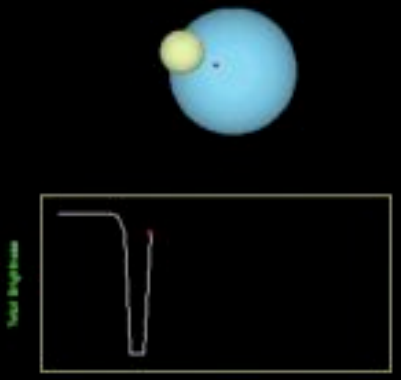
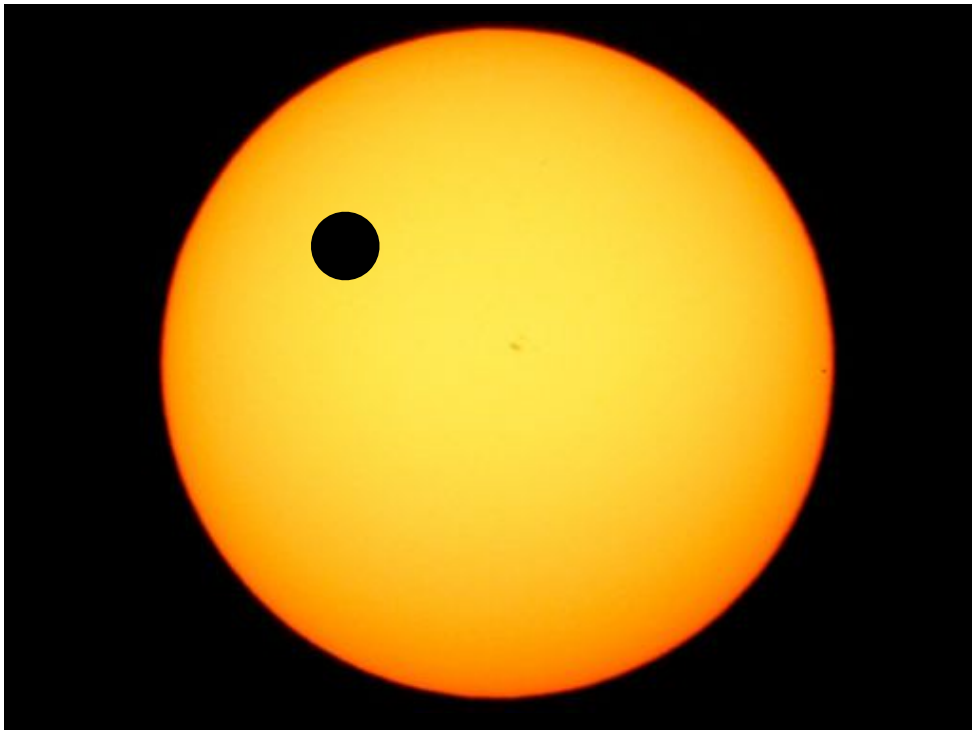
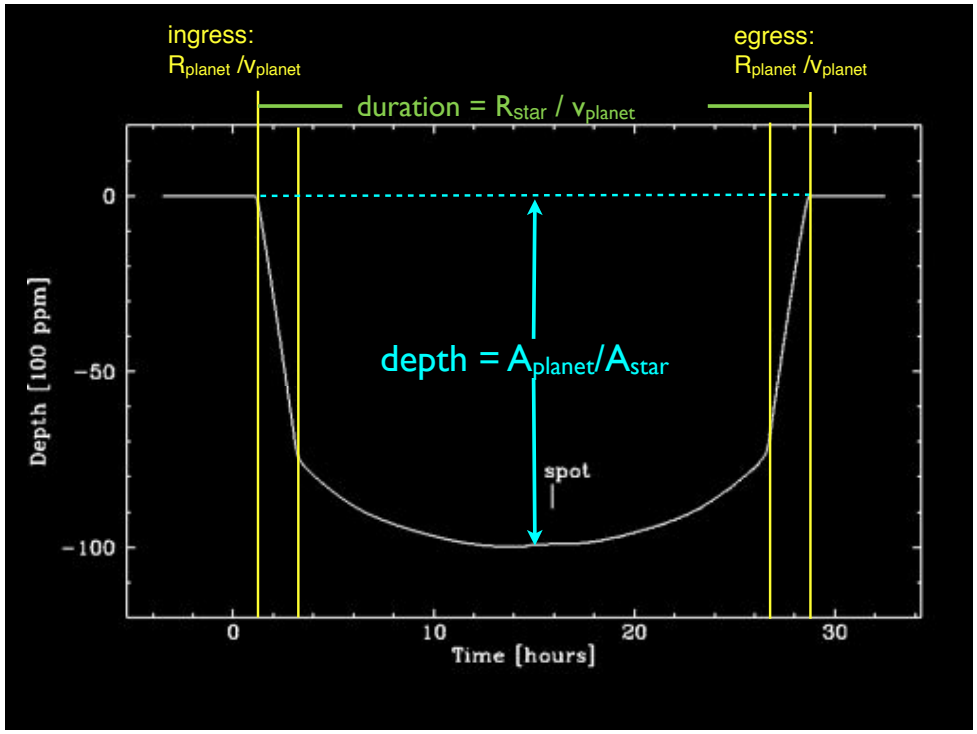
extrasolar planet detection via precision photometry

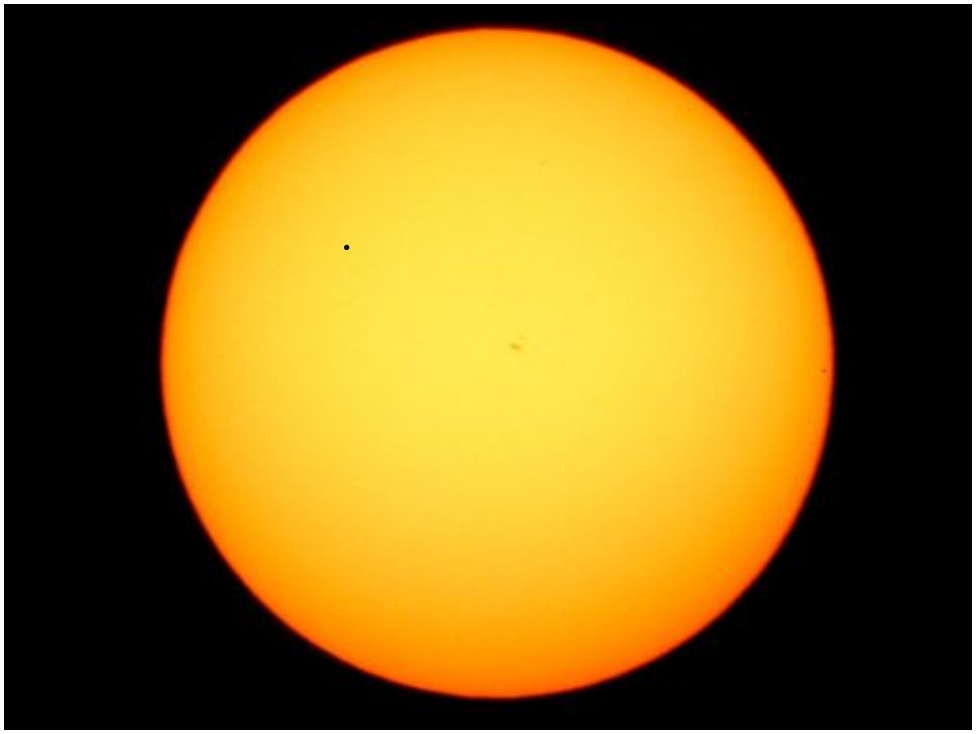


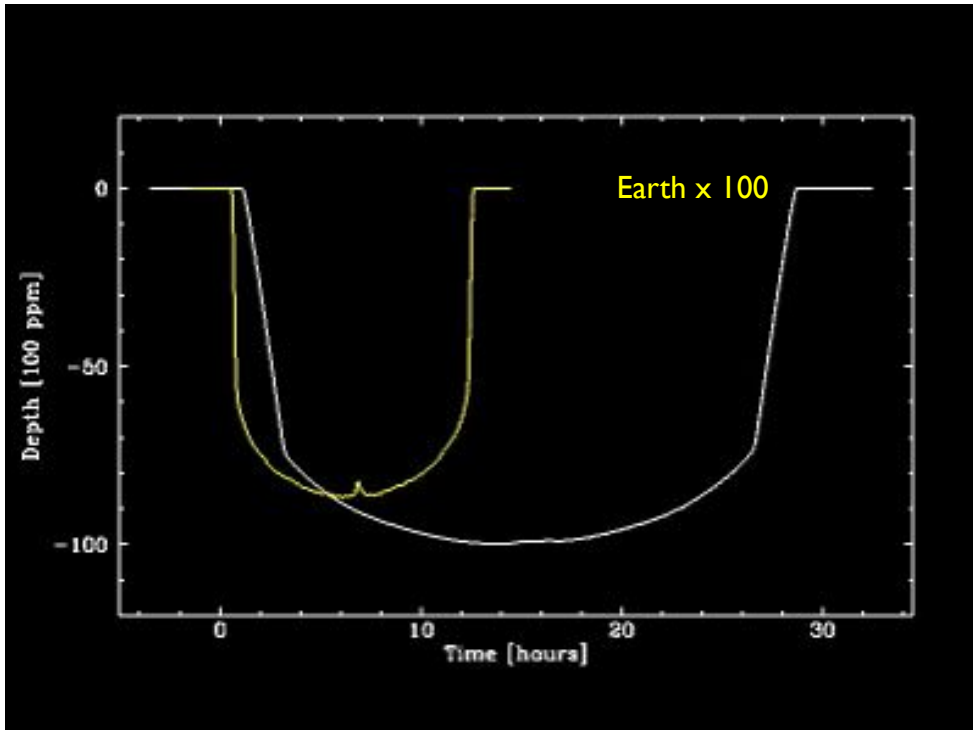
Credit: R. Pogge, OSU

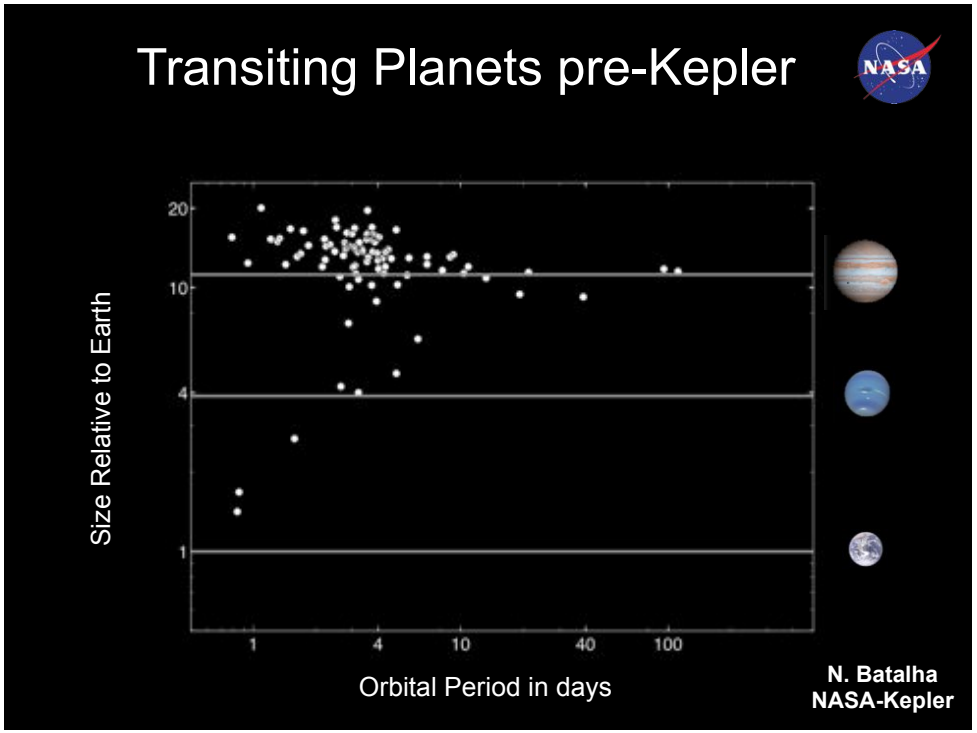
- as of today, number of systems/planets discovered by the transit technique:
  total: 613 planetary systems, 1130 planets
  from space: 416 planetary systems, 938 planets , 3845 candidates

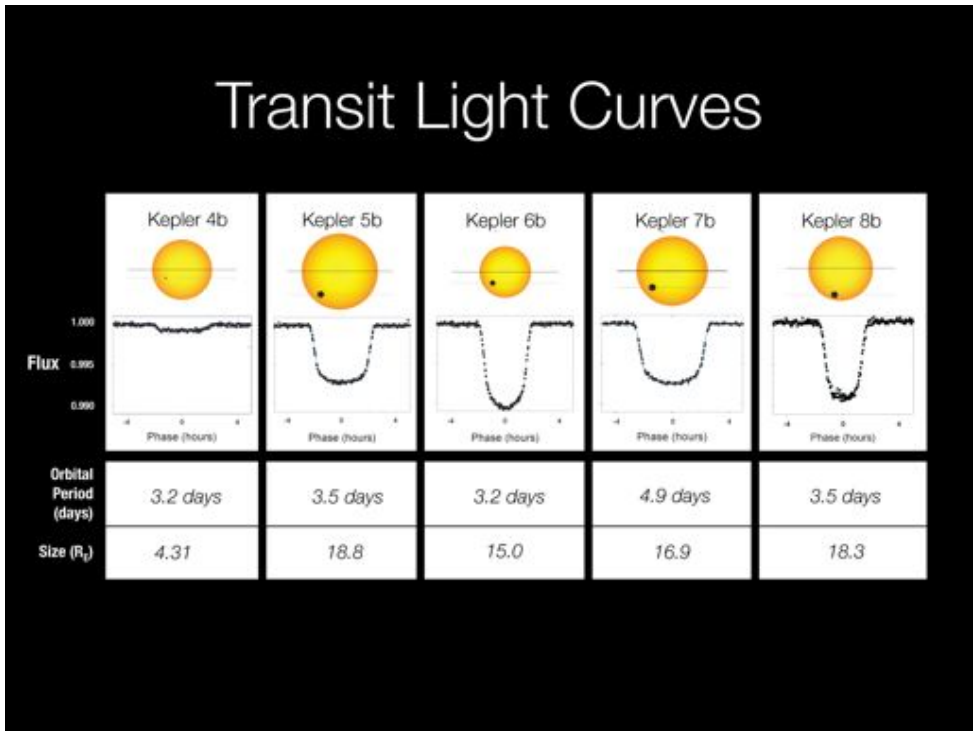


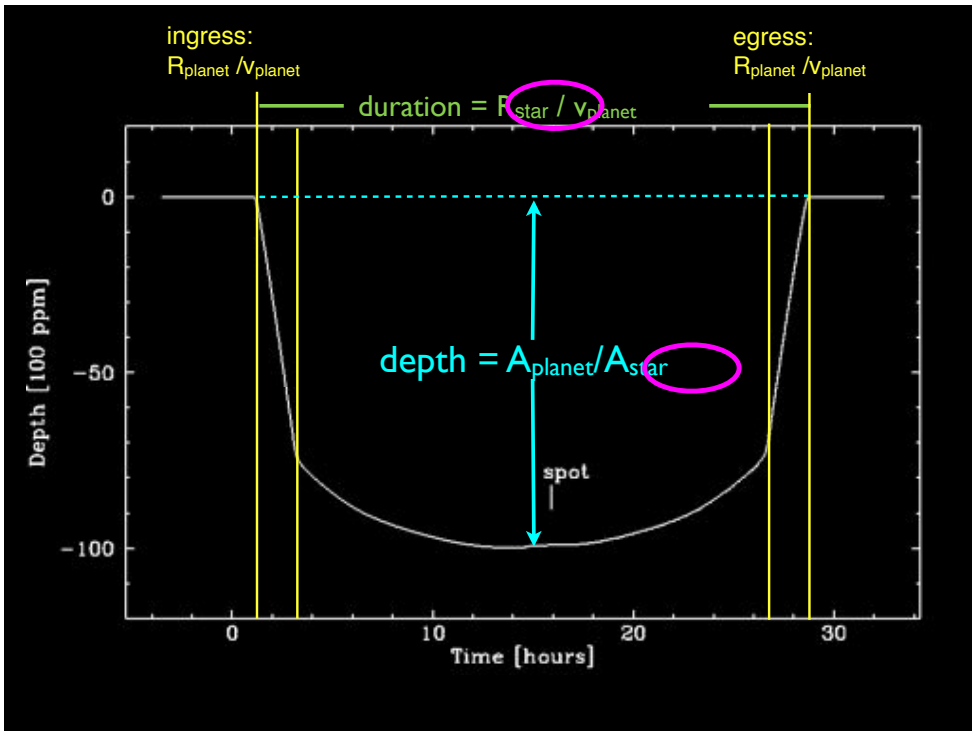


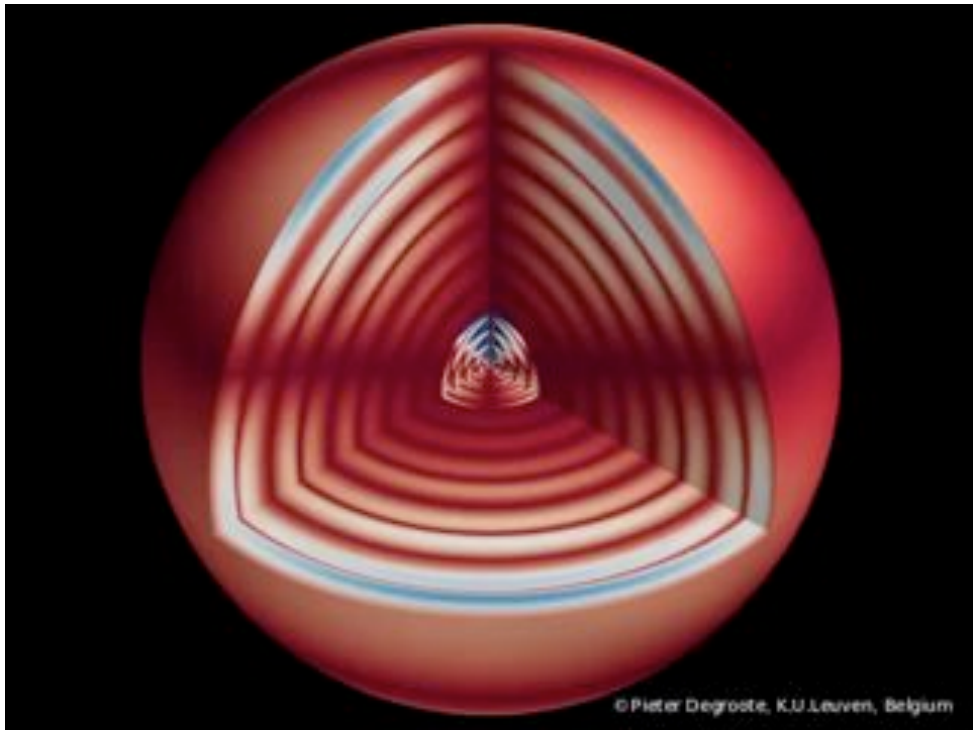



Earth x 100
Depth [100 ppm]
0
-50
-100
0
10
20
30
Time [hours]

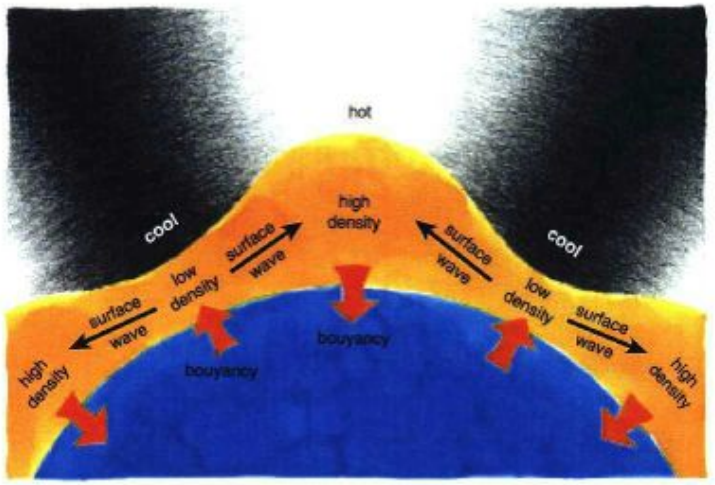

Transiting Planets pre-Kepler
NASA
Size Relative to Earth
20
10
4
1
1
4
10
40
100
Orbital Period in days
N. Batalha
NASA-Kepler

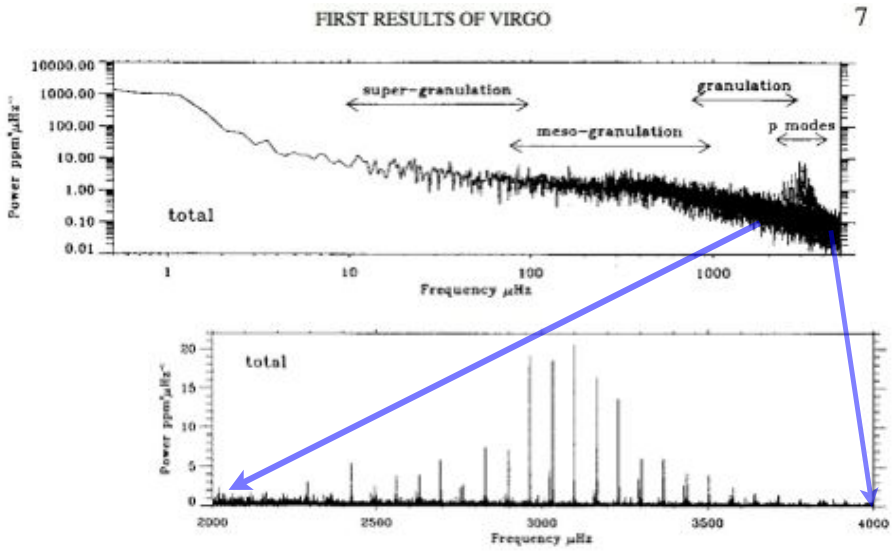

Transit Light Curves
Kepler 4b
Kepler 5b
Kepler 6b
Kepler 7b
Kepler 8b
Flux
1.000
0.995
0.990
Phase (hours)
Orbital Period (days)
3.2 days
3.5 days
3.2 days
4.9 days
3.5 days
Size (R⊕)
4.31
18.8
15.0
16.9
18.3


ingress:
Rplanet /vplanet
egress:
Rplanet /vplanet
duration = Rstar / vplanet
depth = Aplanet/Astar
spot
Depth [100 ppm]
0
-50
-100
0
10
20
30
Time [hours]

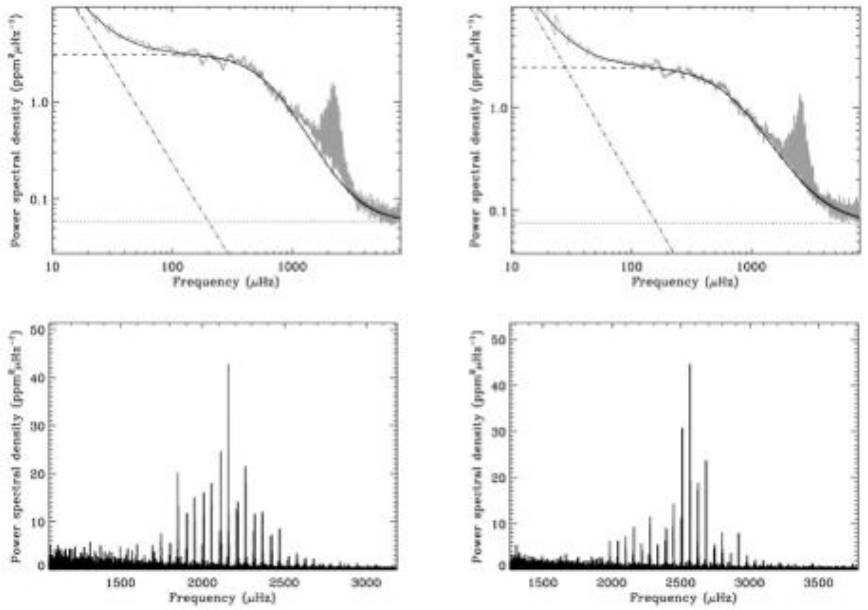


what's going on in the star?

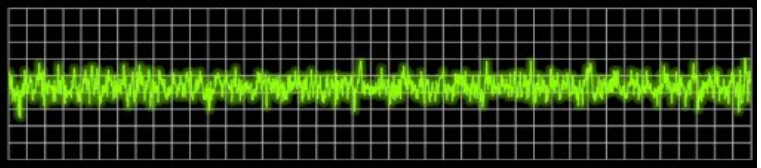




16 Cyg A and B (Metcalfe et al. 2012)

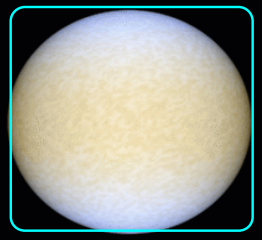


The Sizes of Stars - via Sound Waves



TIME →





KIC 11026764: 2.05 R_{sun}



Sun

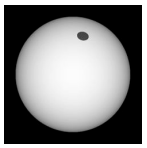


audio realizations by Jon Jenkins (NASA-Ames)

Travis Metcalfe, National Center for Atmospheric Research

Precision & duty cycle needs

(ppm) >>90%

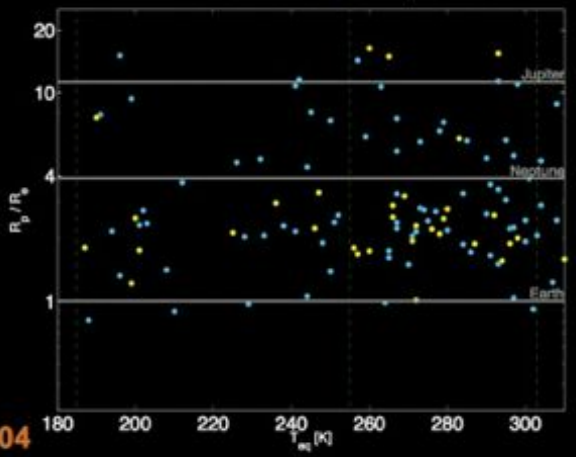




for extrasolar planetary transit surveys
are a nearly identical match
to those for asteroseismology

Kepler Candidates in Habitable Zone

As of November 4, 2013



Total = 104

Reaction wheel failure ends primary mission [40]

May 2013

The New York Times — Space & Cosmos

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We'll do our best to show you more relevant ads in the future.
Help us show you better ads by updating your ads settings.
Google

Breakdown Imperils NASA's Hunt for Other Earths



The Kepler telescope, seen in an artist rendition, has been shut down after the failure of one of the wheels that keep it pointed.

By DENNIS OVERBYE
Published: May 15, 2013

NASA's planet-hunting Kepler spacecraft has been shut down by the

FACEBOOK

The New York Times — Space & Cosmos

Ad muted. Undo
We'll do our best to show you more relevant ads in the future.
Help us show you better ads by updating your ads settings.
Google

Star of NASA Planet Hunting Falls Idle With Broken Parts

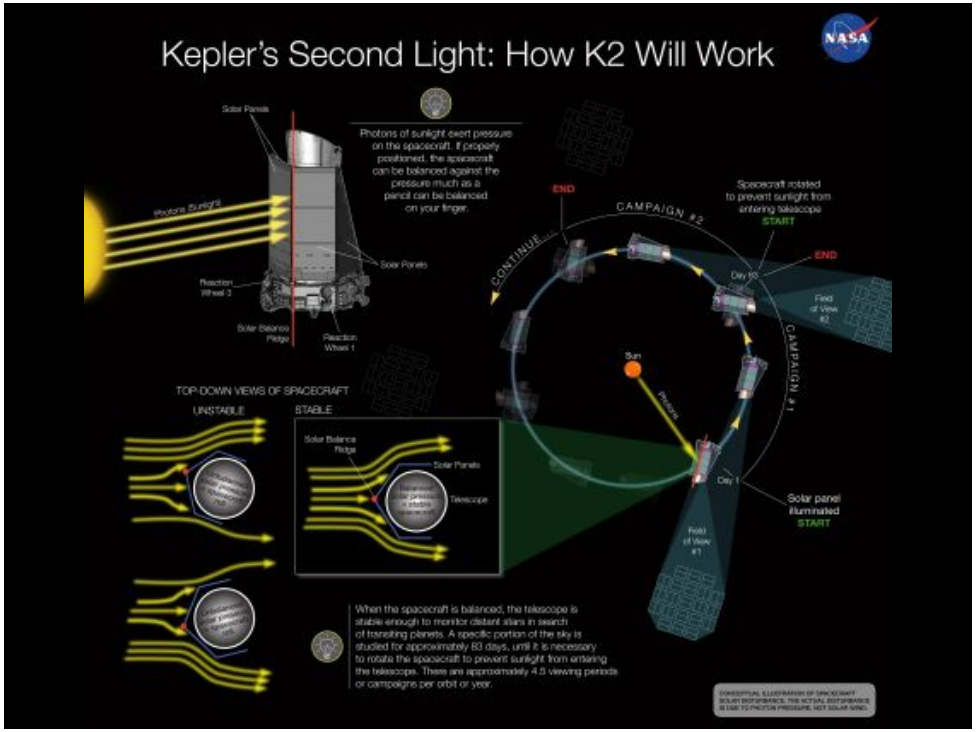


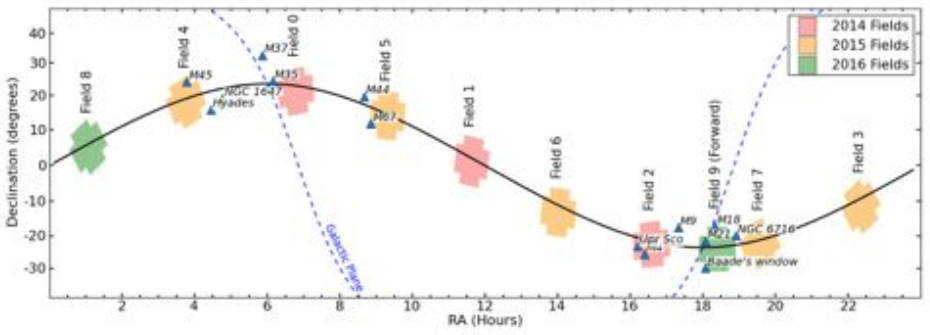
An artist's rendition of the Kepler telescope, which lost the second of four wheels that control its orientation in space.

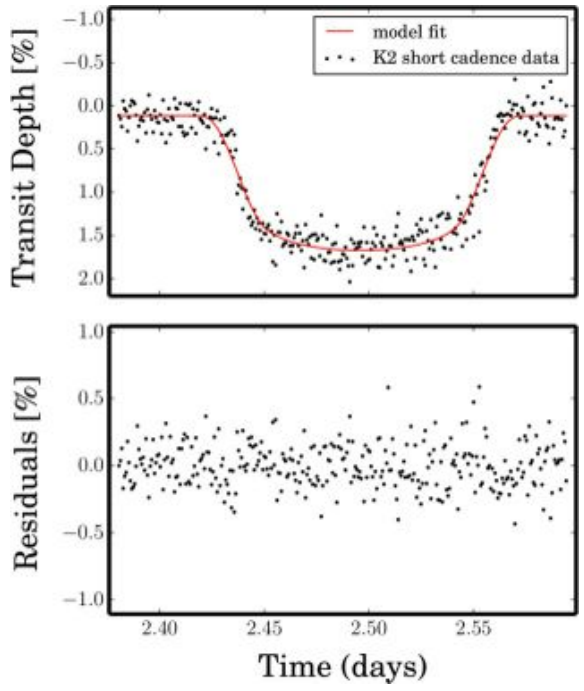
By DENNIS OVERBYE
Published: August 15, 2013 | 112 Comments

NASA said Thursday that its celebrated planet-hunting Kepler spacecraft,

FACEBOOK


Kepler's Second Light: How K2 Will Work
NASA
Solar Panels
Photons of sunlight exert pressure on the spacecraft. If properly positioned, the spacecraft can be balanced against the pressure much as a pencil can be balanced on your finger.
Photons (sunlight)
Solar Panels
Reaction Wheel 2
Solar Balance Ridge
Reaction Wheel 1
END
CAMPAIGN #2
CONTINUE...
Spacecraft rotated to prevent sunlight from entering telescope
START
END
Day 83
Field of View #2
CAMPAIGN #1
Sun
Photons
Day 1
Solar panel illuminated
START
Field of View #1
TOP-DOWN VIEWS OF SPACECRAFT
UNSTABLE
STABLE
Solar Balance Ridge
Solar Panels
Telescope
When the spacecraft is balanced, the telescope is stable enough to monitor distant stars in search of transiting planets. A specific portion of the sky is studied for approximately 80 days, until it is necessary to rotate the spacecraft to prevent sunlight from entering the telescope. There are approximately 4.5 viewing periods or campaigns per orbit or year.

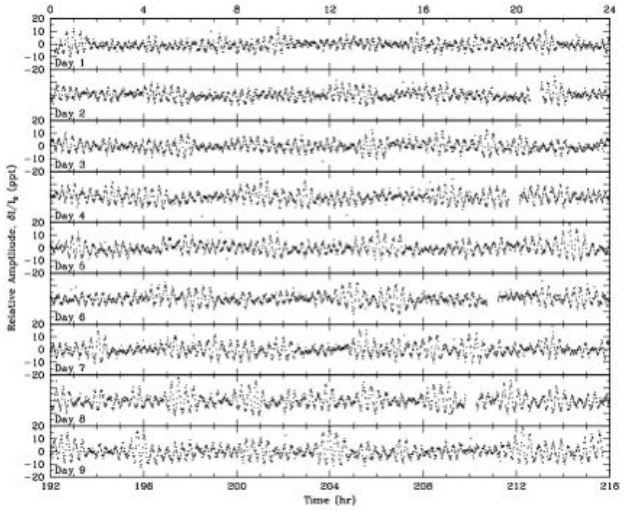

2014 Fields
2015 Fields
2016 Fields
Declination (degrees)
RA (Hours)
Field 8
Field 4
Field 0
Field 5
Field 1
Field 6
Field 2
Field 9 (Forward)
Field 7
Field 3
M45
M37
M35
M44
M67
NGC 1647
Hyades
M9
M18
M21
NGC 6716
Oph Sco
Baade's window
Galactic Plane


model fit
K2 short cadence data
Transit Depth [%]
Residuals [%]
Time (days)


I'm not dead yet!

GD1212 - a pulsating white dwarf:

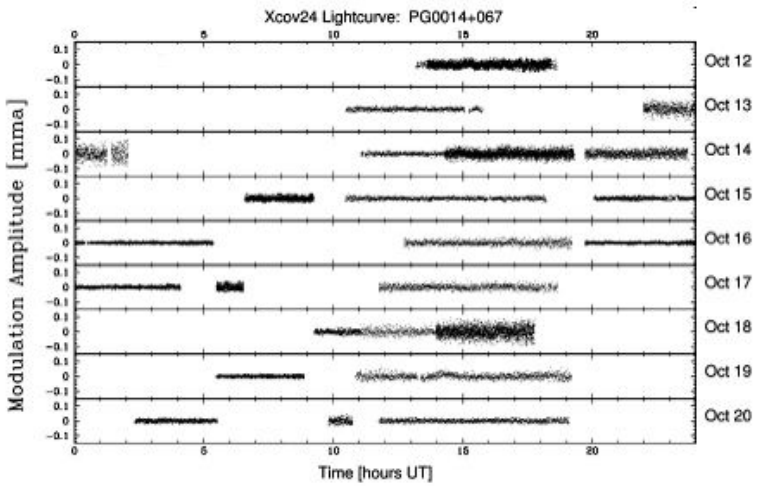
9 days with K2



(Hermes et al., submitted)

PG0014 - a pulsating sdB star:

9 days with the Whole Earth Telescope



(Vucovic et al., 2006)

n_p = habitable planets: the 'Habitable Zone'

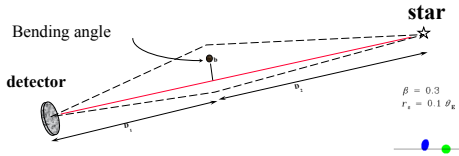
- water essential to life (as we know it)
- liquid water has to exist on (or in) the planet
- must be right distance from star
  - heat from star ~ maintain $0^oC < T < 100^oC$
  - too close - runaway greenhouse (Venus)
  - too far - CO_2 ice - no greenhouse (Mars)



n_p ~ 0.5 to 2

BUT - life exists in extreme environments on Earth
- liquid water a constraint for "normal" life only!

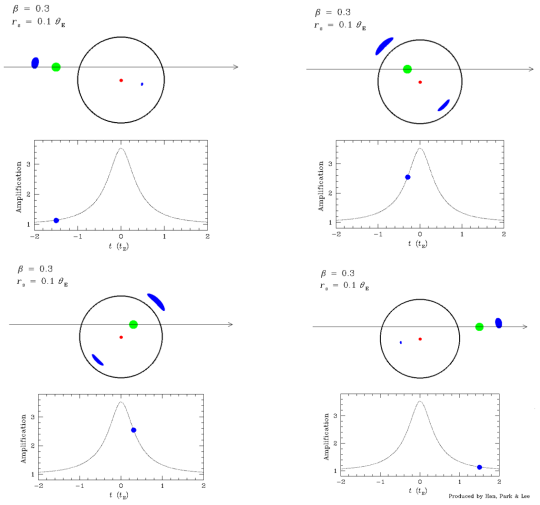
another technique - microlensing



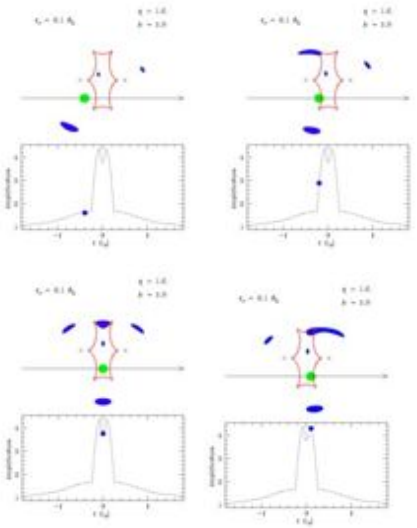
For Galactic Microlensing, the image separation is < 1 mas, so images are not resolved. The observable parameter is the time varying magnification: *A*

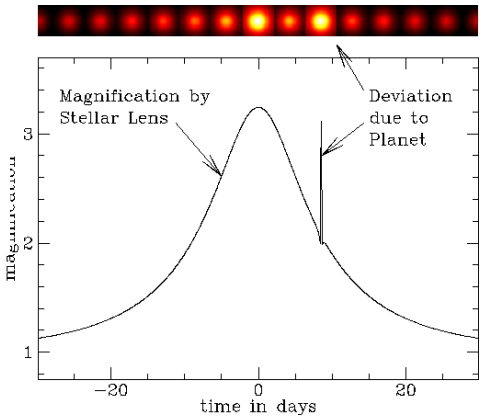
$$A(u=1) = 1.34$$
$$\Delta t \approx 3 \text{ days} \sqrt{\frac{M}{M_{jupiter}}}$$

$$R_E = \sqrt{\frac{4GM}{c^2}\frac{D_1 D_2}{(D_1 + D_2)}}$$



another technique - microlensing





A planetary microlensing event light curve resembles a single lens light curve most of the time. But, if one of the lensed images approaches the location of a planet, then the light curve can have the strong caustic crossing features of a binary lens event.

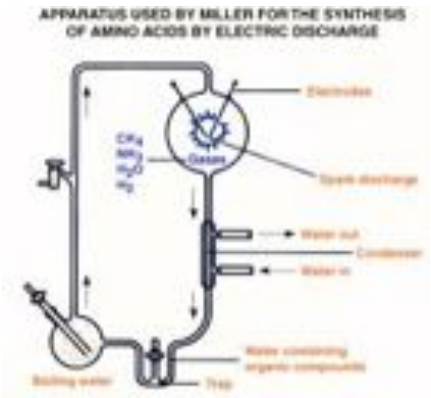
Biological Factors

Given the proper ingredients

- energy (starlight, lightning, geothermal...)
- raw materials (carbon, hydrogen, nitrogen, oxygen)
- time (1 billion years or so)

Will Life Develop?

the Miller-Urey experiment (1953)





The Oldest Fossils

- Cyanobacteria date back to 3.5 Billion years ago
- they remain one of the most common forms of bacteria today
- responsible for generation of oxygen in early atmosphere

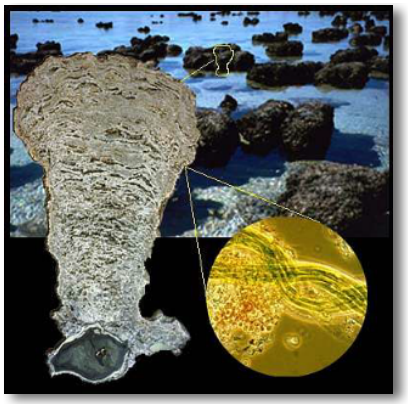

Palaeolyngbya (fossil)


Oscillatoria (modern)

$f_L \sim 0.1$ to 1 ?

Life's Early Start on Earth

- earliest fossils in excess of 3.5 billion years old
- stromatolites - 1st 'macroscopic' form (bacteria colonies)




a view of life on Earth ca. 2,000,000,000 B.C.E

starting 500,000,000 years ago

increasing complexity and explosion of diversity

leading to...



$f_i \sim 0.5$? 1 ?