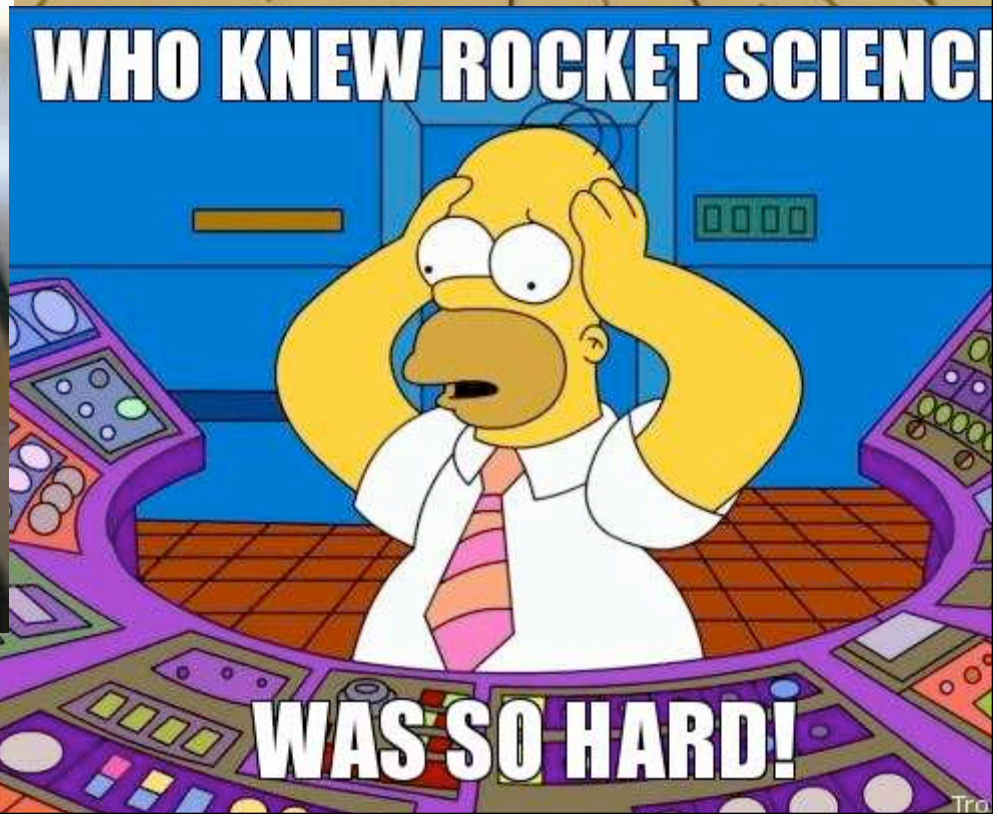


Homer's Physics

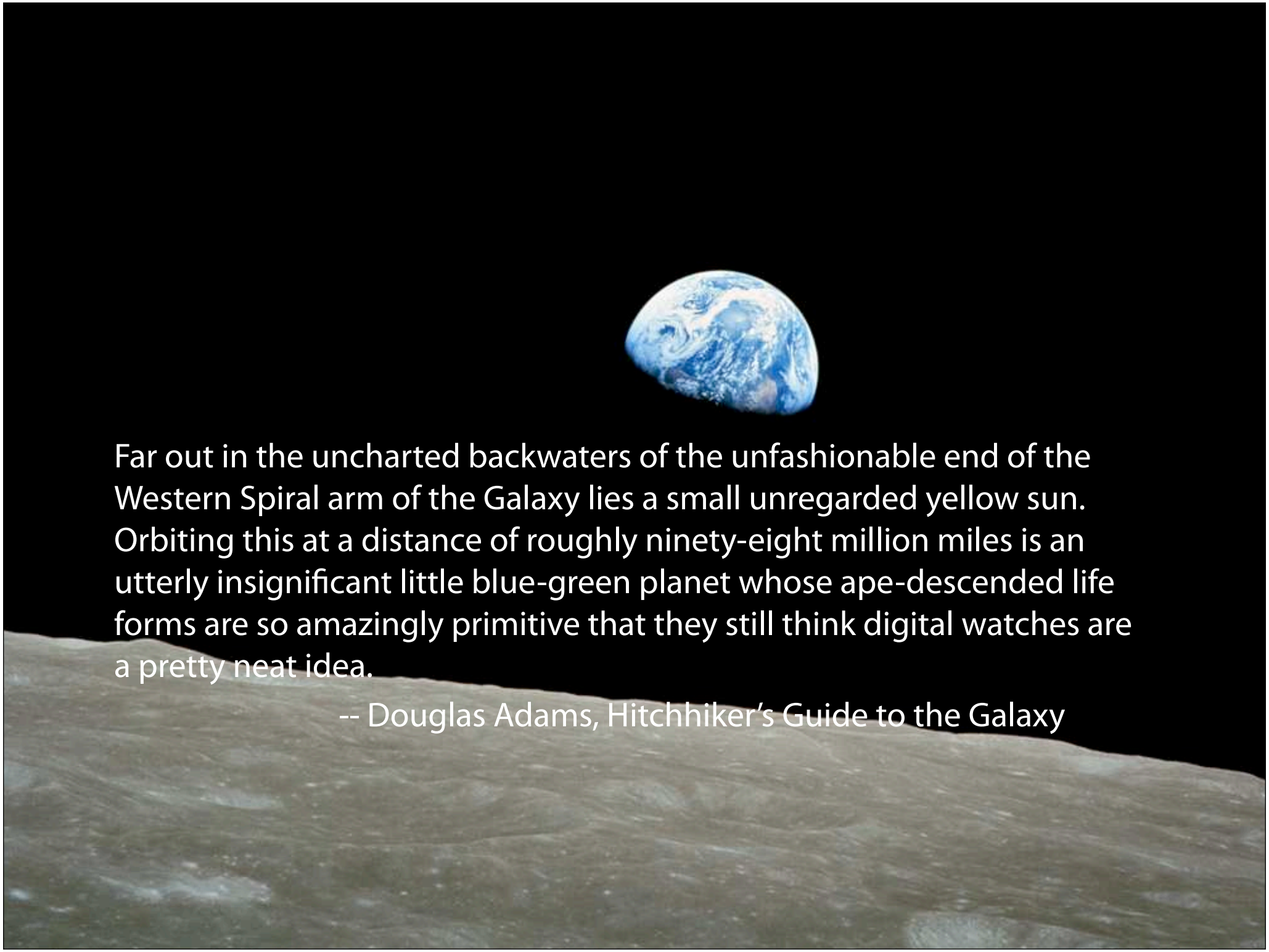
Feb 8th 2013

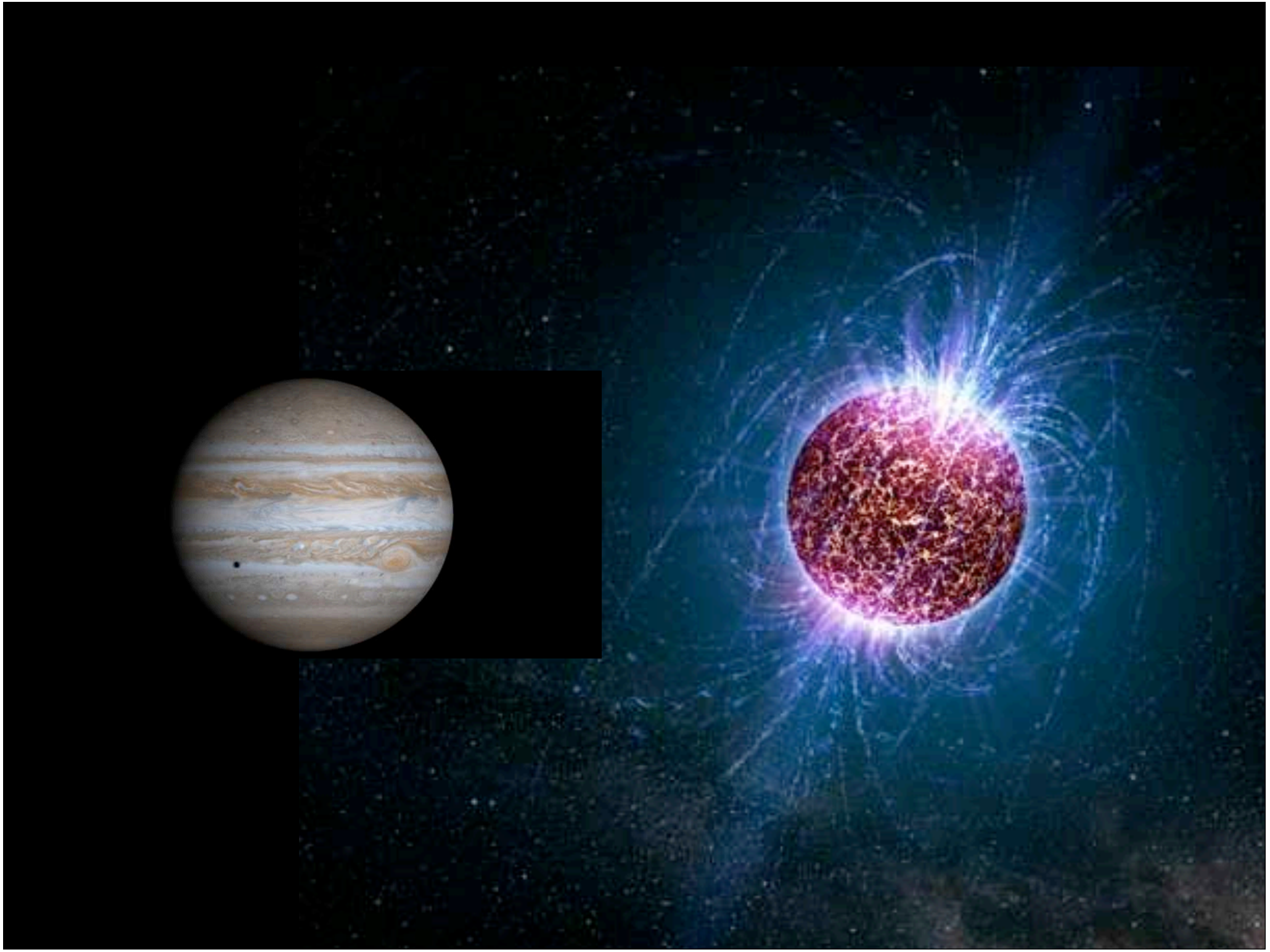
http://www.youtube.com/watch?v=a2D7IqKyIdA

"At Least One in Six Stars Has an Earth-sized Planet"
NASA Kepler mission announcement, January 2013

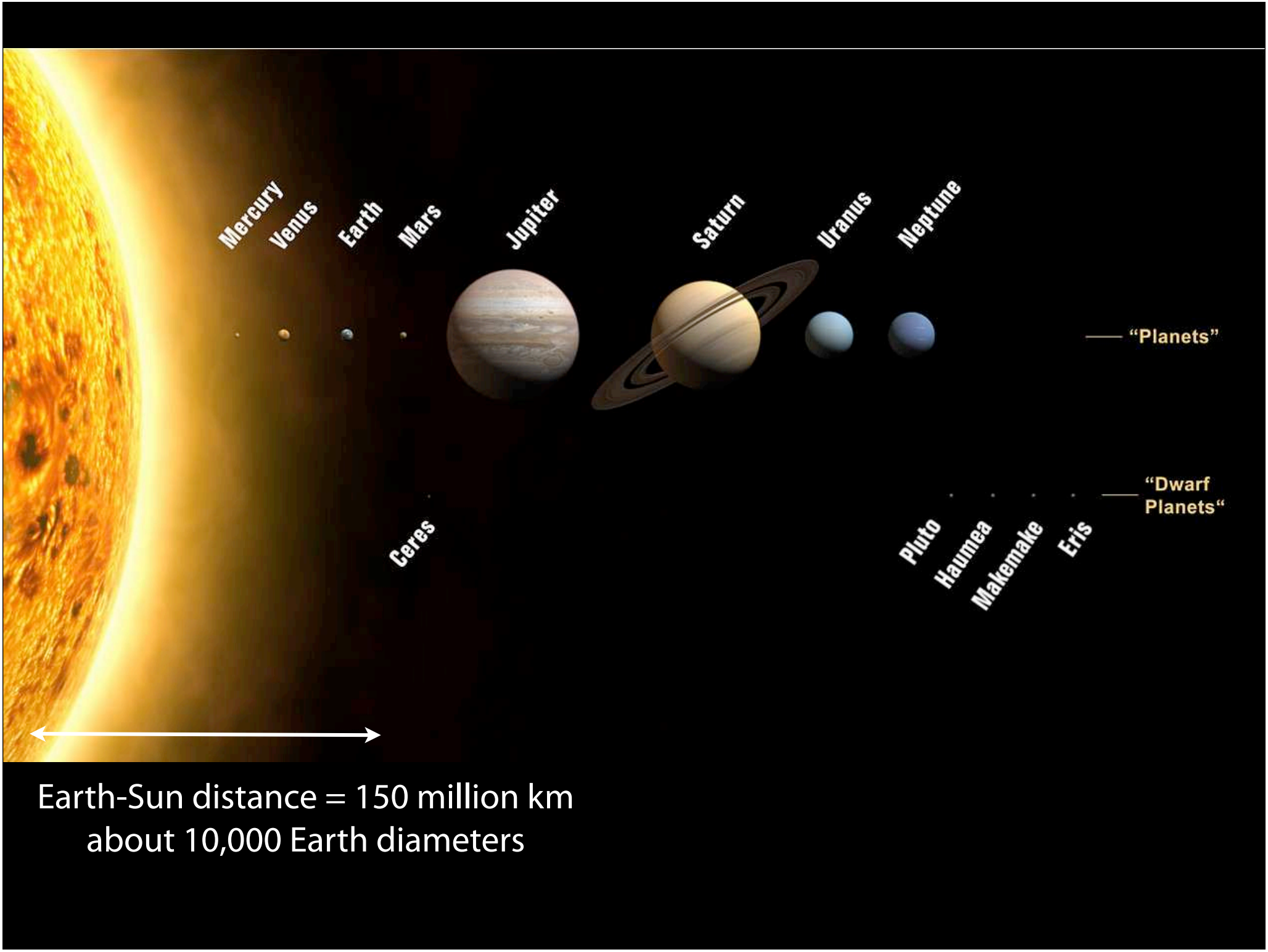
There are in fact 100 billion galaxies, each of which contain something like 100 billion stars... We find that we live on an insignificant planet, of a humdrum star, lost in a galaxy, tucked away in some forgotten corner of the universe, in which there are far more galaxies than people.

-- Carl Sagan, Cosmos (episode 1)


Far out in the uncharted backwaters of the unfashionable end of the Western Spiral arm of the Galaxy lies a small unregarded yellow sun. Orbiting this at a distance of roughly ninety-eight million miles is an utterly insignificant little blue-green planet whose ape-descended life forms are so amazingly primitive that they still think digital watches are a pretty neat idea.
-- Douglas Adams, Hitchhiker's Guide to the Galaxy




Why study planets?
- We live on one
- Where did we come from?
- Are we alone?
- "Extreme" conditions



Earth-Sun distance = 150 million km
about 10,000 Earth diameters

Eduardo N del Campo, Mr <eduardo… 7 February, 2013 5:06 PM
To: Andrew Cumming (cumming@p…
(No Subject)

Hi Andrew,

What do you think?
You think we will be in the bell room tomorrow at no
on the link below, Asteroid is very close to earth.

Cheers!

Eddie

http://www.cbc.ca/news/technology/story/2012/06/flyby-earth.html

CBCnews | Technology & Science

Home | World | Canada | Politics | Business | Health | Arts & Entertainment | Technology

Technology & Science | Quirks & Quarks Blog | Photo Galleries

Huge asteroid to pass near Earth tonight

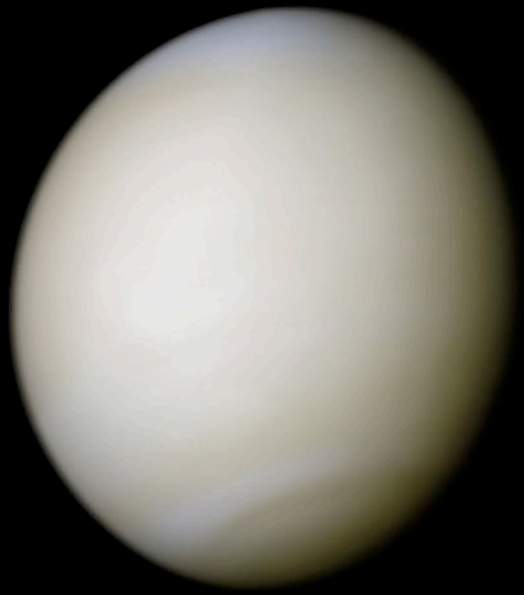
Flyby of city-block-sized space rock to be broadcast live online

CBC News Posted: Jun 14, 2012 9:53 AM ET | Last Updated: Jun 14, 2012 9:49 AM ET 233

closest approach to Earth = 5.4 million km

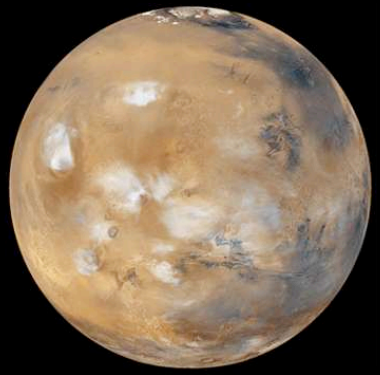
The terrestrial planets

Mercury



Venus

Earth



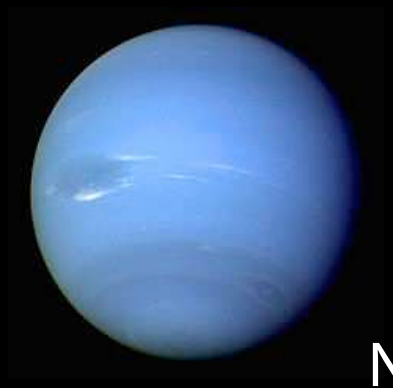
Mars

The gas giants

Jupiter

Saturn

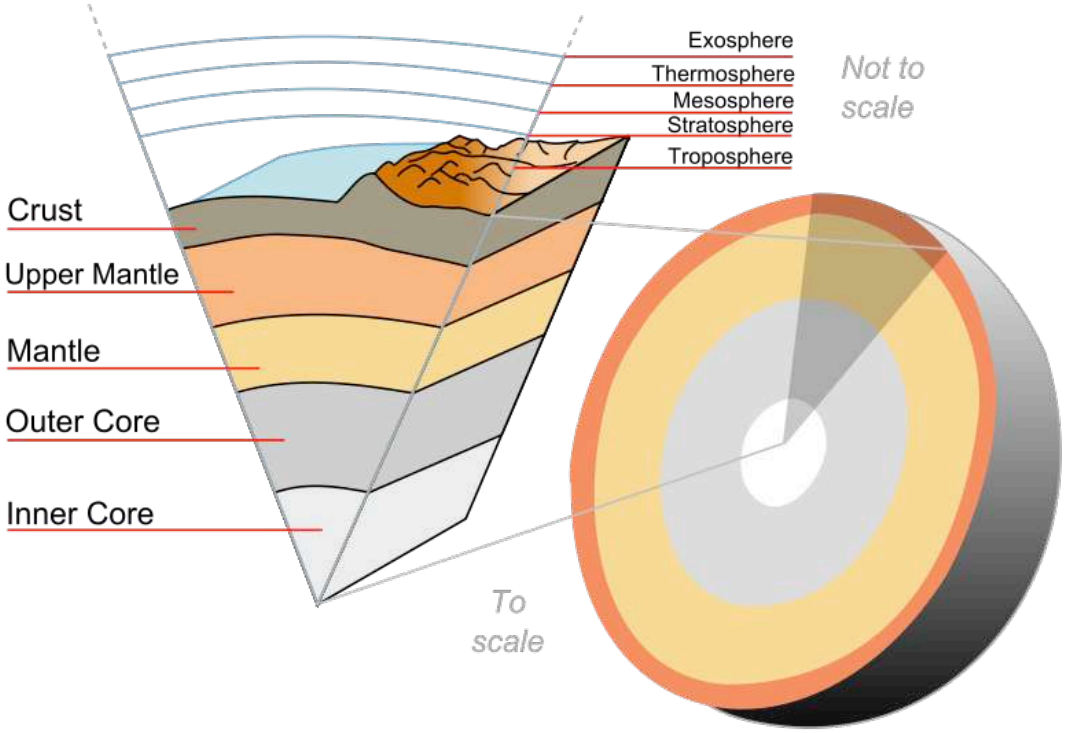
Uranus



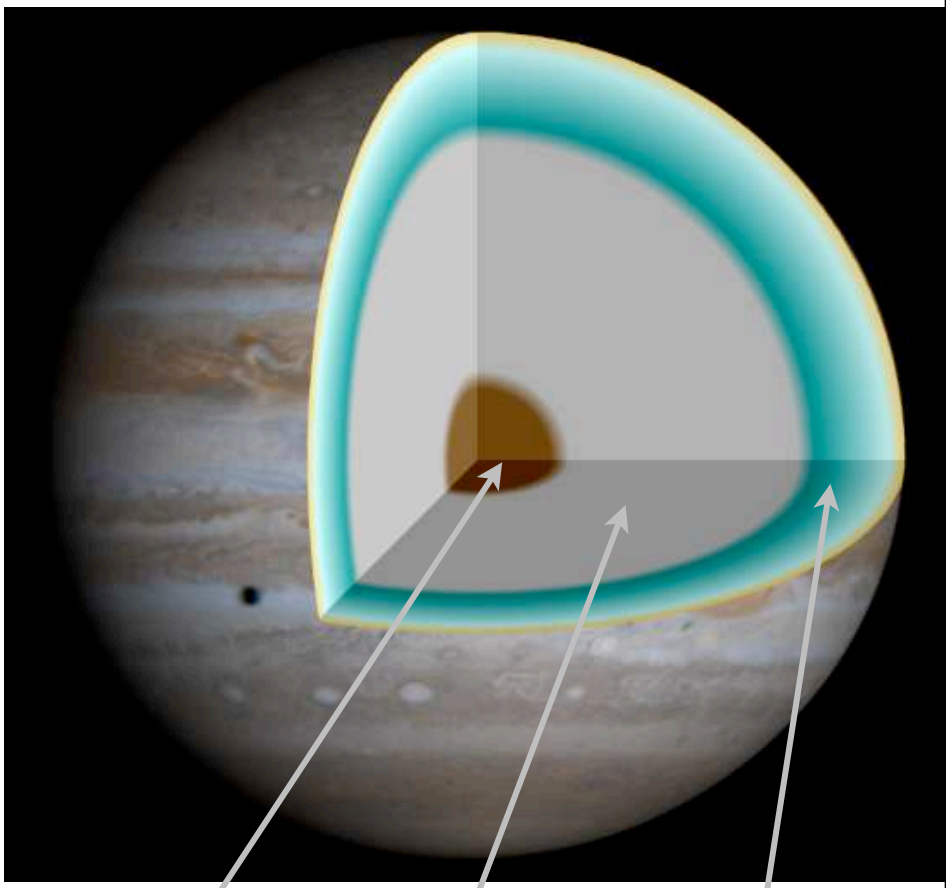
Neptune

Internal structure

Earth



Jupiter

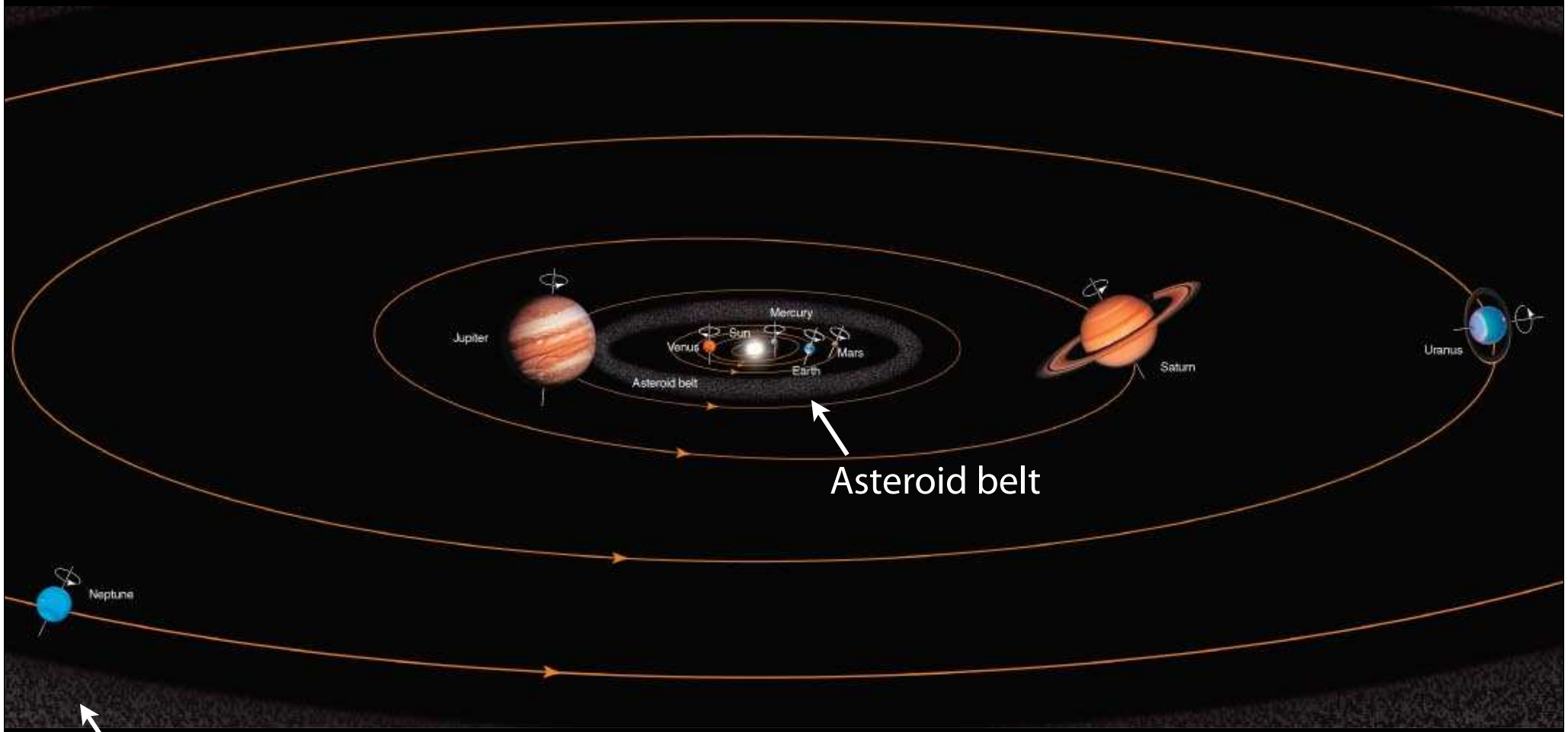


Rocky core (<10 Earth masses)

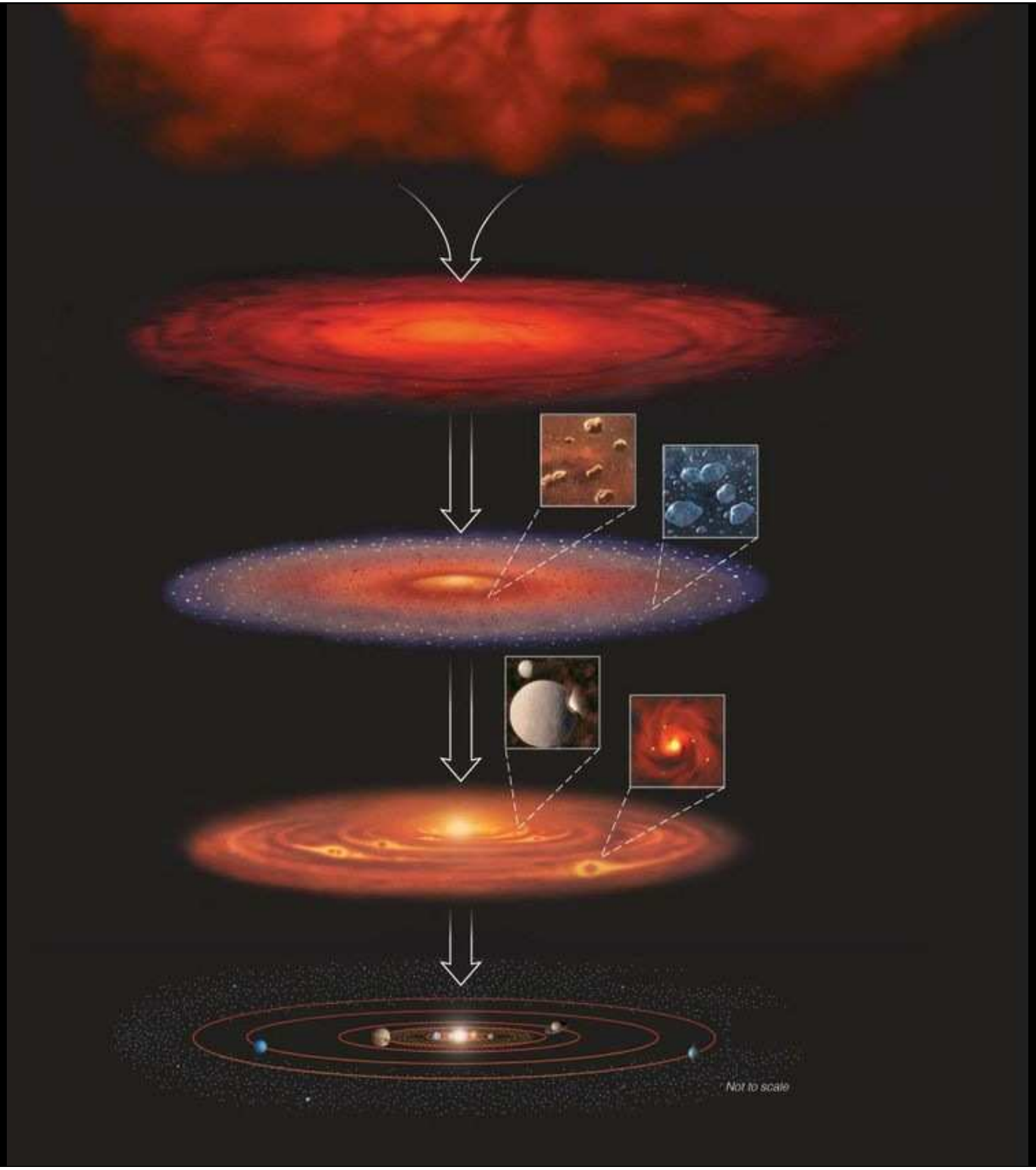
Metallic hydrogen

Molecular hydrogen

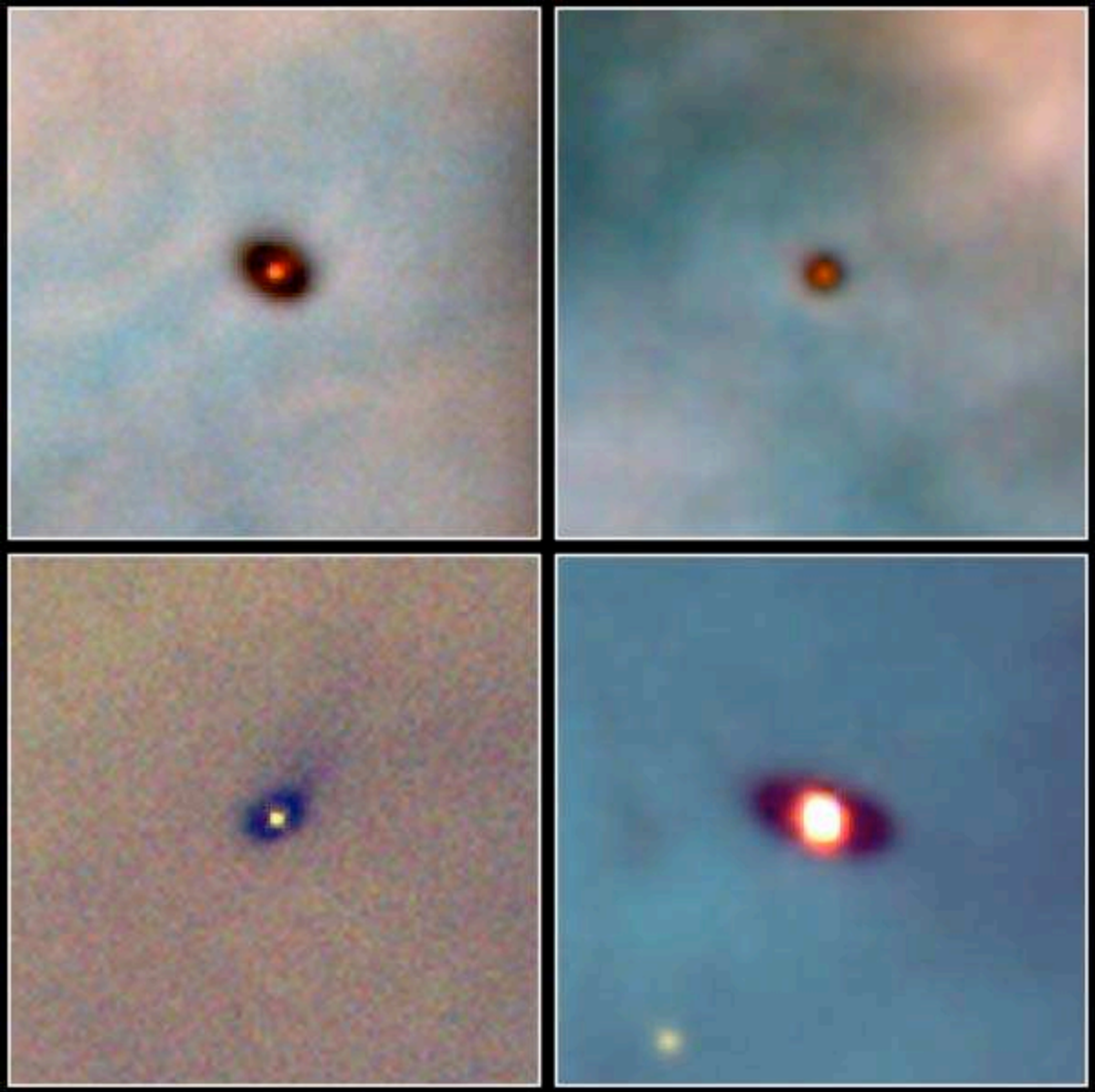
Overall architecture of the Solar System



Who ordered that?


Not to scale

Dusty disks around forming stars: building blocks of planets

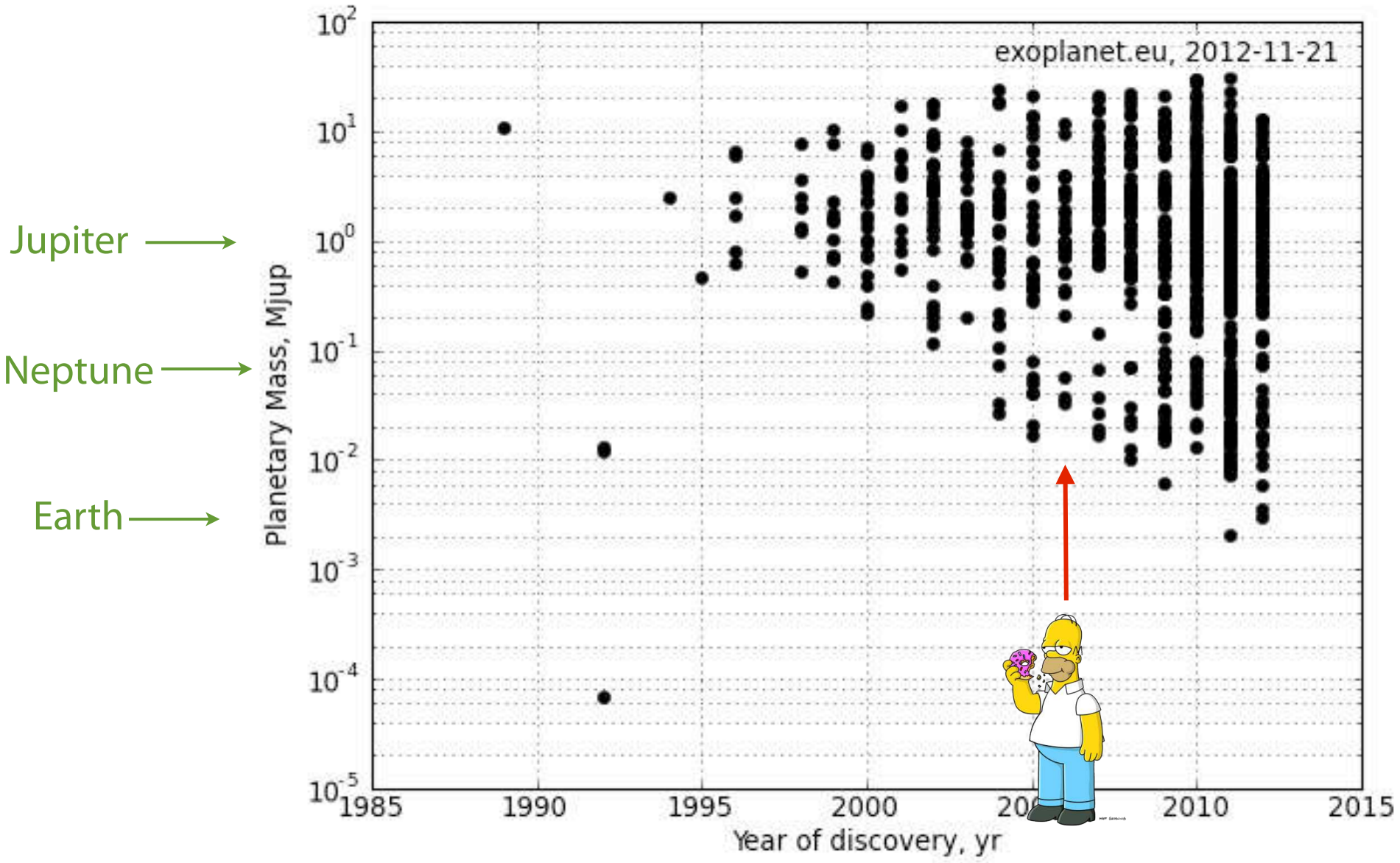


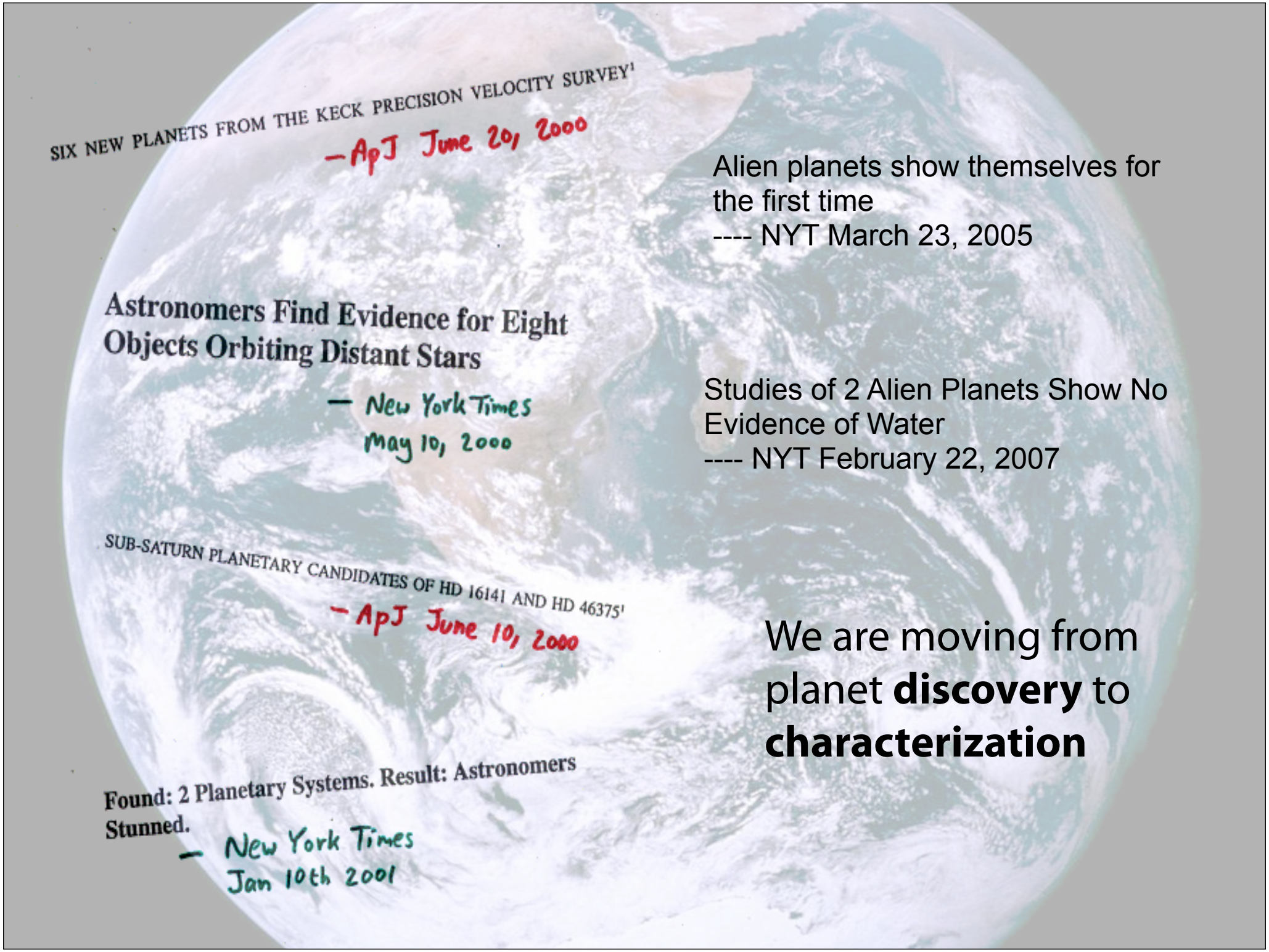
Protoplanetary Disks
Orion Nebula

HST · WFPC2

PRC95-45b · ST ScI OPO · November 20, 1995
M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA

A history of exoplanet discoveries




SIX NEW PLANETS FROM THE KECK PRECISION VELOCITY SURVEY¹
– ApJ June 20, 2000
Alien planets show themselves for the first time
---- NYT March 23, 2005
Astronomers Find Evidence for Eight Objects Orbiting Distant Stars
– New York Times
May 10, 2000
Studies of 2 Alien Planets Show No Evidence of Water
---- NYT February 22, 2007
SUB-SATURN PLANETARY CANDIDATES OF HD 16141 AND HD 46375¹
– ApJ June 10, 2000
We are moving from planet **discovery** to **characterization**
Found: 2 Planetary Systems. Result: Astronomers Stunned.
– New York Times
Jan 10th 2001

Planet hunting: Radial velocity searches

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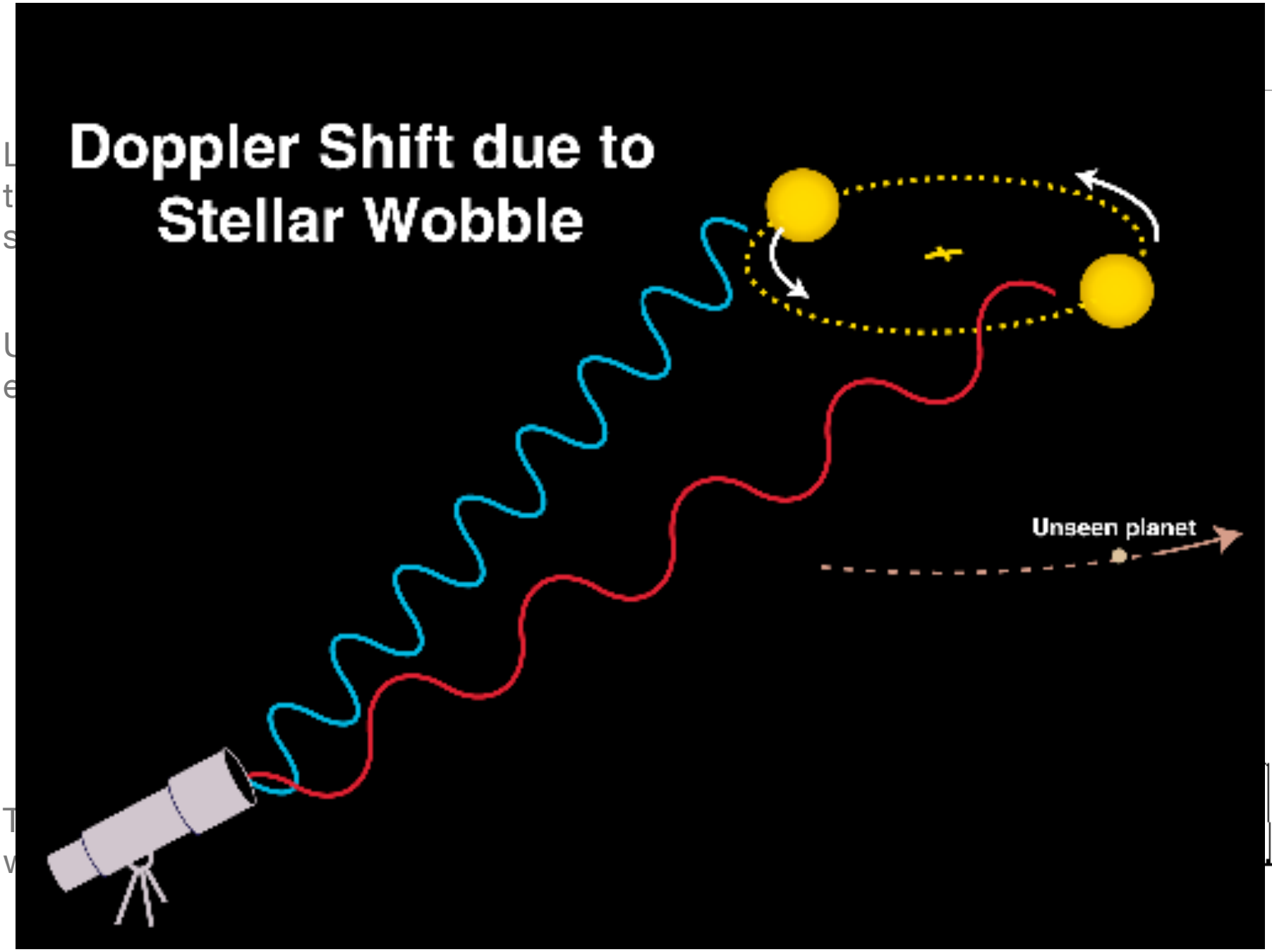
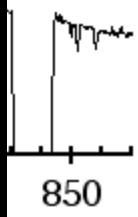
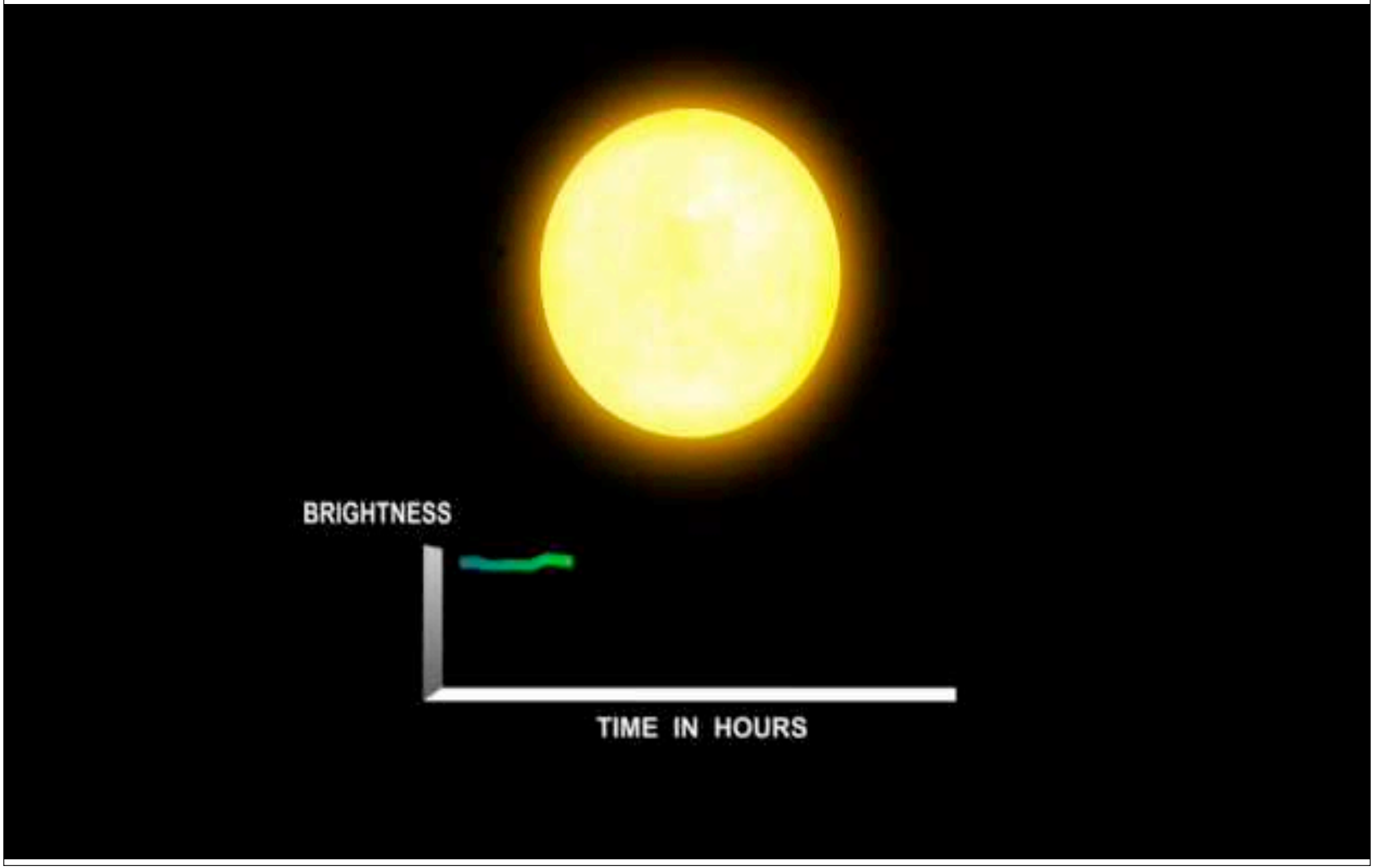


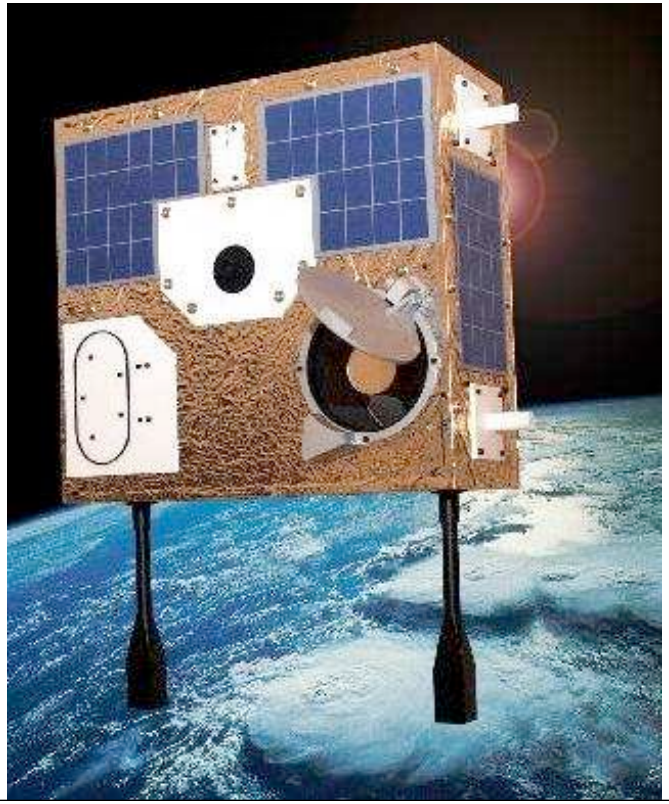


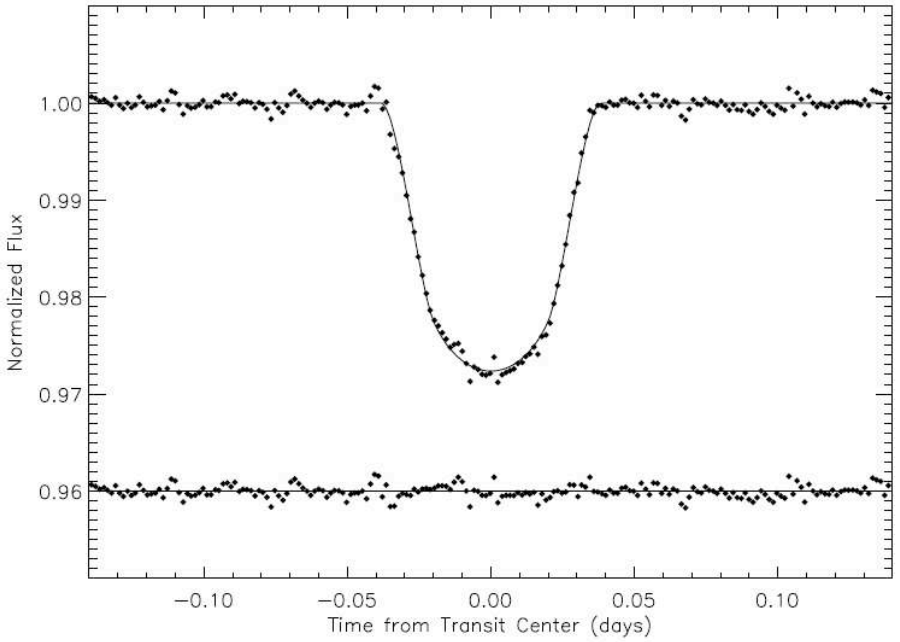
Planet hunting: Transits

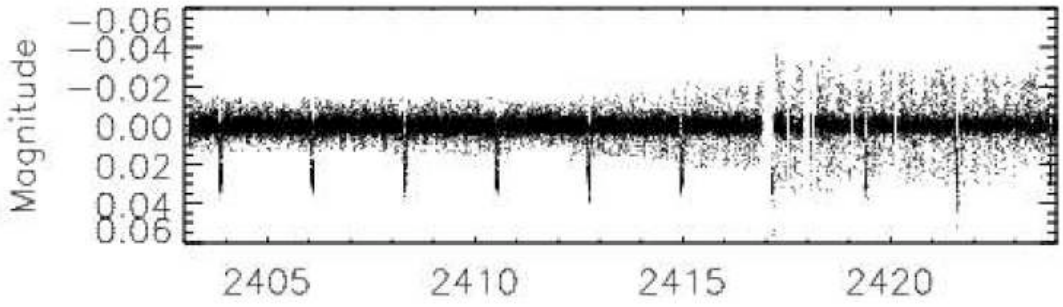


Planet hunting: transits

- An example transit lightcurve for the hot jupiter HD 189733b
- This data is from the Canadian space telescope MOST (led by Jaymie Mathews UBC)

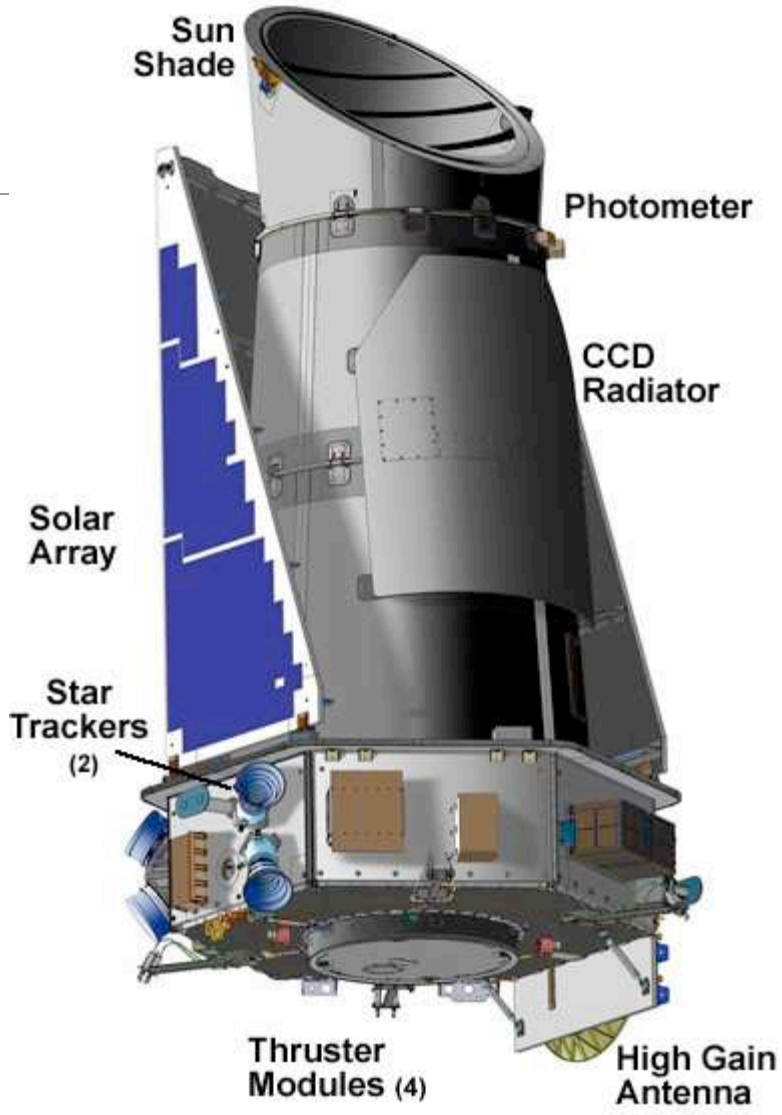






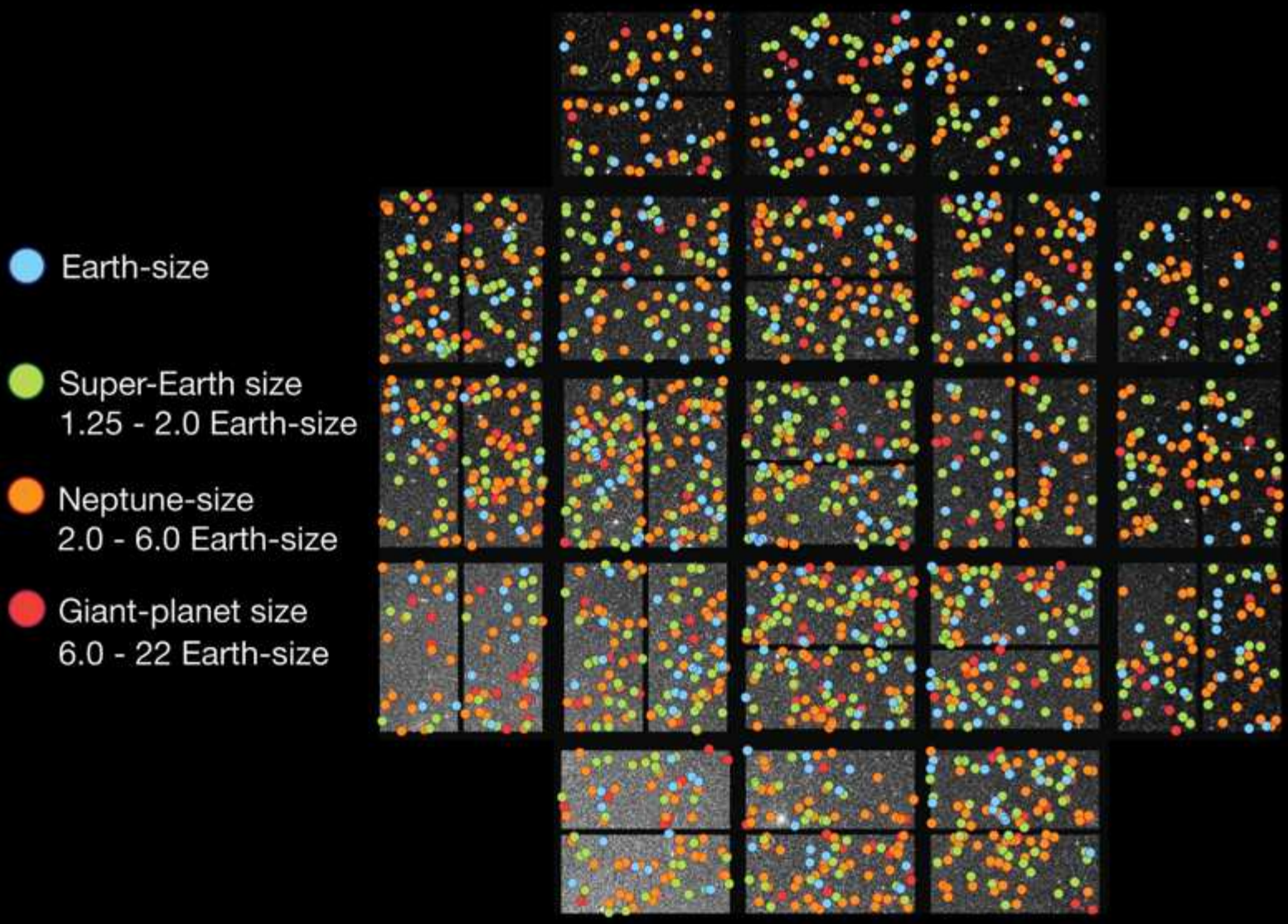
The Kepler mission

- Launched March 6, 2009
- Is monitoring 100,000 stars to look for transits
- Has so far announced almost 3000 planet candidates
- The goal is to detect Earth-like planets in the habitable zone



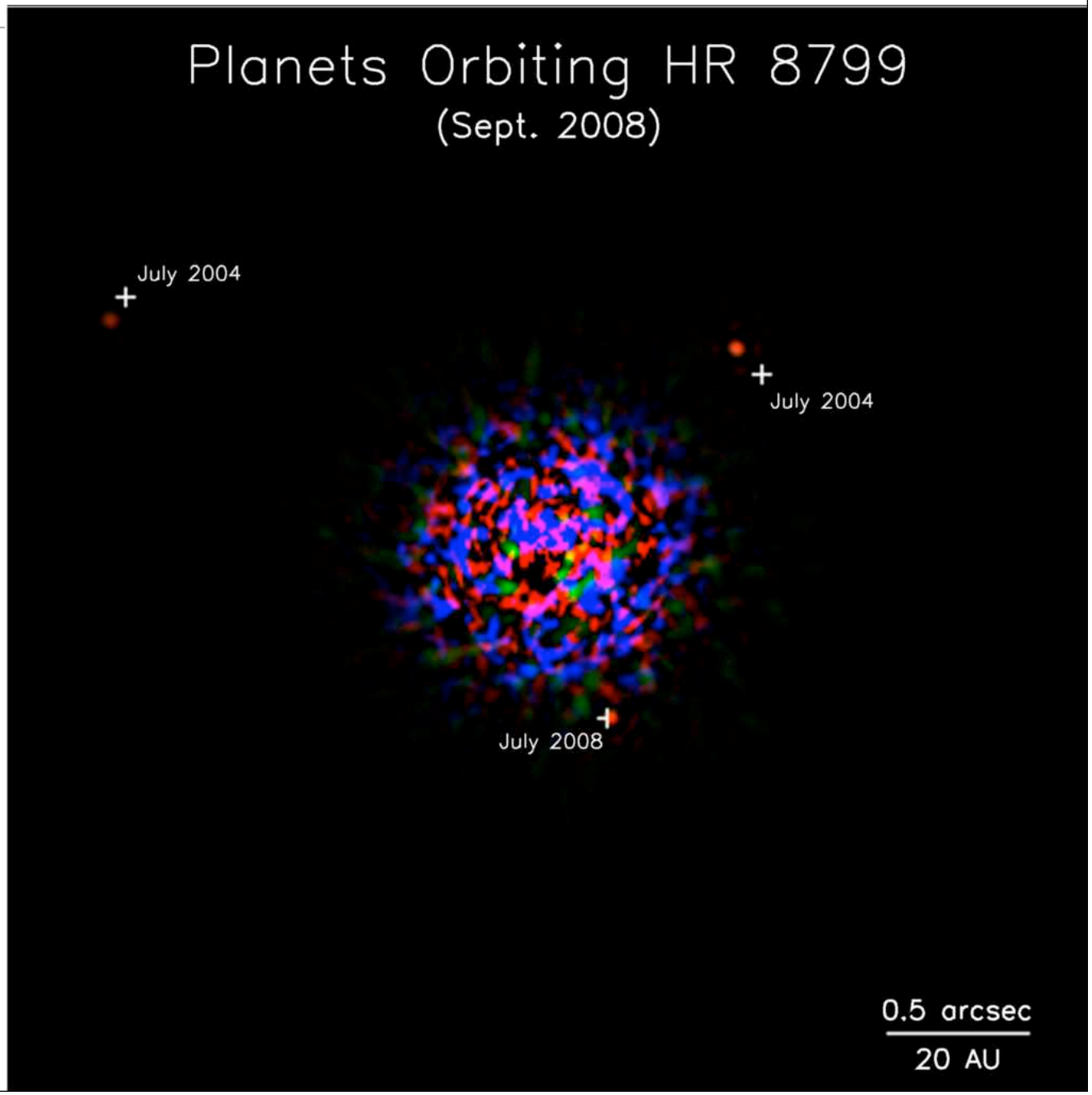
Locations of Kepler Planet Candidates

As of January 7, 2013

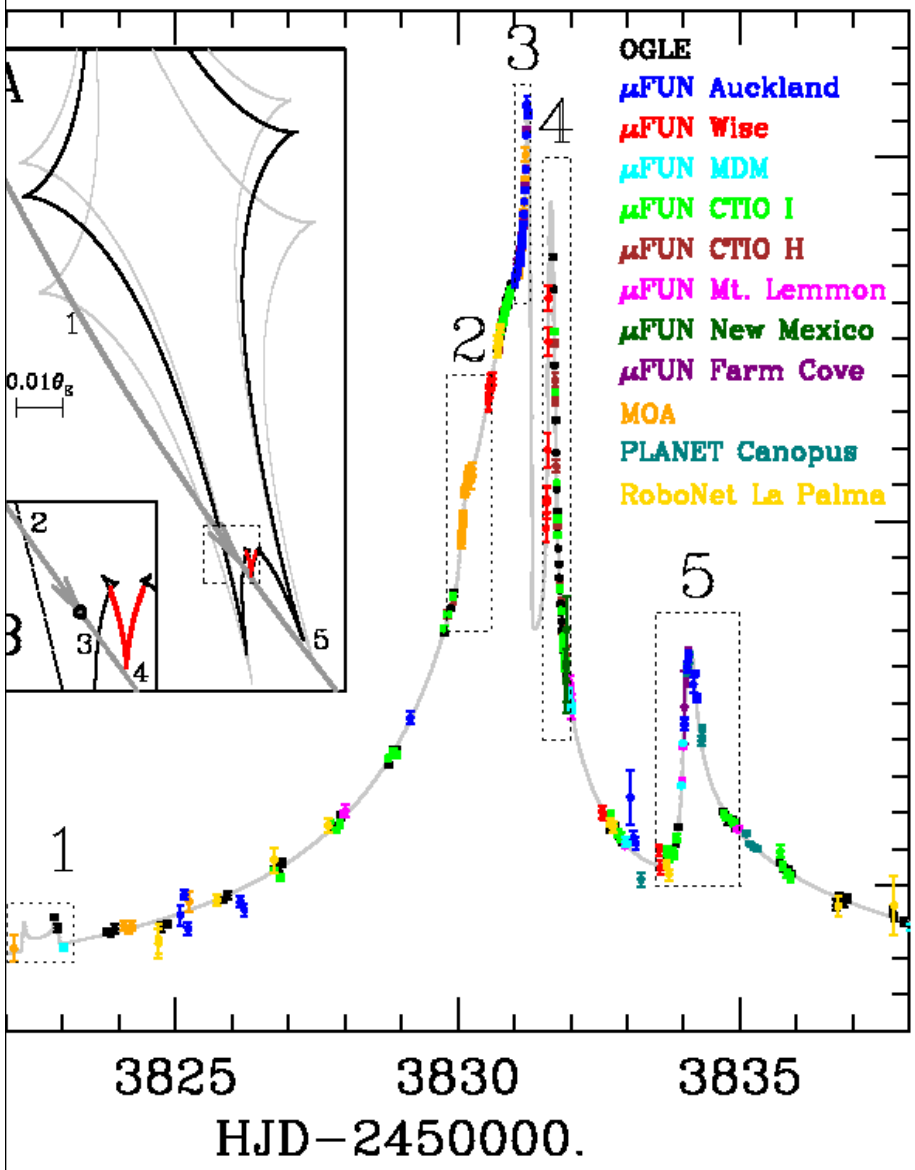


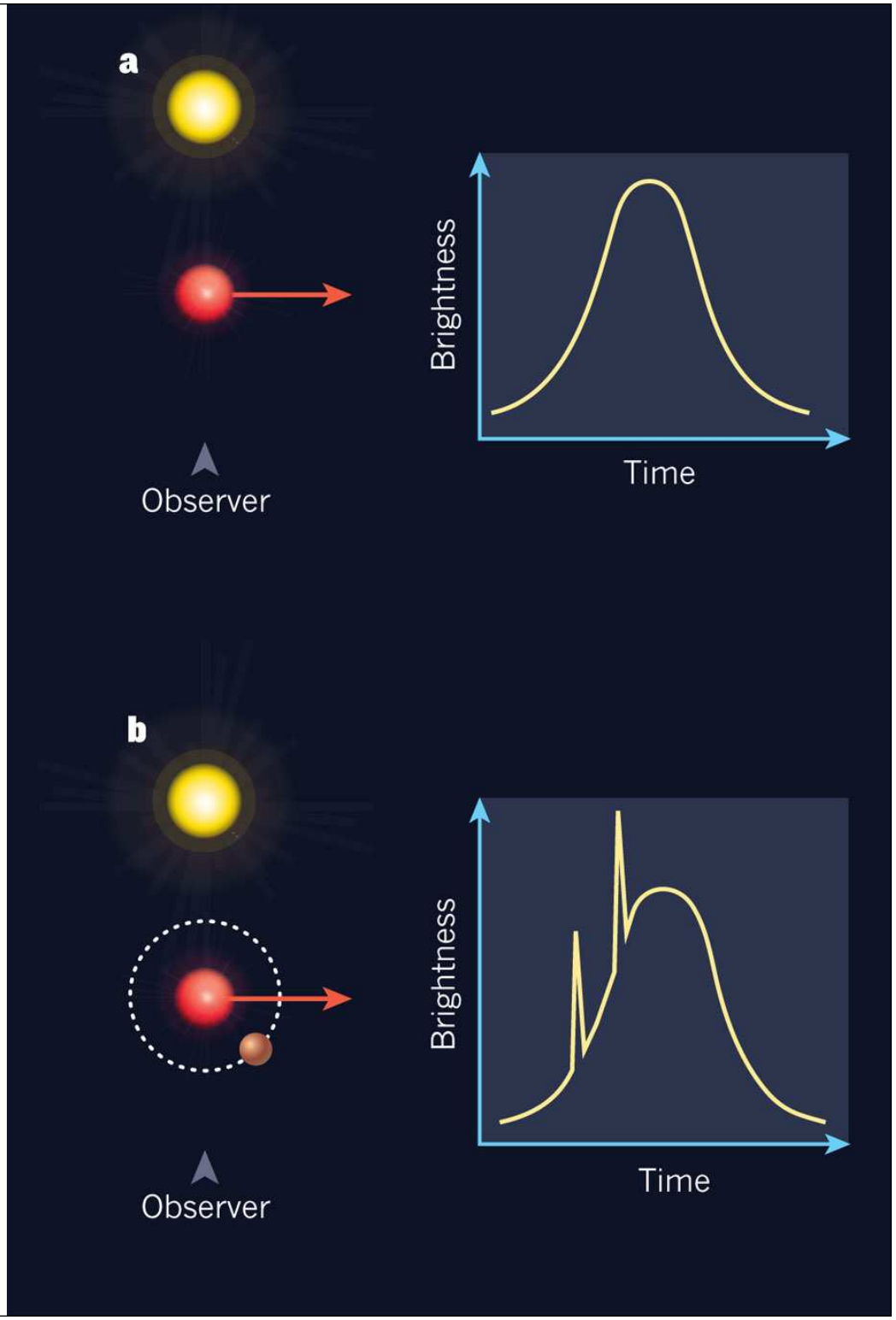
Direct imaging of planets

- This system was announced by a team including Rene Doyon of University of Montreal
- Three planets orbiting a young star (about 60 million years old) with masses between 5 and 13 times Jupiter
- Extremely difficult because the star is so much brighter than the planets. We look at infrared to increase the contrast, and at young stars so that the planets are still young and hot.



Gravitational microlensing





Exoplanet catalogs on the web

- The Extrasolar Planets Encyclopedia

  http://exoplanet.eu

- exoplanets.org

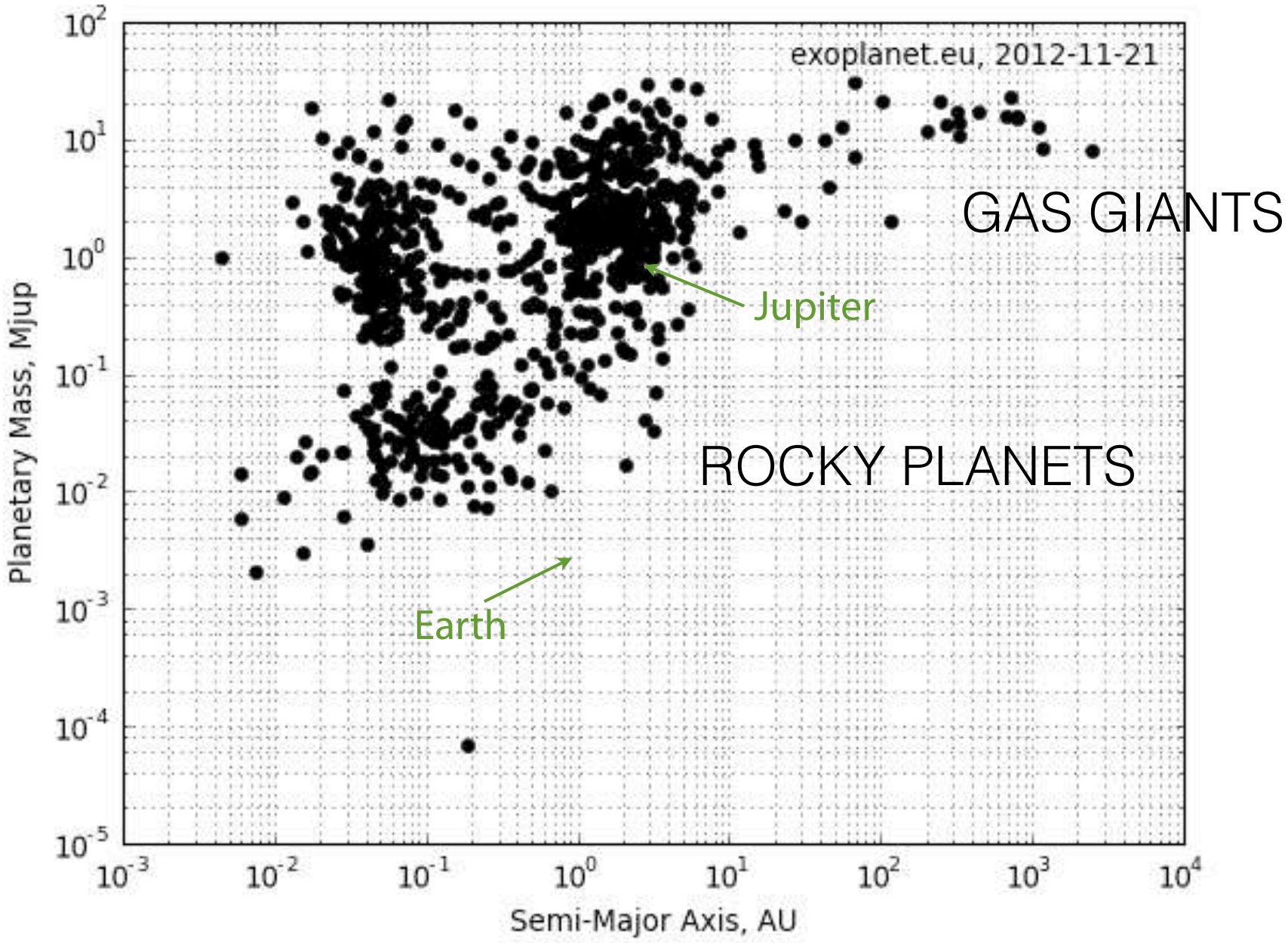
  http://exoplanets.org

- JPL Planet Quest website

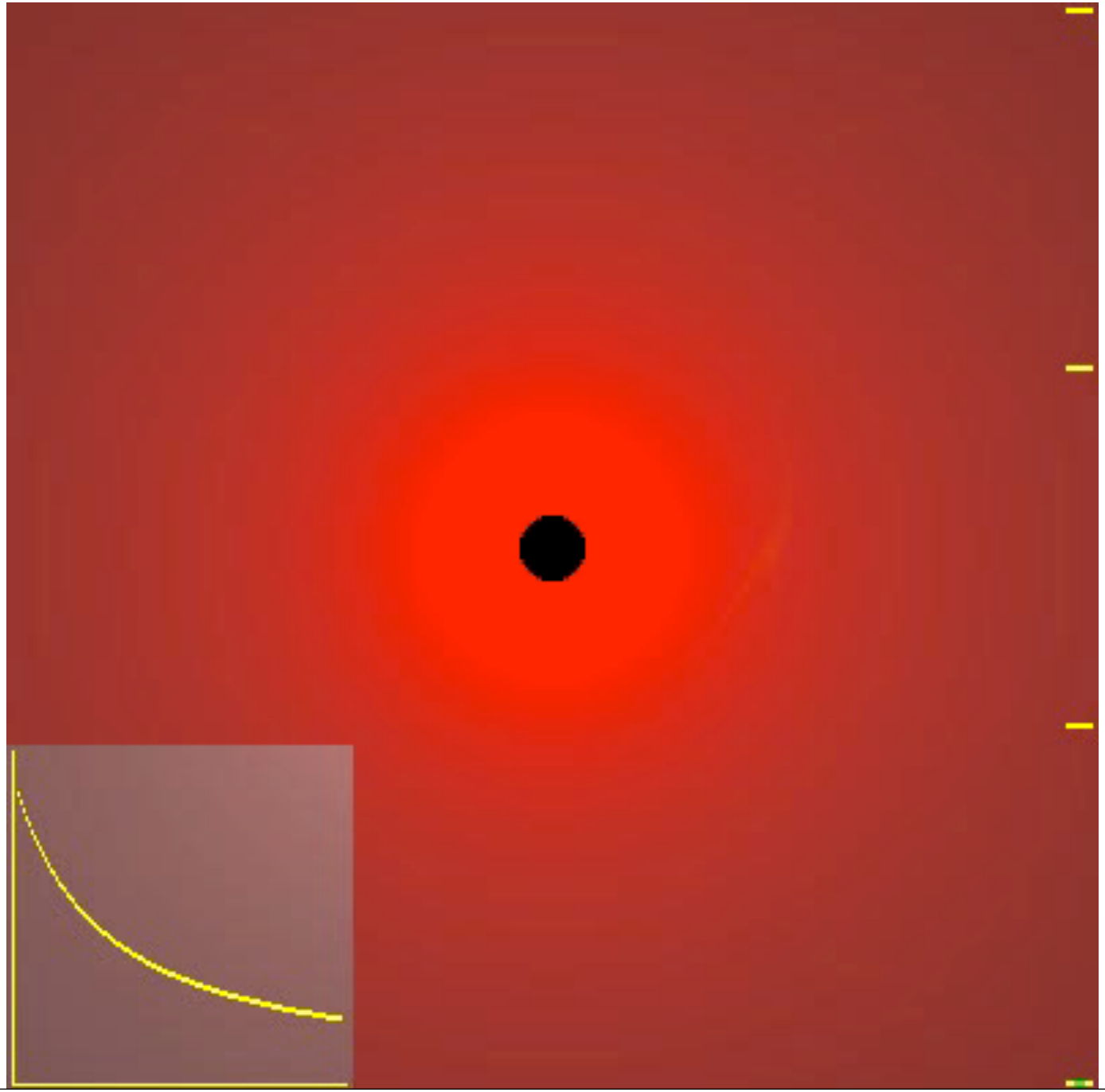
  http://planetquest.jpl.nasa.gov

- As of today (8th February 2013) exoplanets.eu lists 862 planets

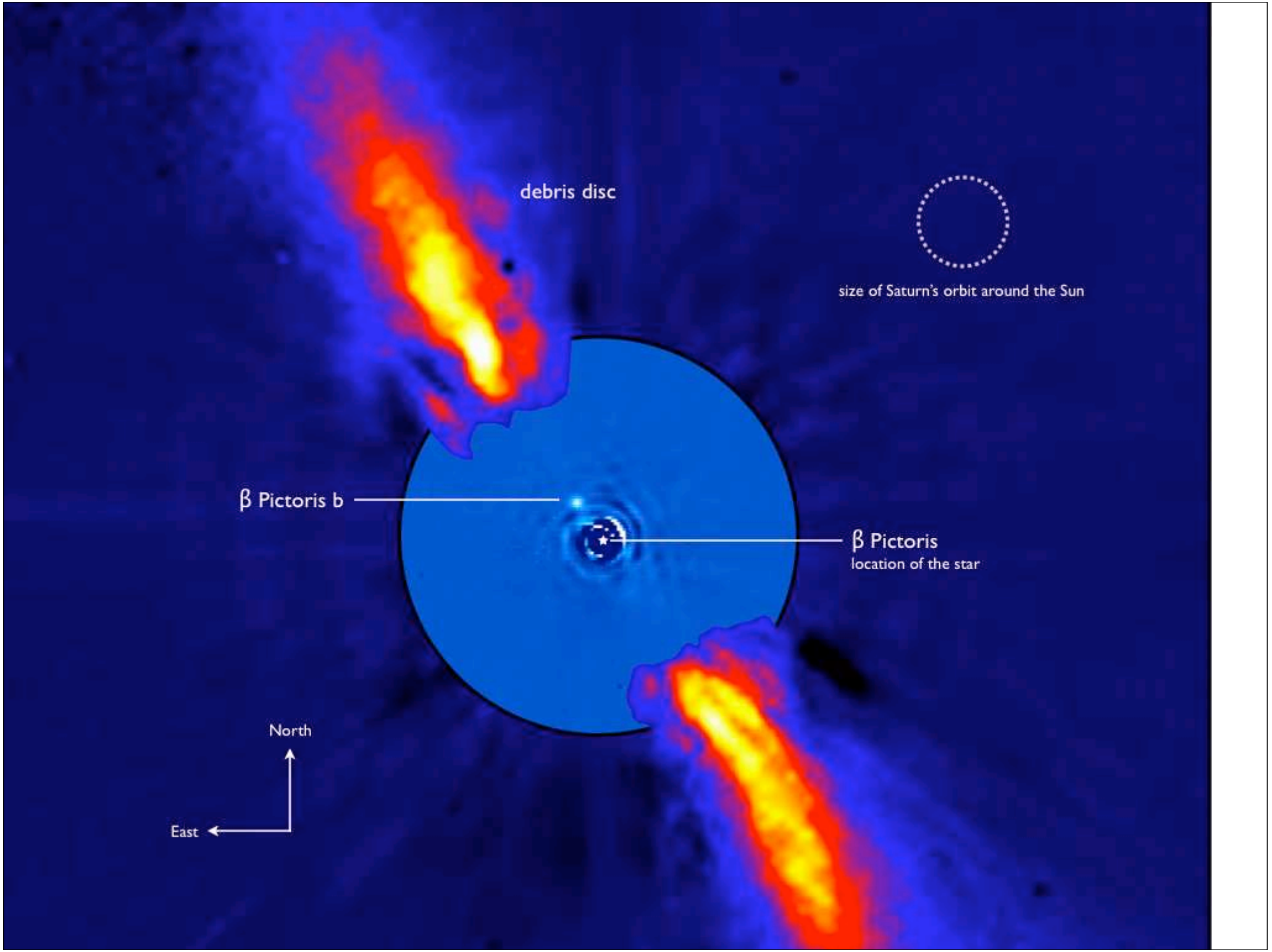
Other Solar Systems? Yes and no ..



A new ingredient: Migration

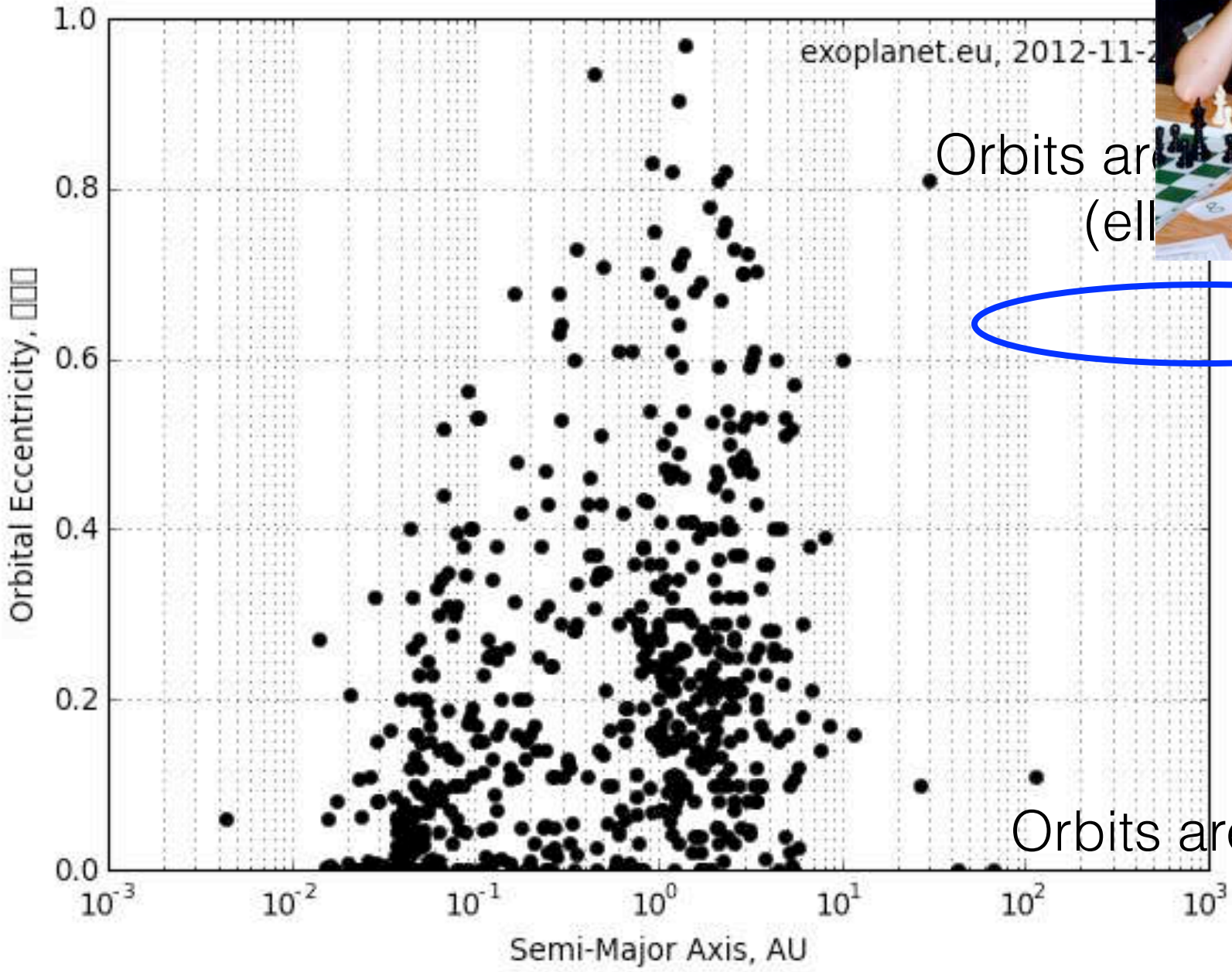


Movie from
Phil Armitage,
Colorado


debris disc
size of Saturn's orbit around the Sun
β Pictoris b
β Pictoris
location of the star
North
East

Eccentric orbits

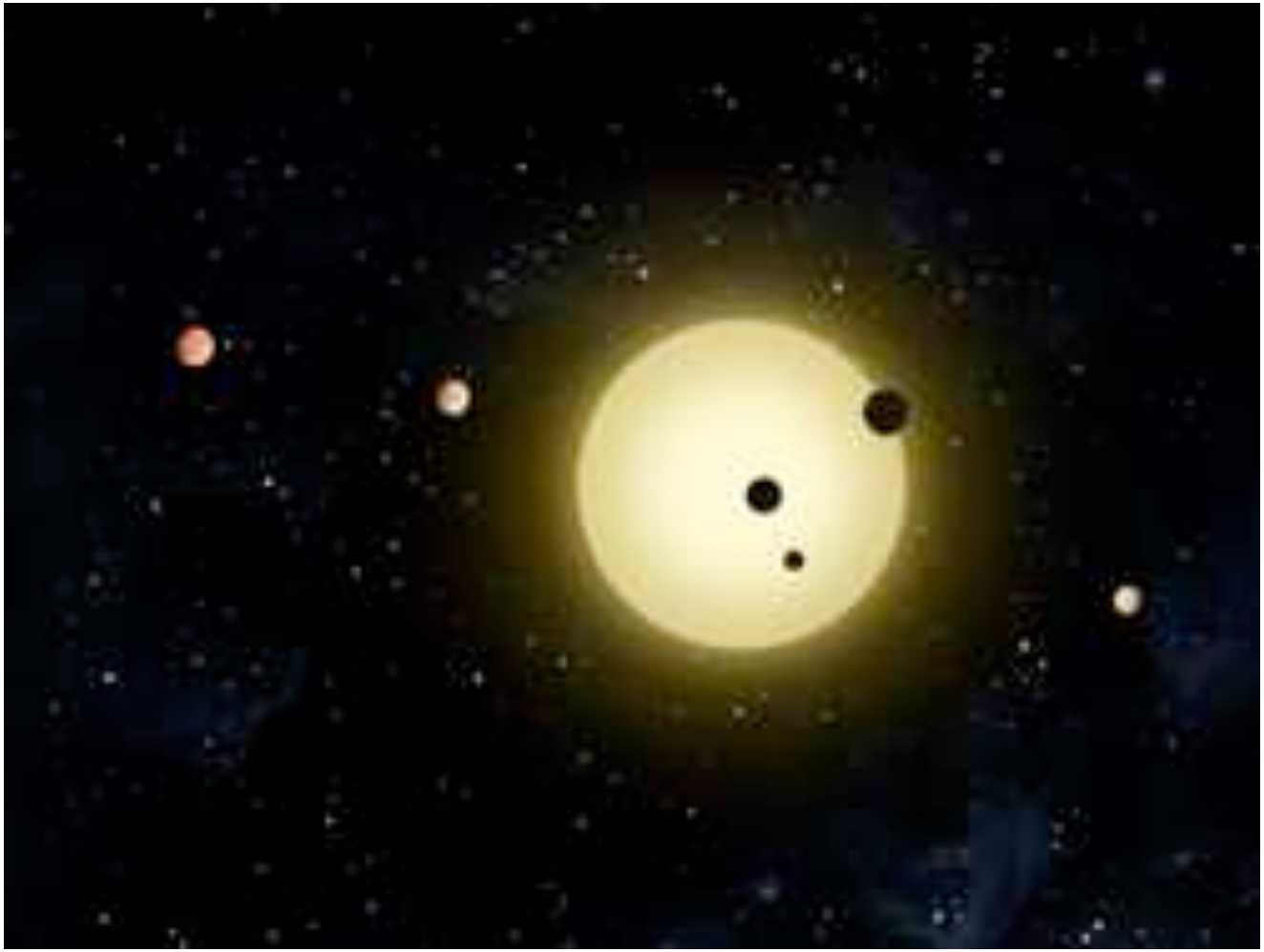
Diana Dragomir



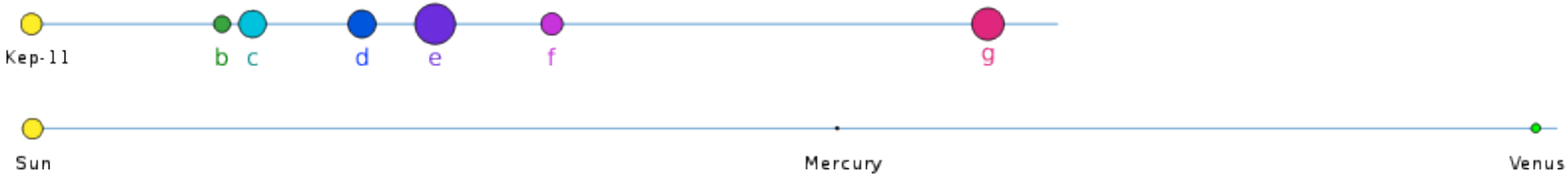
Orbits ar
(ell

Orbits are circular

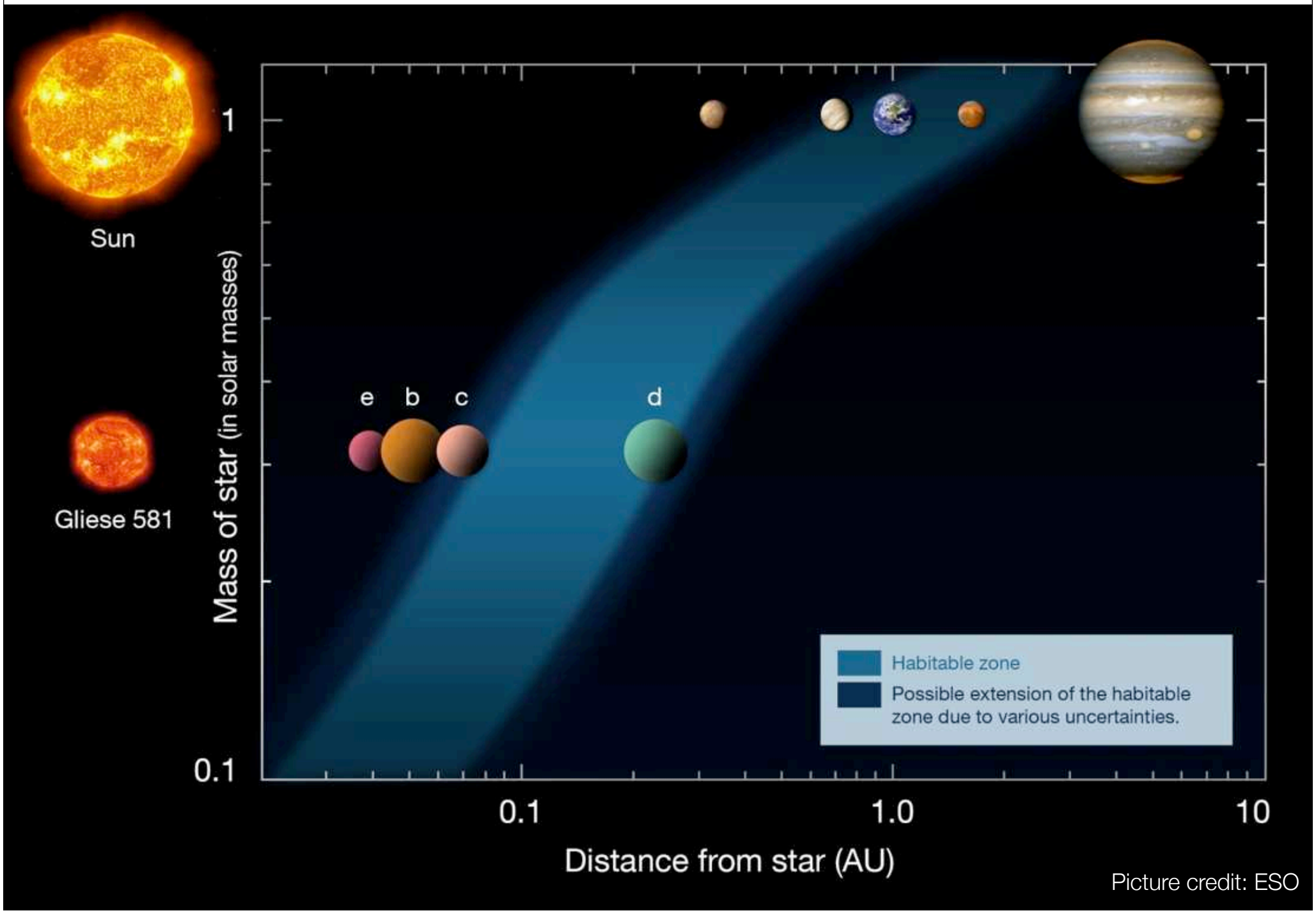
Planets tend to orbit in the same plane



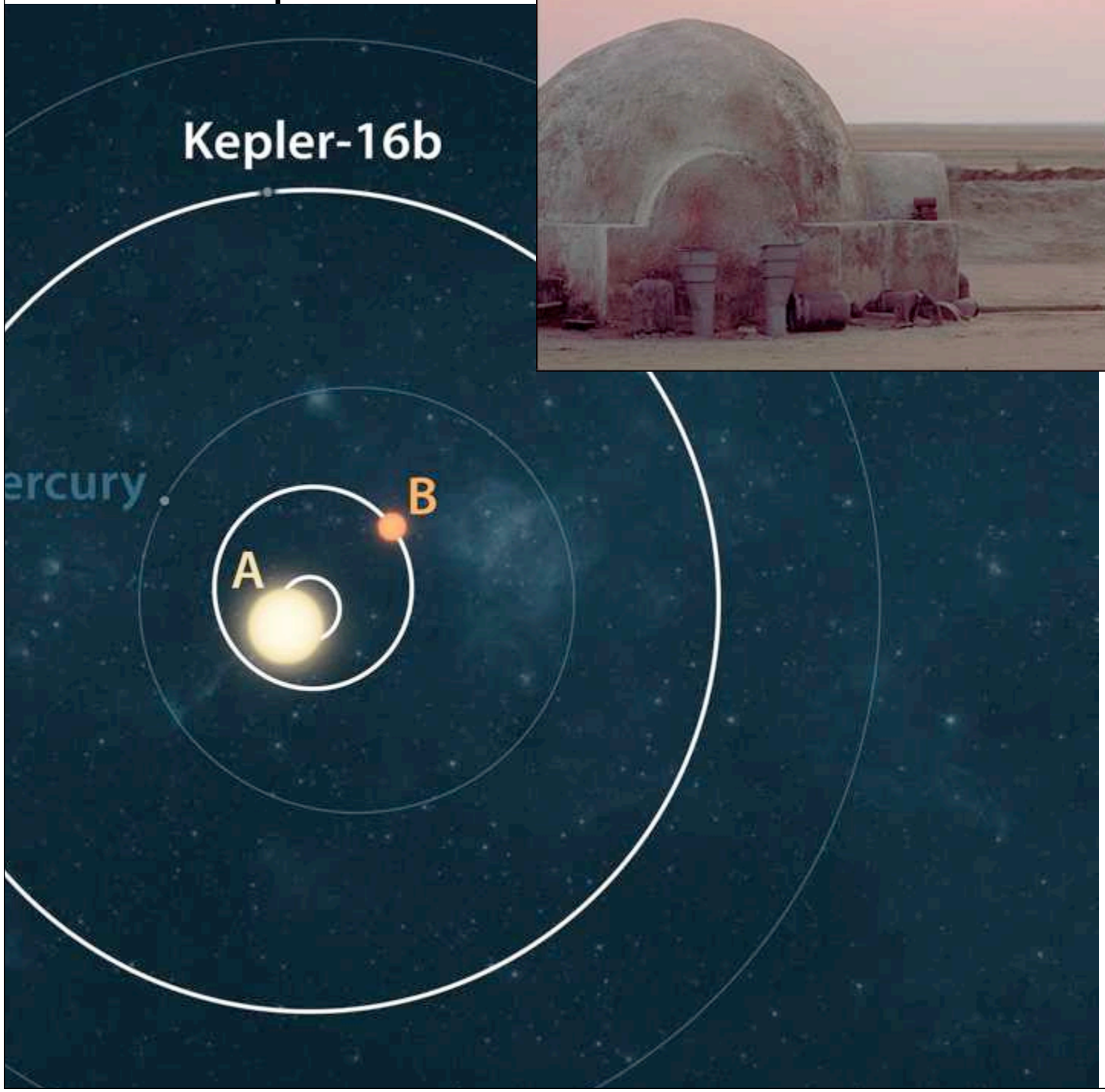
Kepler -11 system



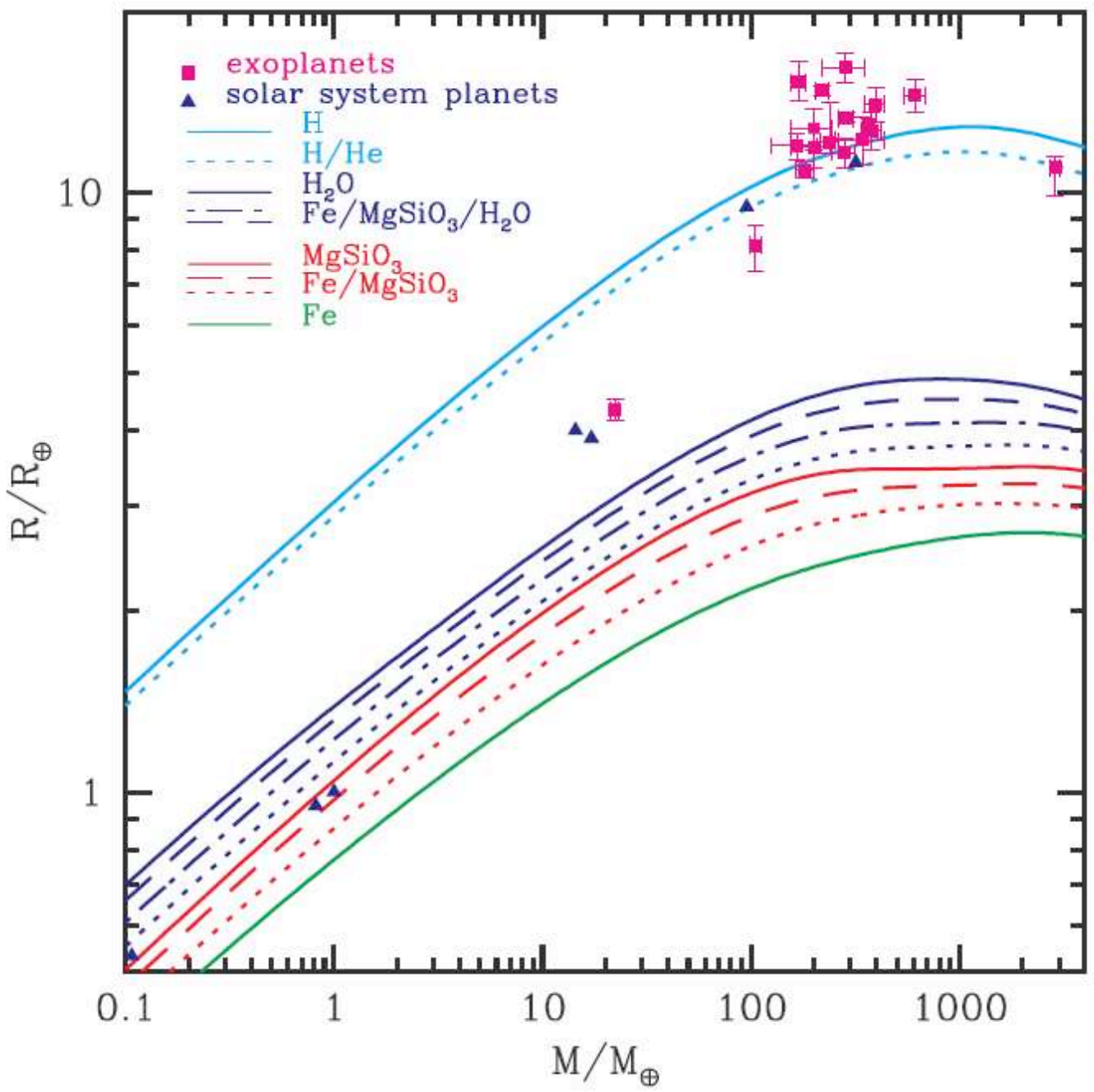
The Habitable Zone



Tatooine planets



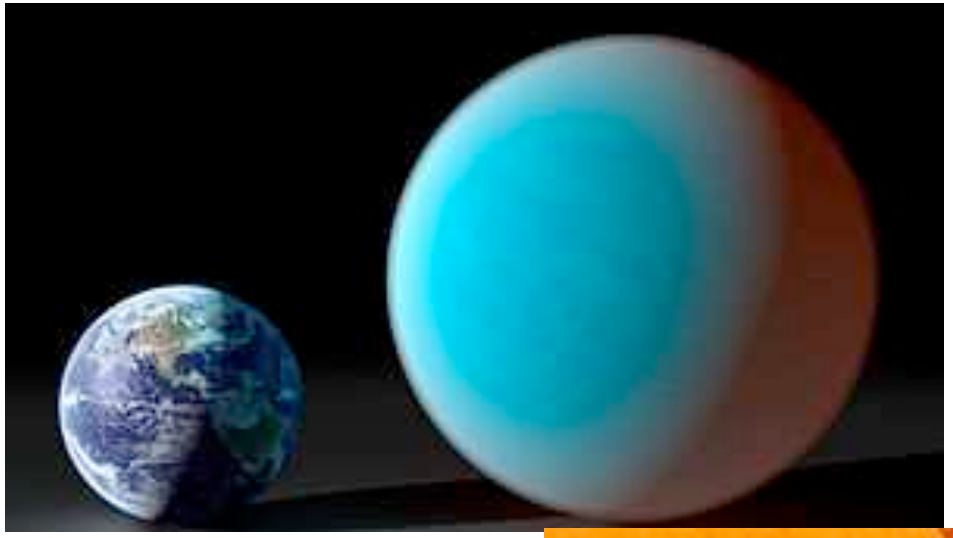
Planet radii tell us about internal structure

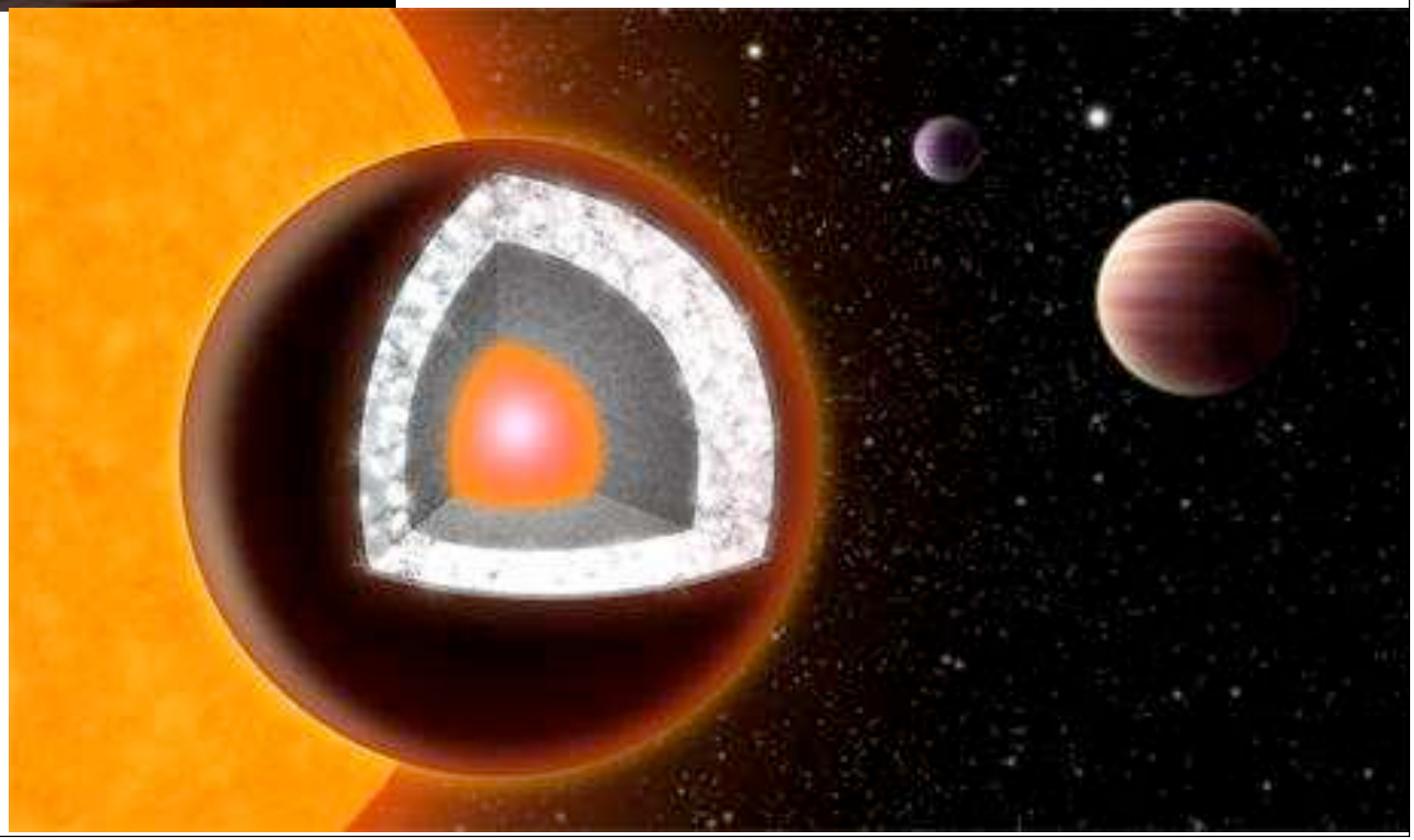


Seager et al. (2007)

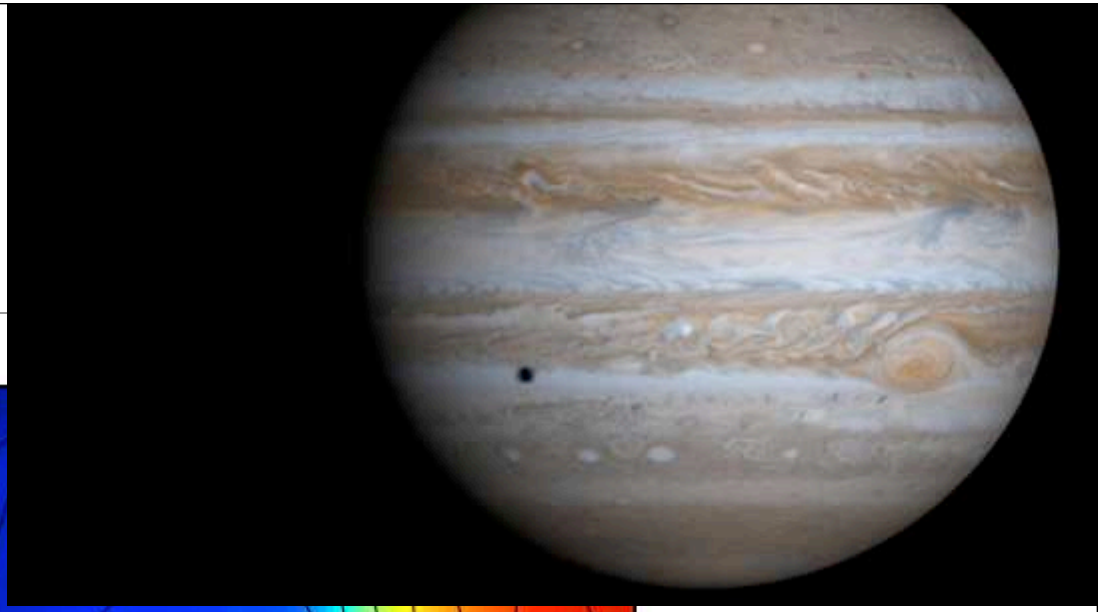
55 Cancri e: a "diamond planet"?

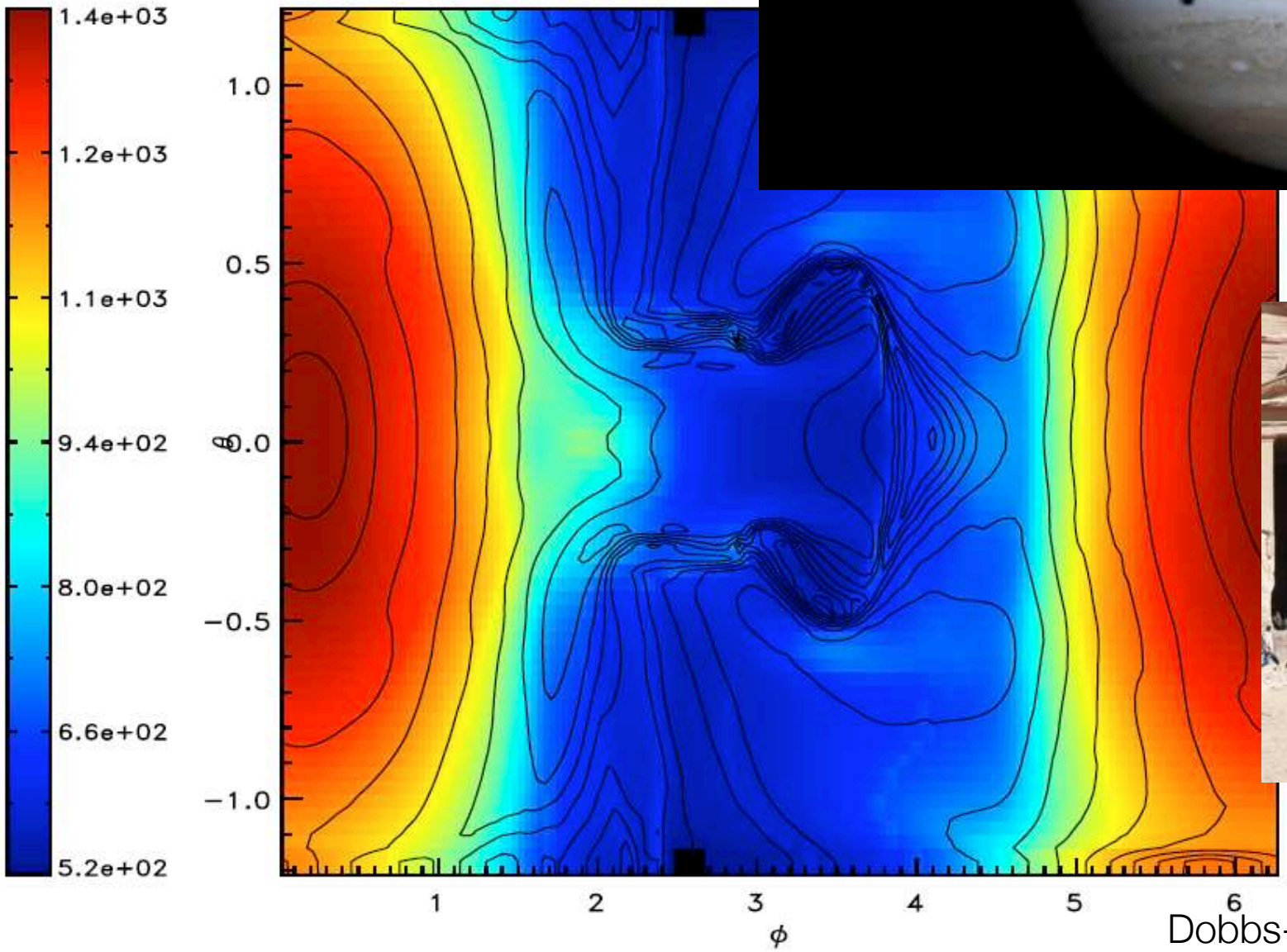
discovered by Dawson et al. (2010)





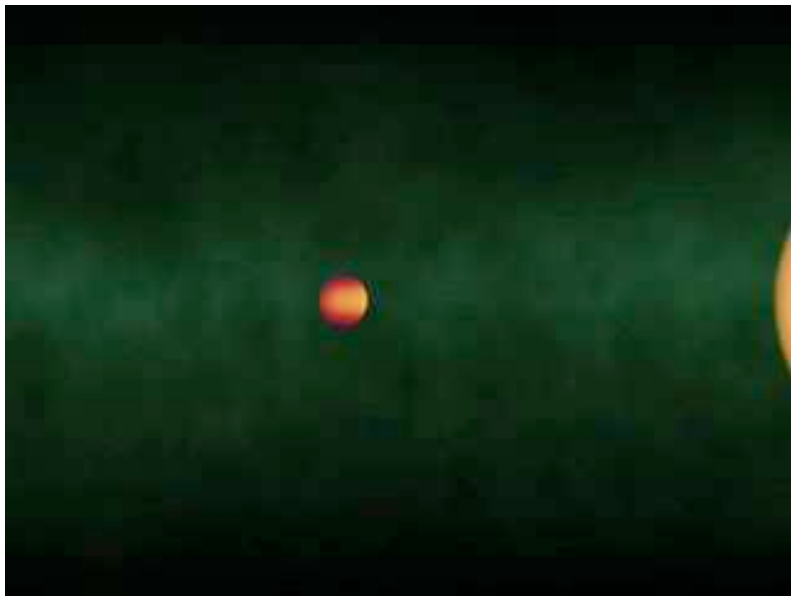
Winds on hot jupiters

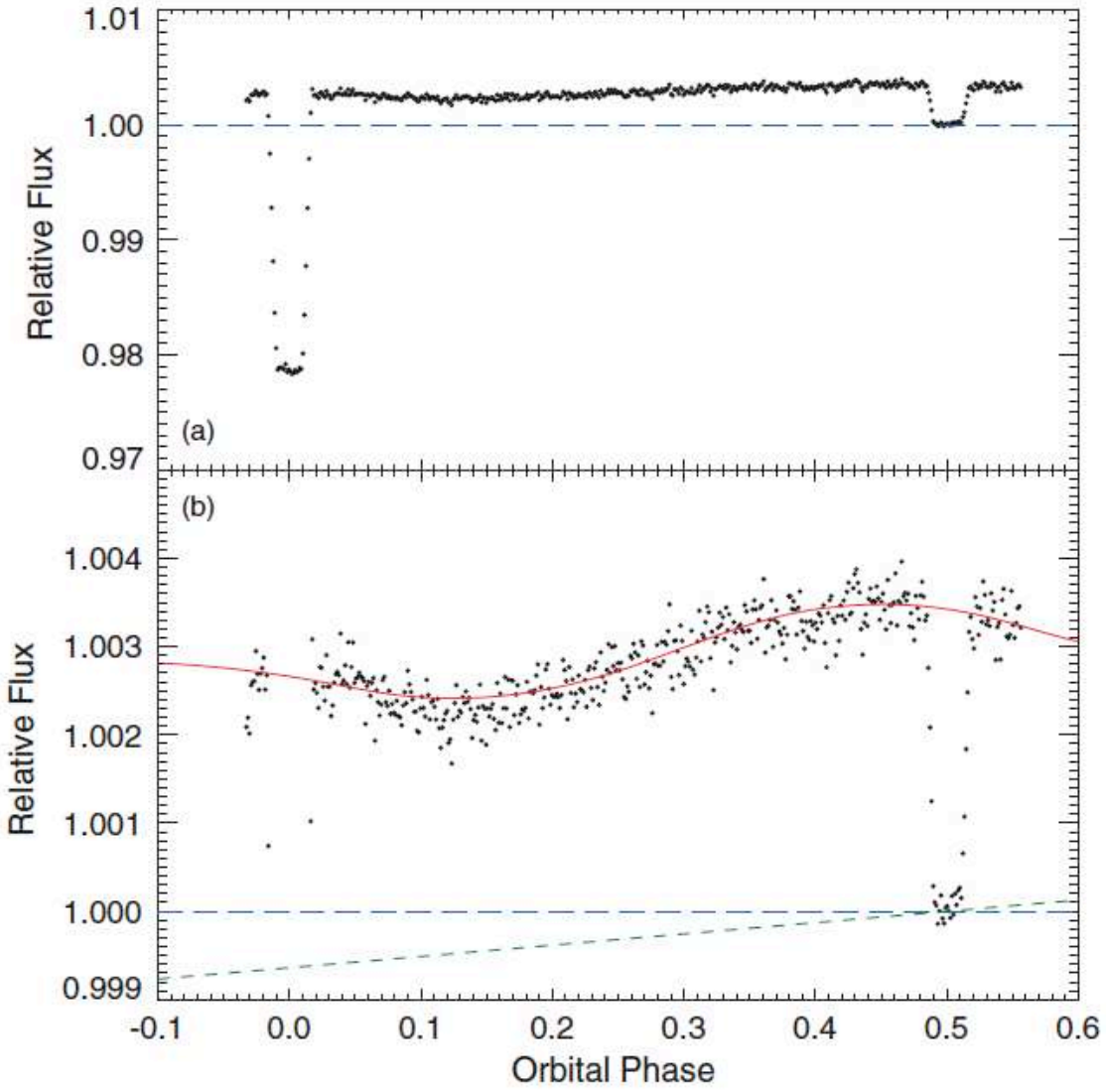




Dobbs-Dixon et al. (2010)

Secondary eclipse of hot jupiters

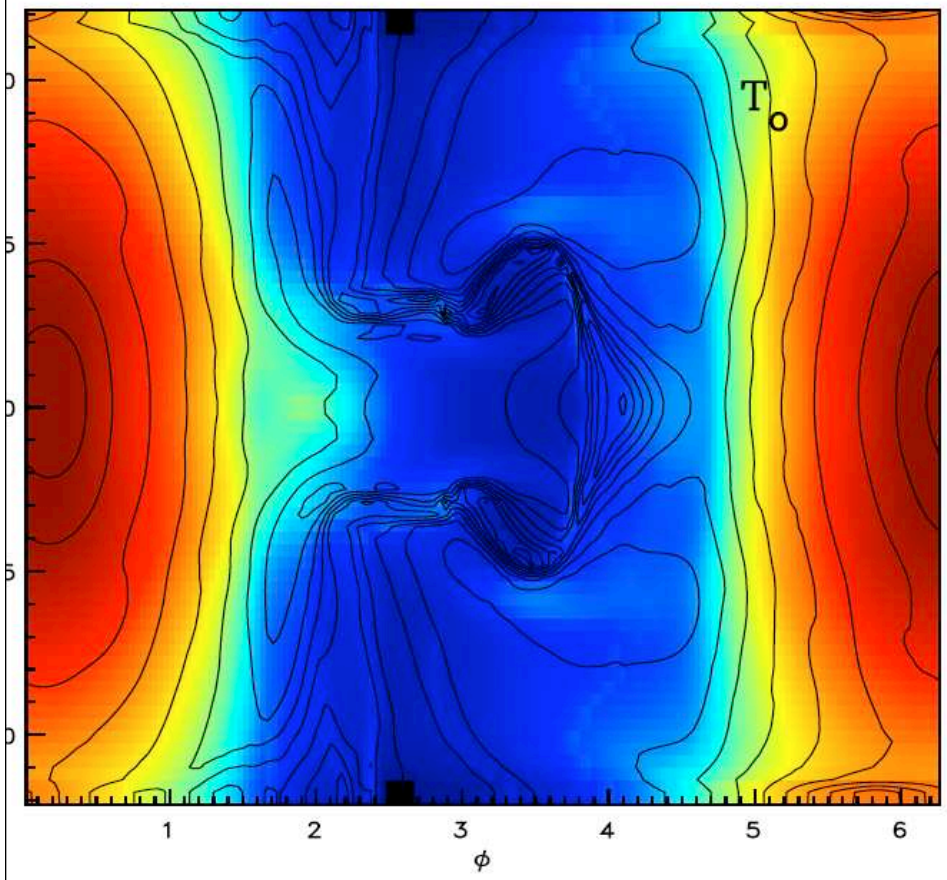




Results from the Spitzer space telescope by Knutson et al. (2009)

Ohmic heating in gas giants

w/ Chelsea Huang Princeton



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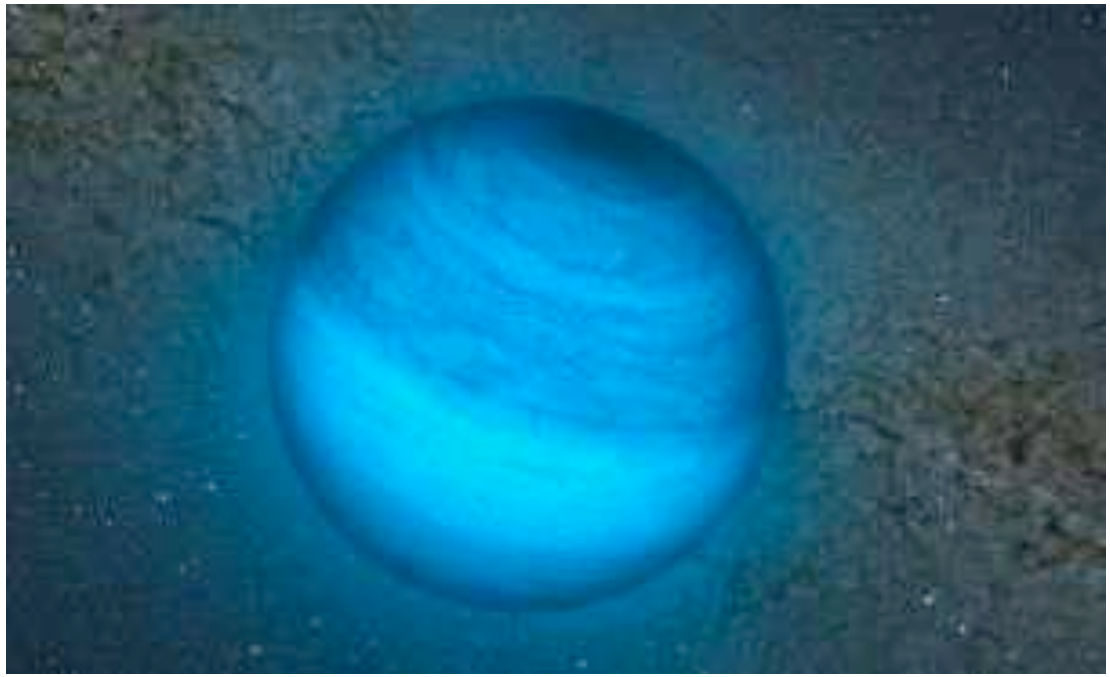
CFBDSIR2149: Another example of a directly-imaged object

Young “free-floating” planet (50-120 Myrs old)
4-7 times Jupiter’s mass
About 700K temperature

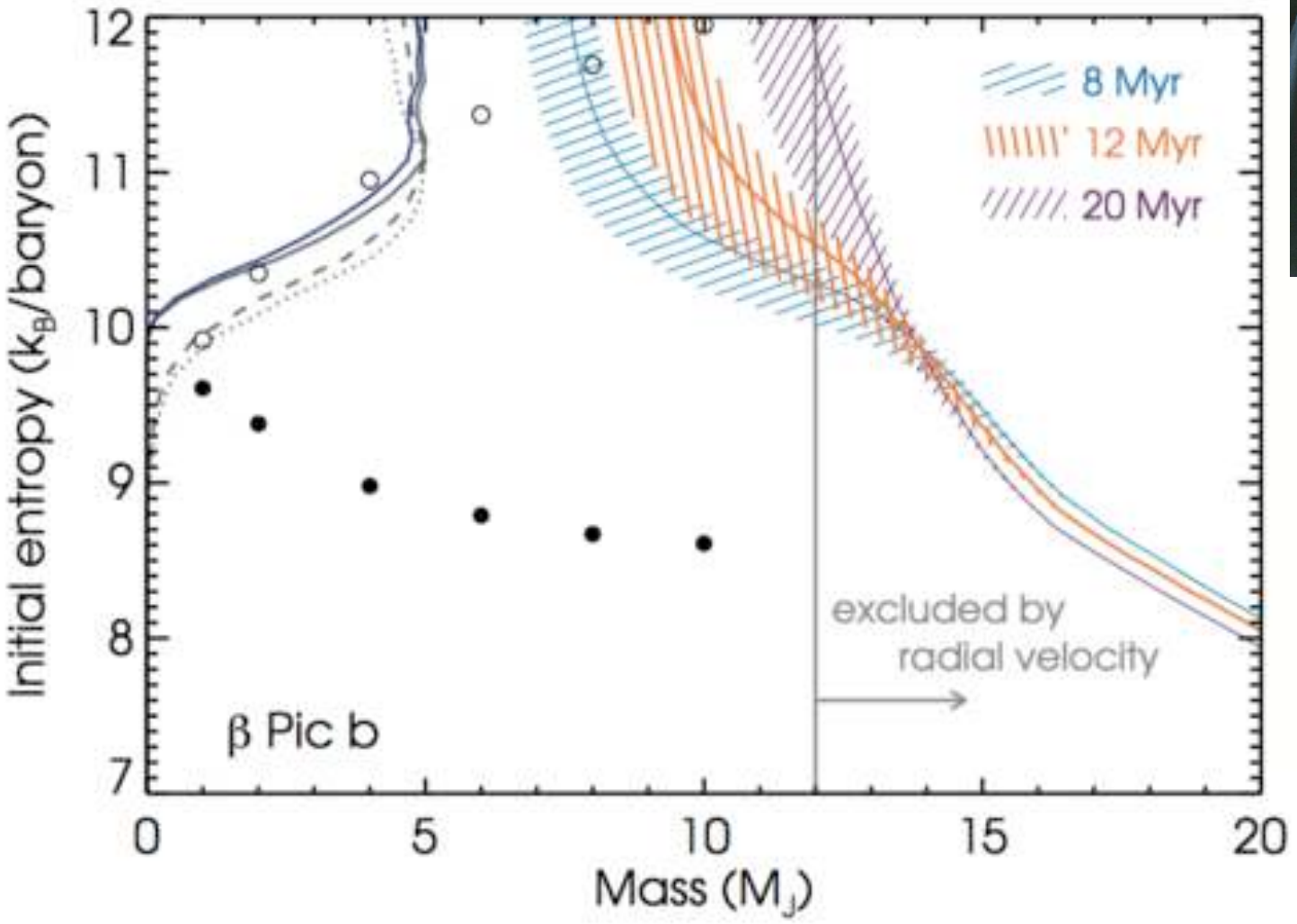
Astronomers find “homeless” planet wandering through Space

MERCREDI, 14 NOVEMBRE 2012 10:32 | NEWS

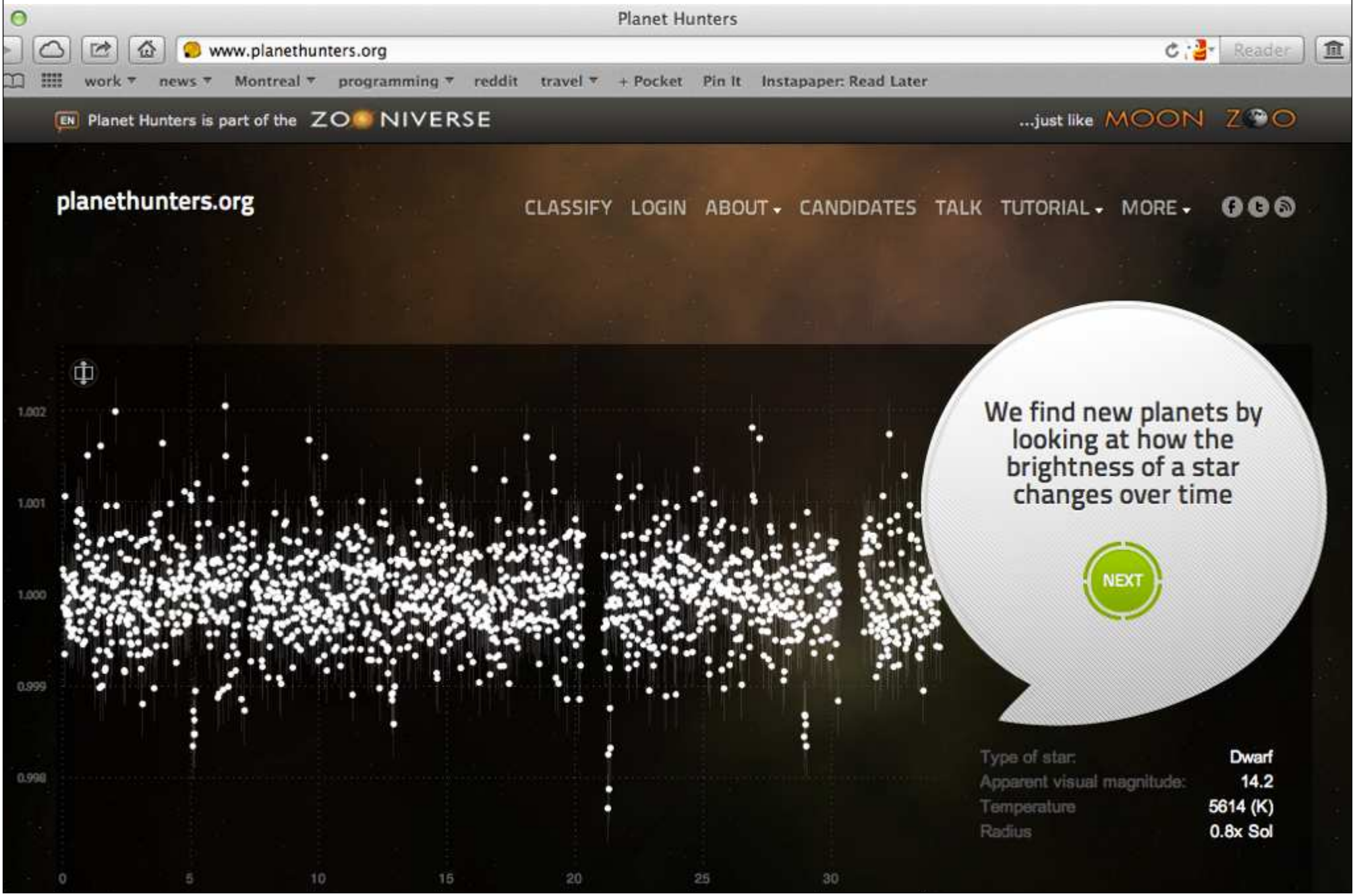


How do gas giant planets form?

Gabriel-Dominique Marleau



Citizen science: planethunters.org



http://www.astro.physics.mcgill.ca/astronight.php

It has been a fantastic seven years of Homer's physics...

- Next anniversary - a department field trip ?

($200,000 a ticket)