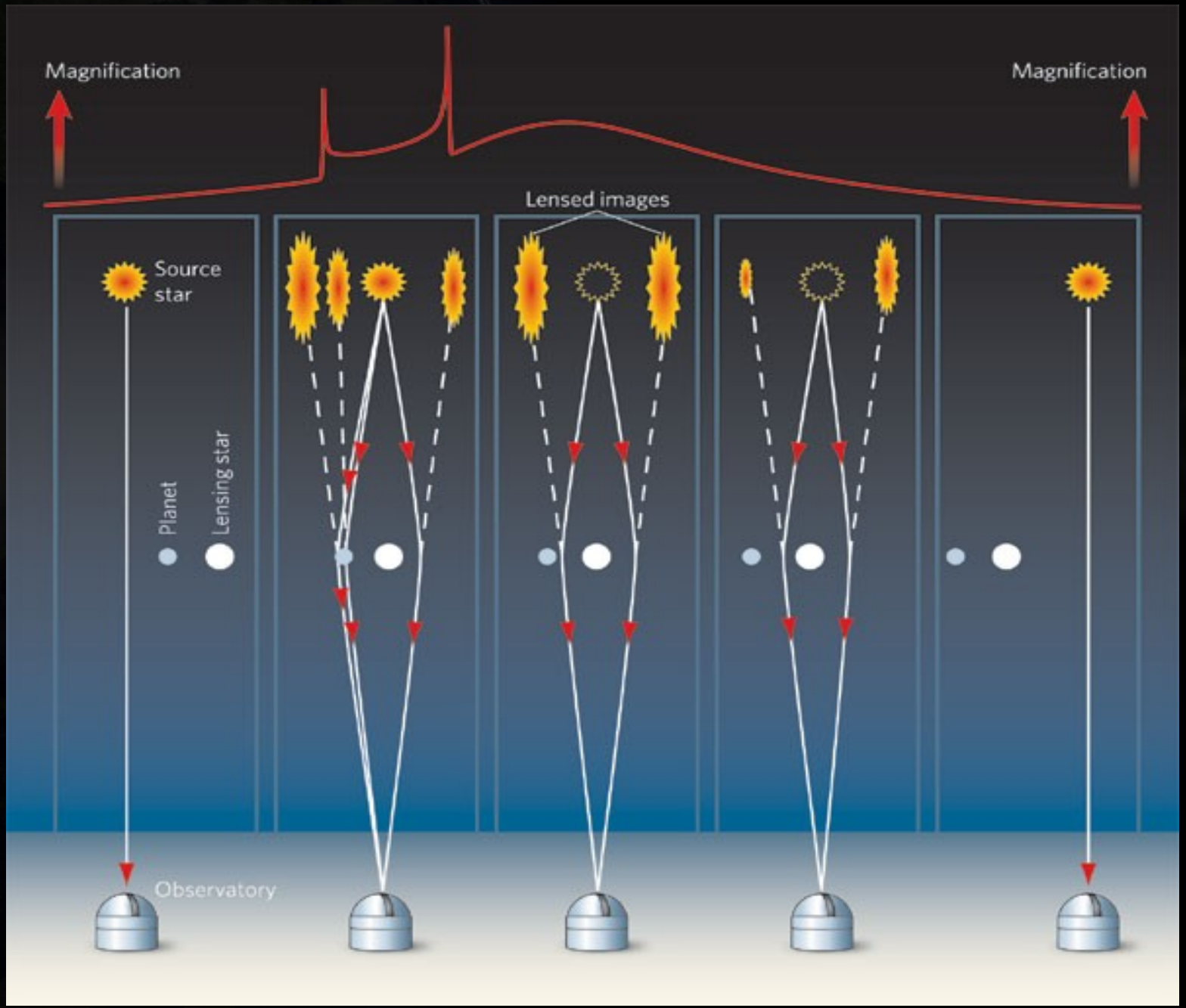
Astrometrie

Stern „wackelt“ am Himmel

Planet unsichtbar

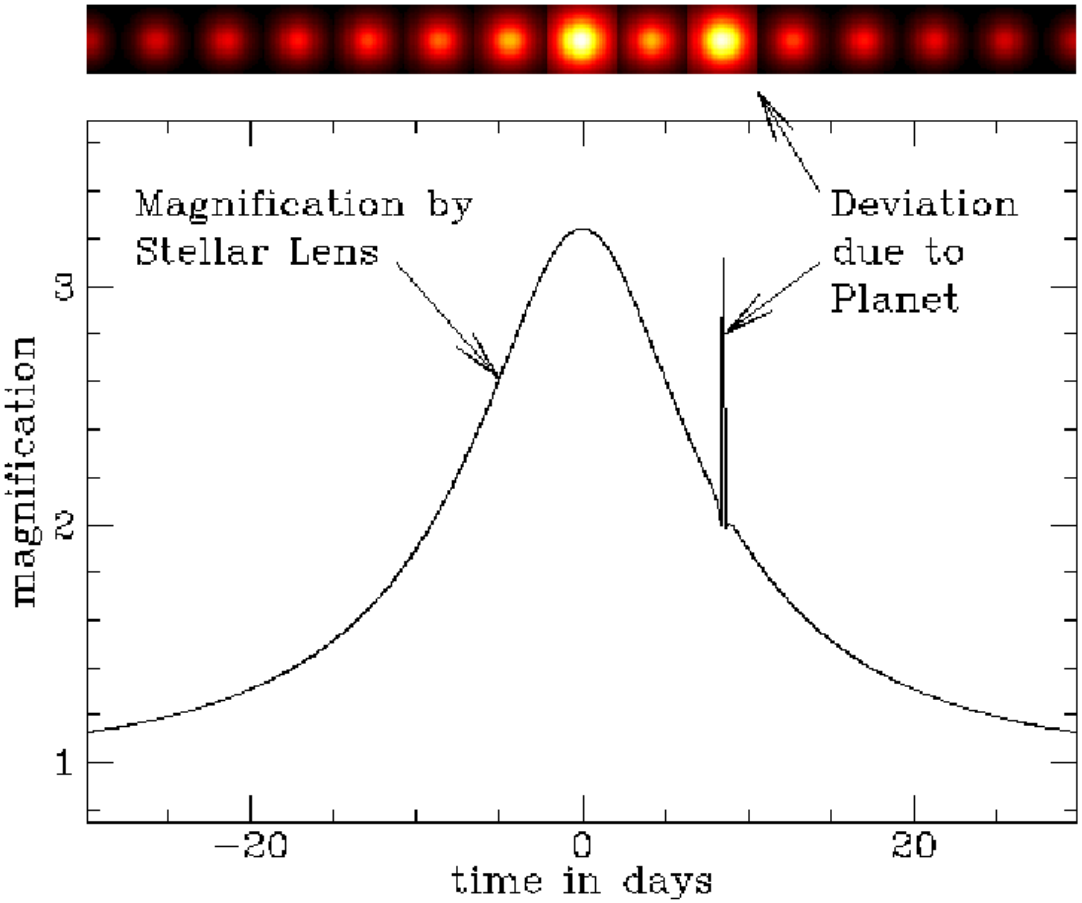
keine genaue Massen-bestimmung möglich
→ **Minimum mass**

Gravitational Mircolensing

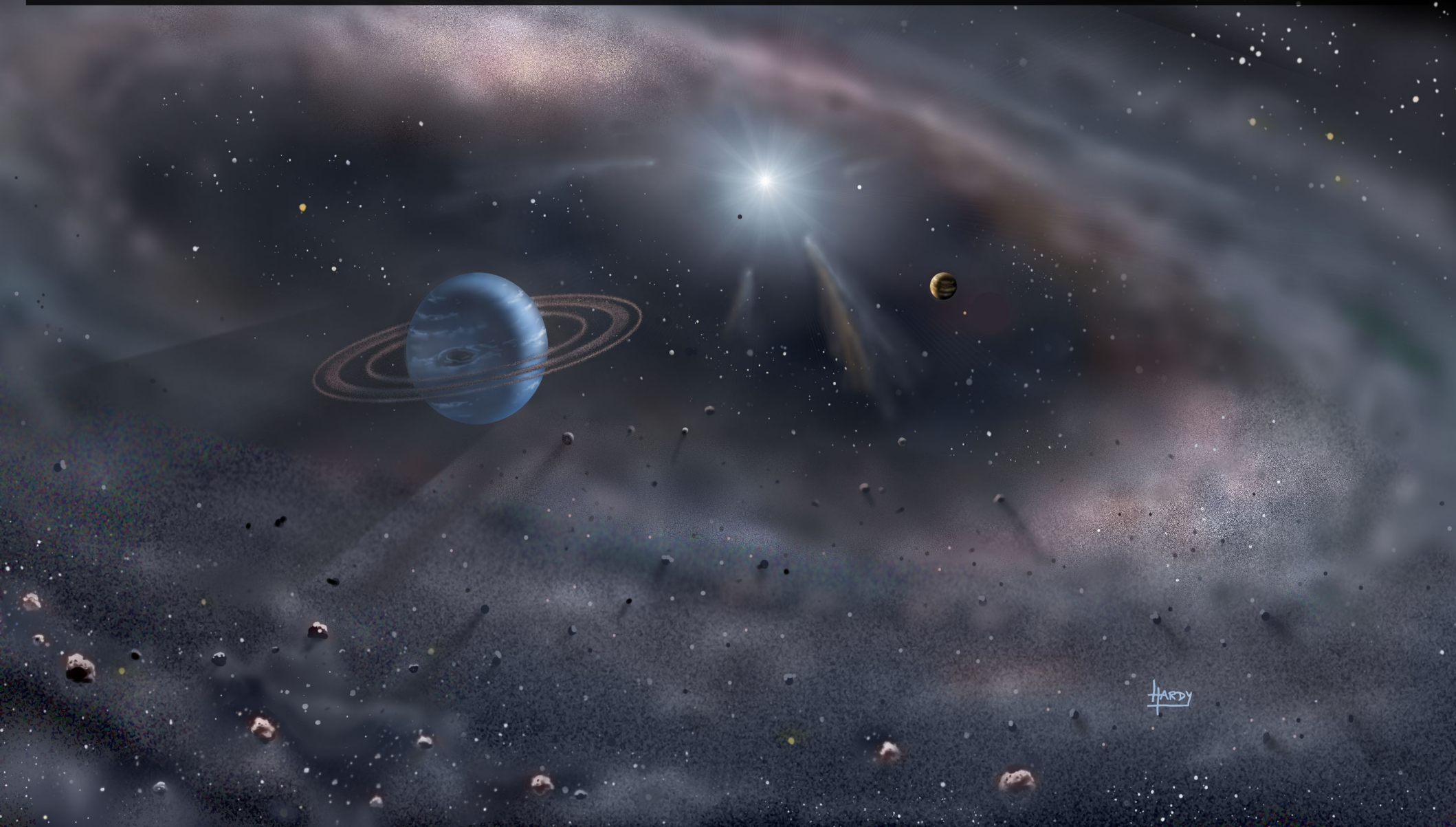


Gravitational Mircolensing

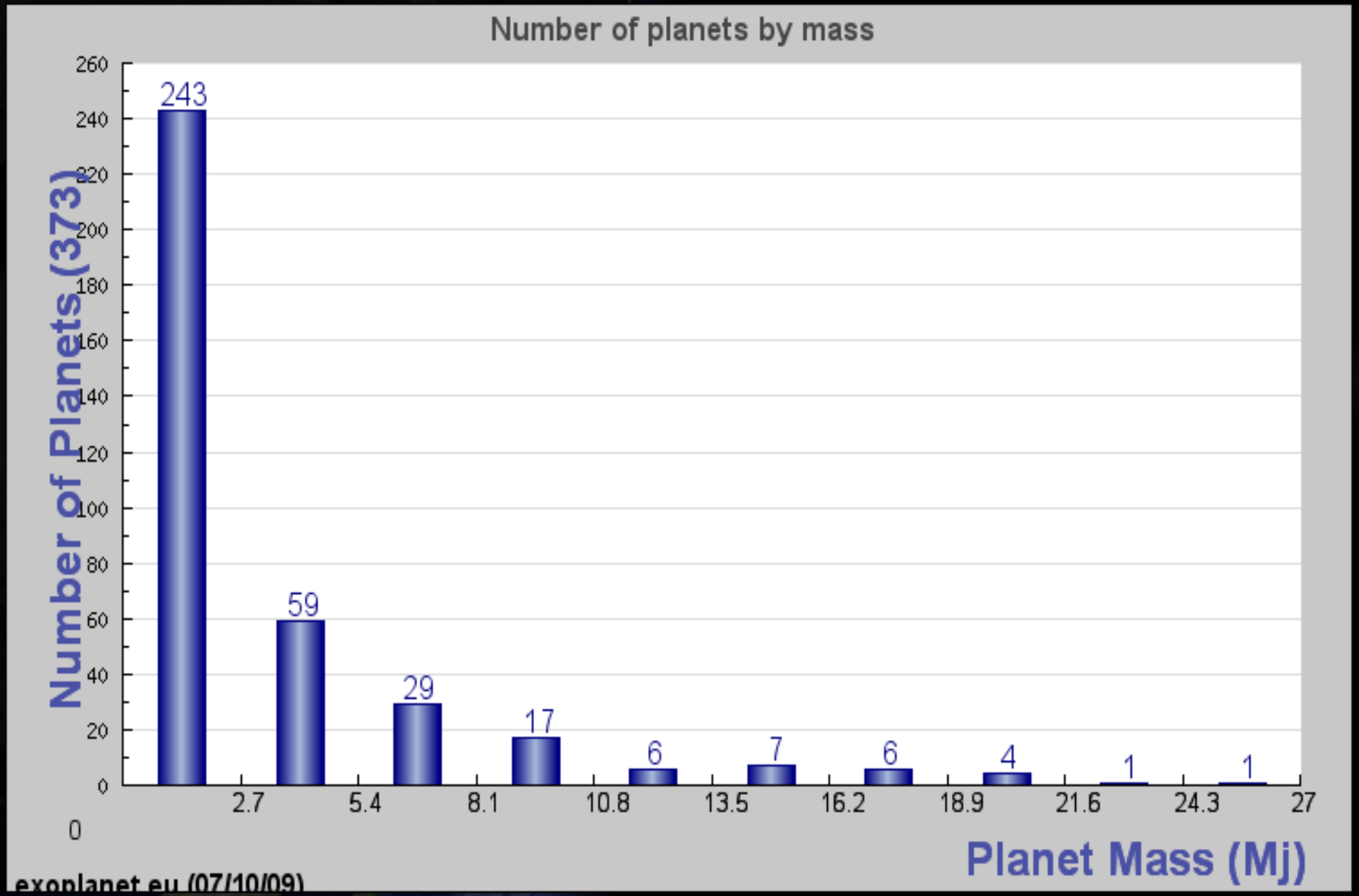
Microlensing by Planets (schematically):



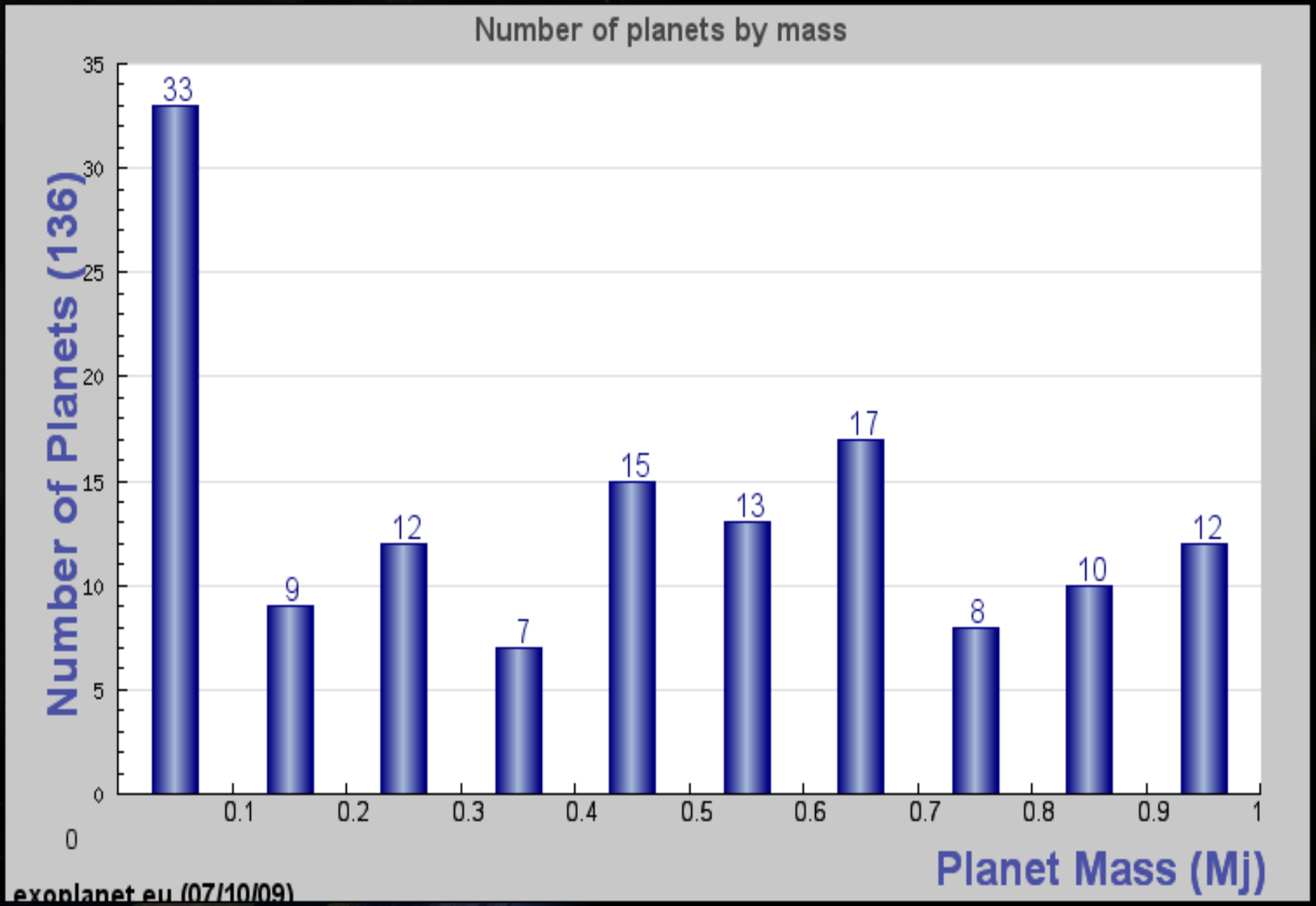
Eigenschaften von Exoplanetensystemen



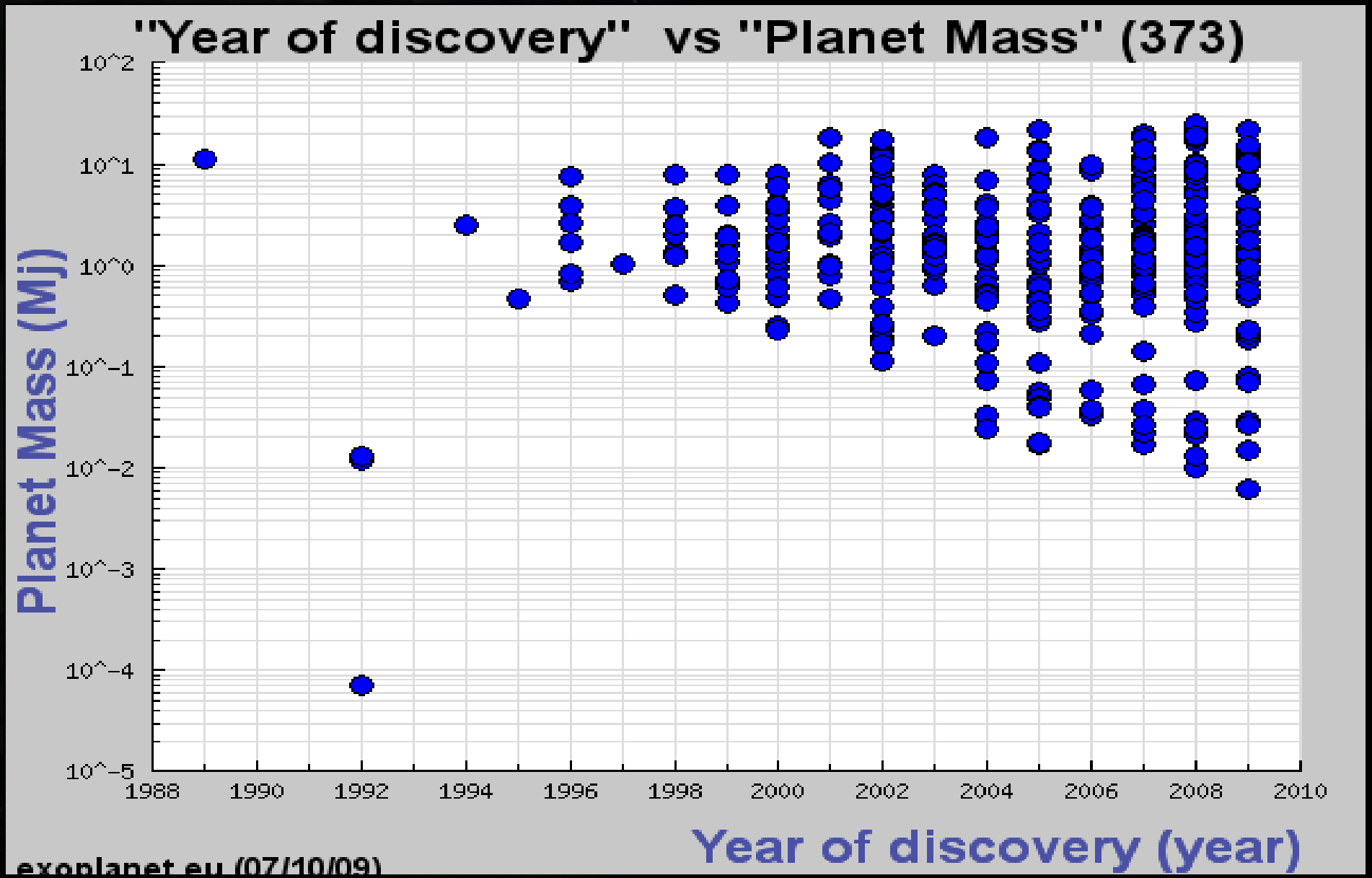
Eigenschaften von Exoplaneten



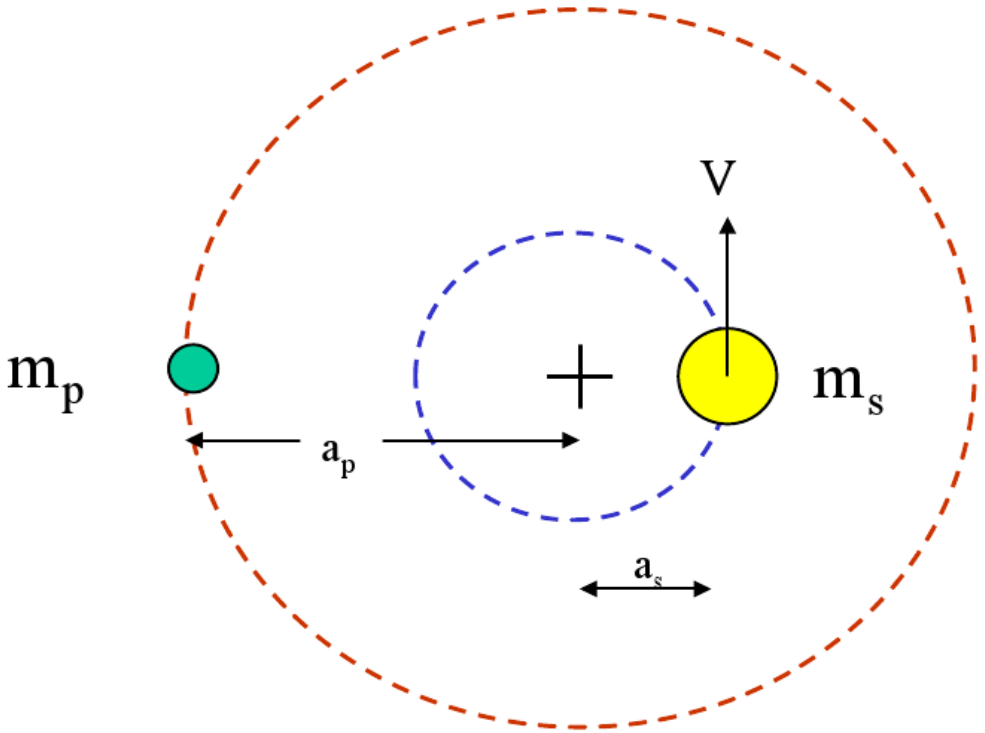
Eigenschaften von Exoplaneten



Eigenschaften von Exoplaneten

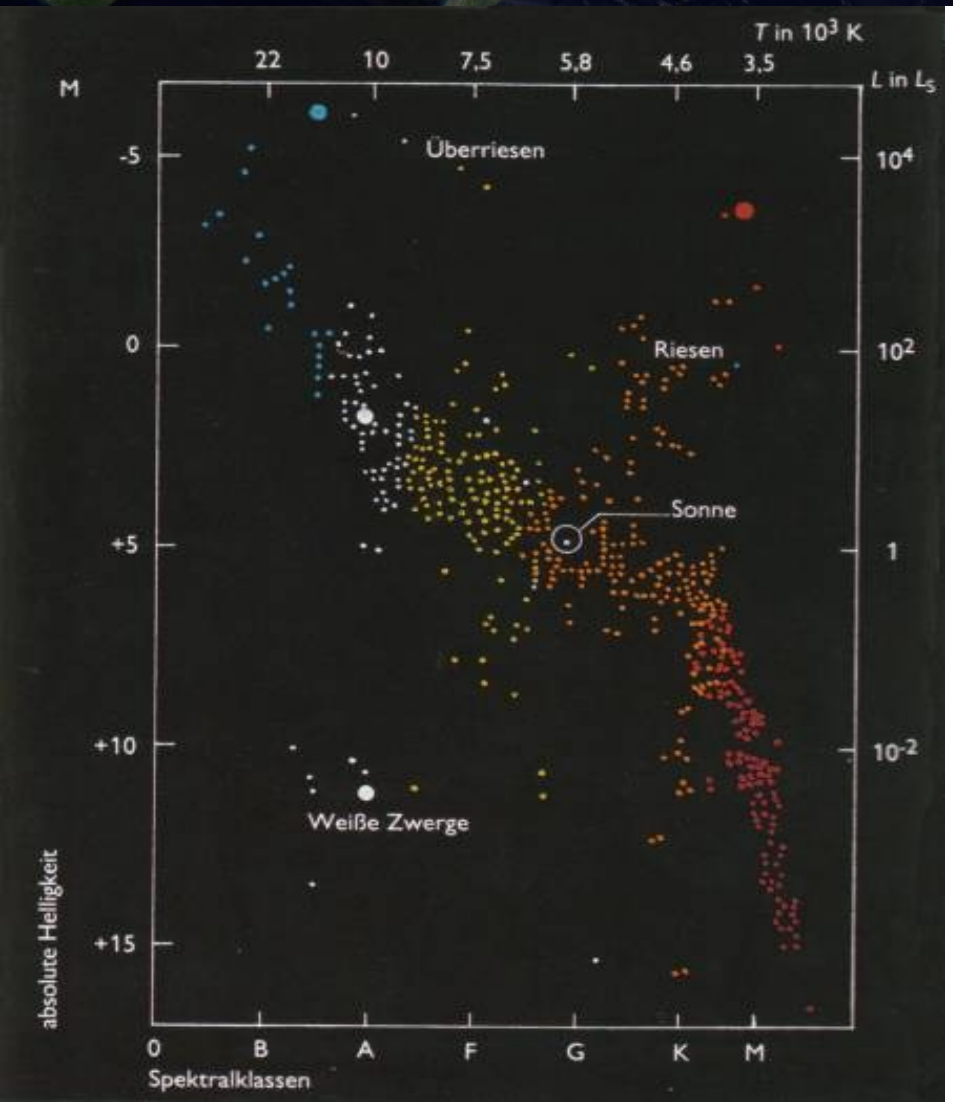


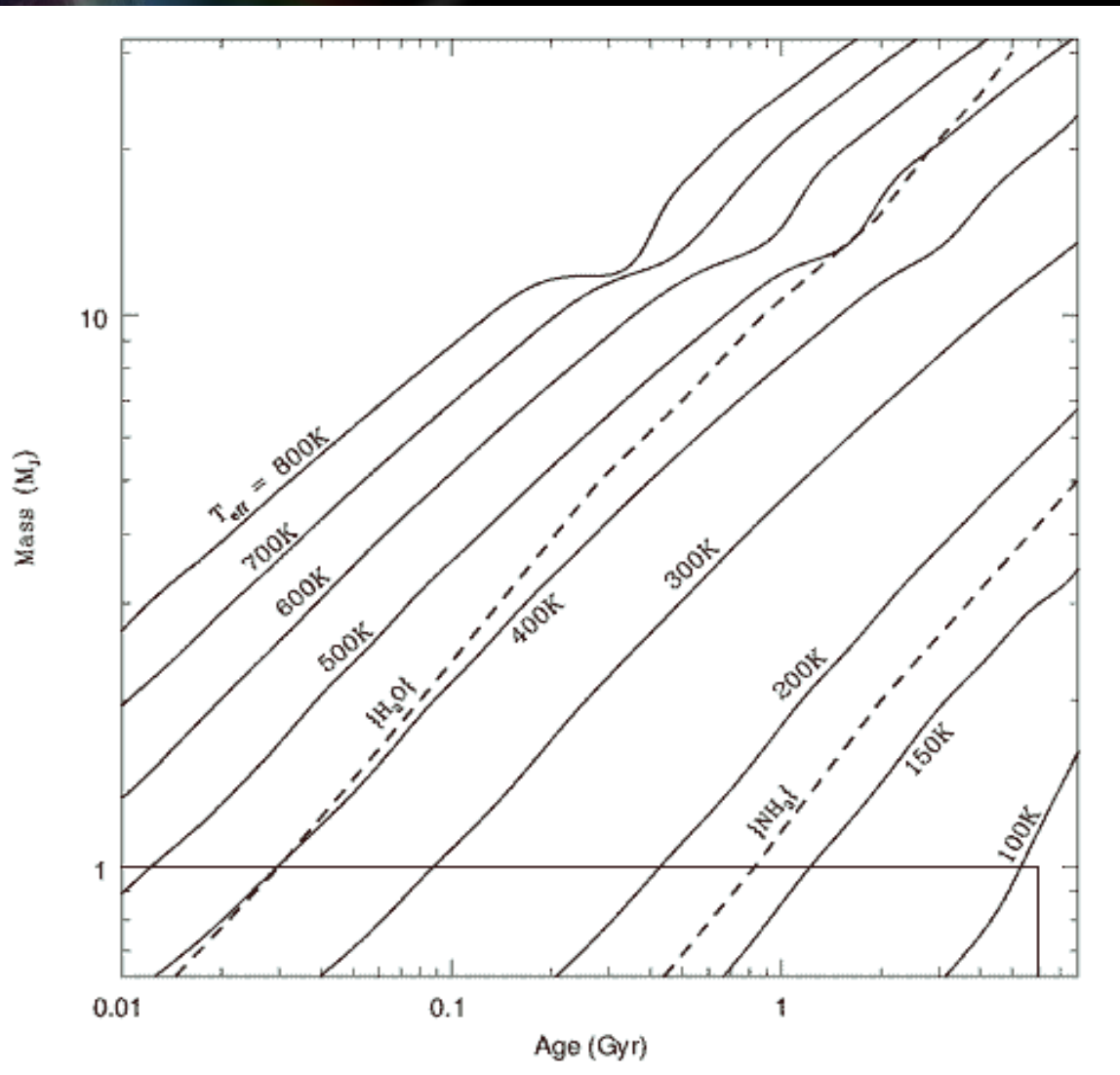
Massen??? → Kepler 3



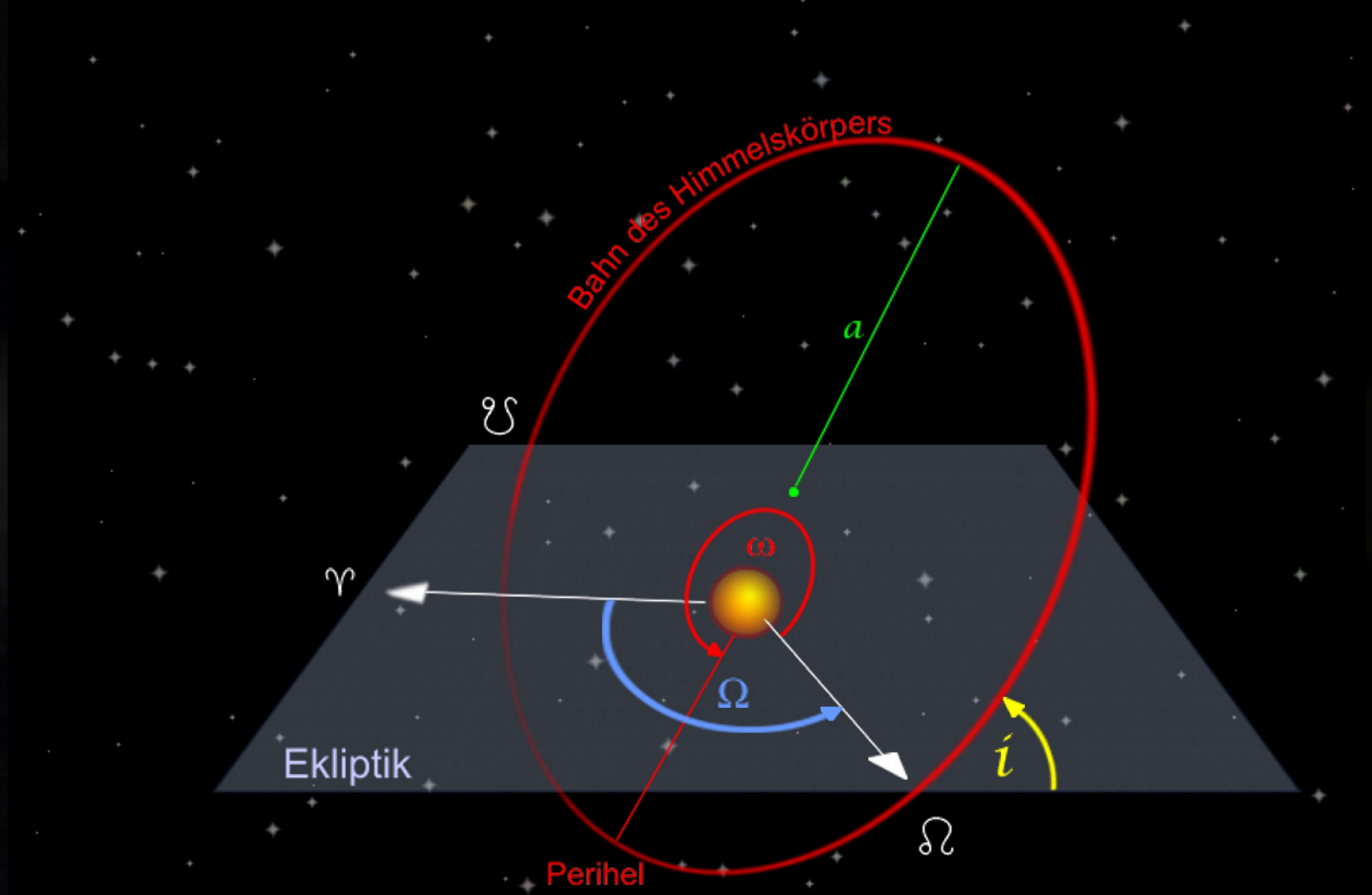
$$P^2 = \frac{4\pi^2 (a_s + a_p)^3}{G(m_s + m_p)}$$

Masse des Sterns →
HRD + M-L Beziehung

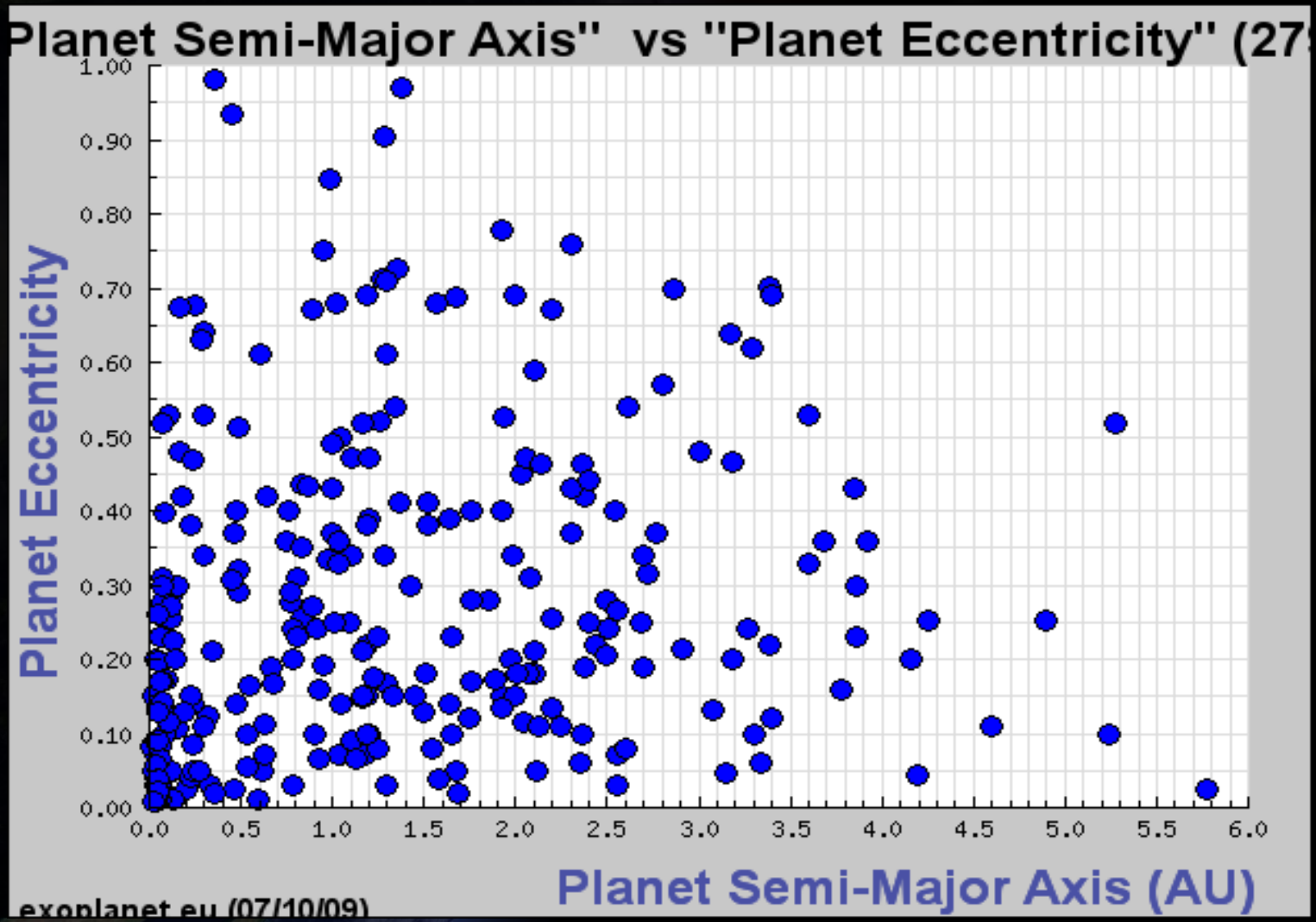




Kepler Elemente



Sehen Exoplanetensysteme so aus wie unser Sonnensystem?



Habitabilität...

Leben wie WIR es kennen...

flüssiges Wasser an der Planetenoberfläche...

Habitabilität hängt ab von...

Exzentrizität der Bahn

Sterntyp

Atmosphäre des Planeten

Sternalter

Zusammensetzung

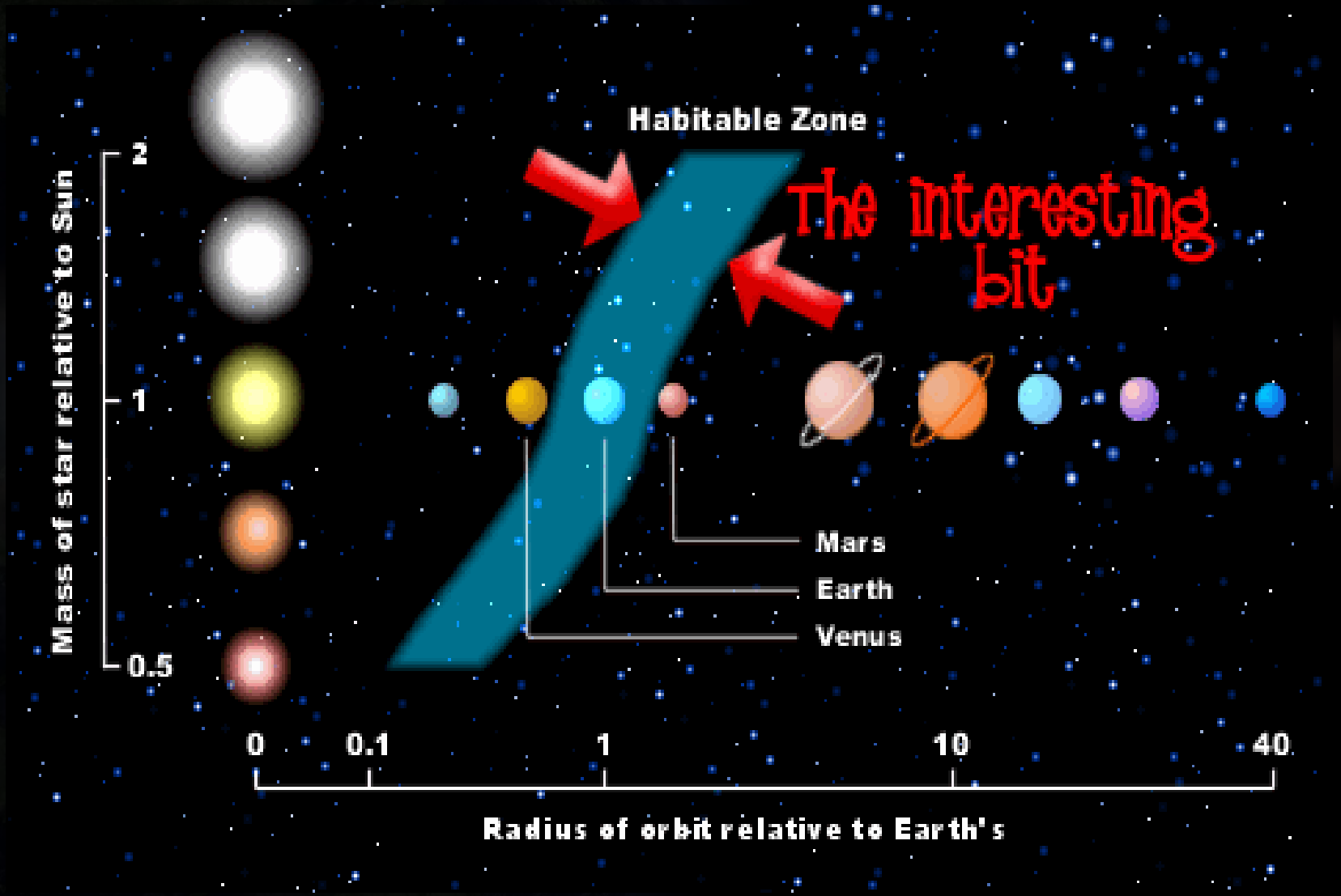
Masse des Planeten

Albedo

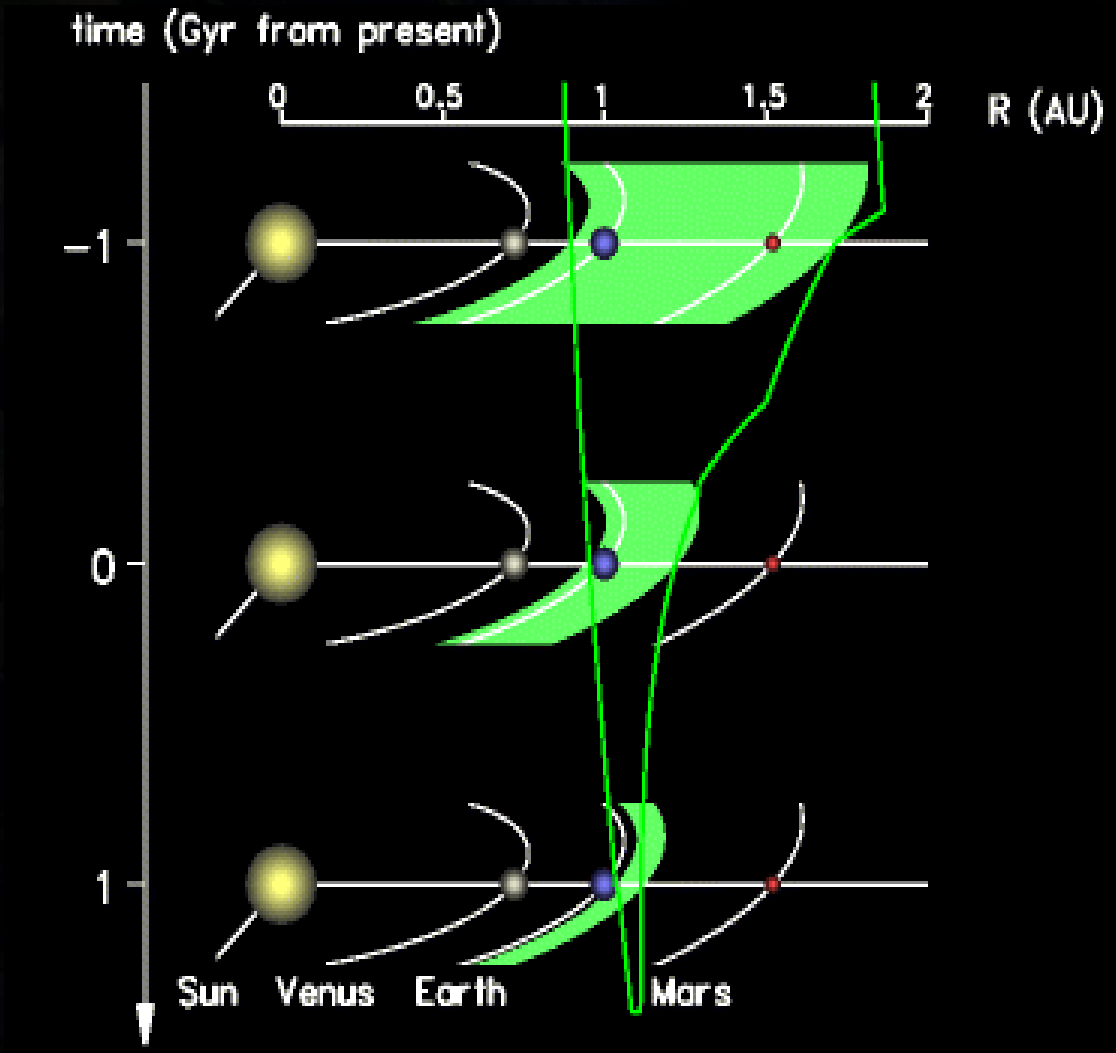
Dynamische Lebensdauer/Stabilität

Wolken

Habitabilität...

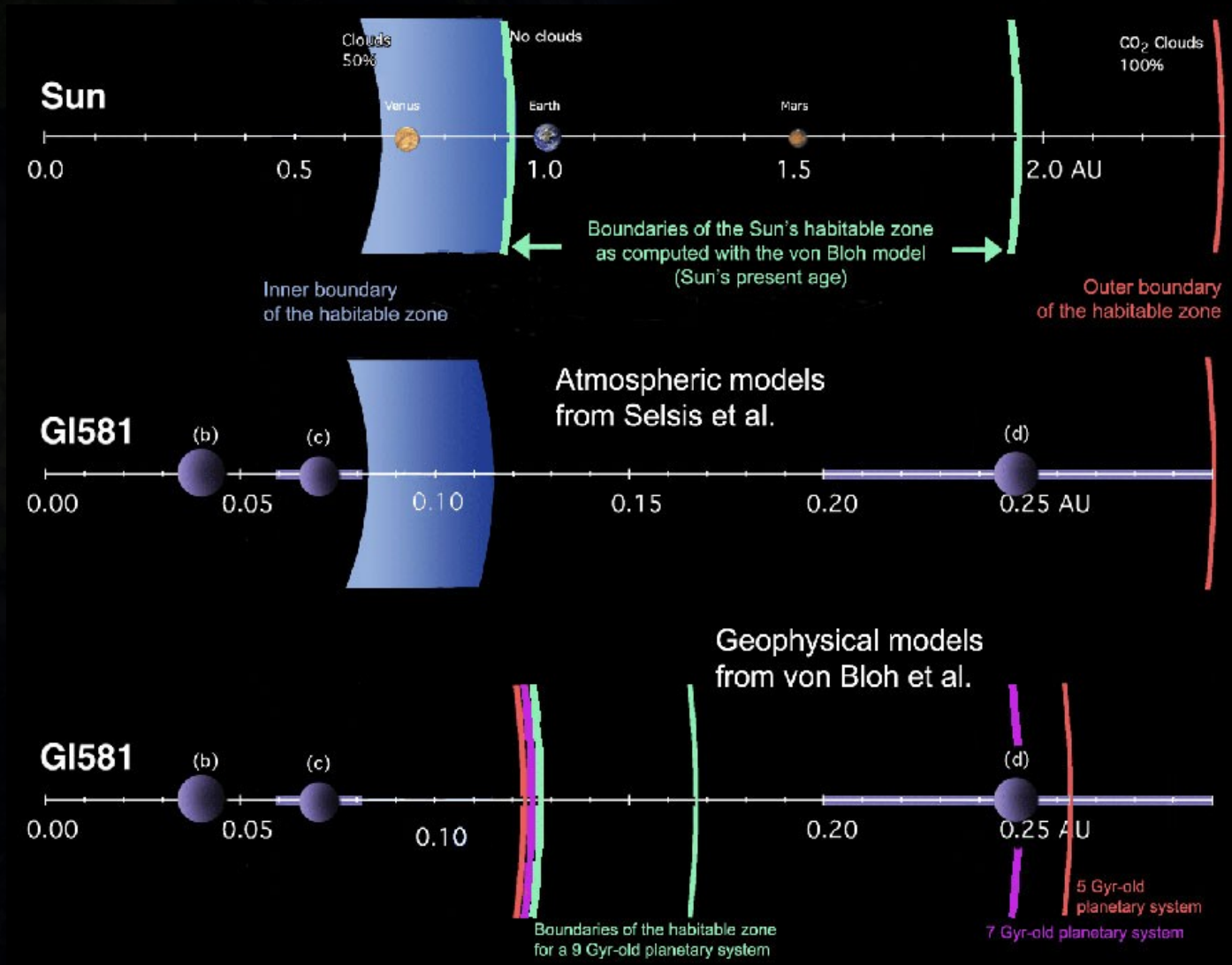


Habitabilität...



W. von Bloh (2002)

Habitabilität...



Danke für Ihre Aufmerksamkeit!