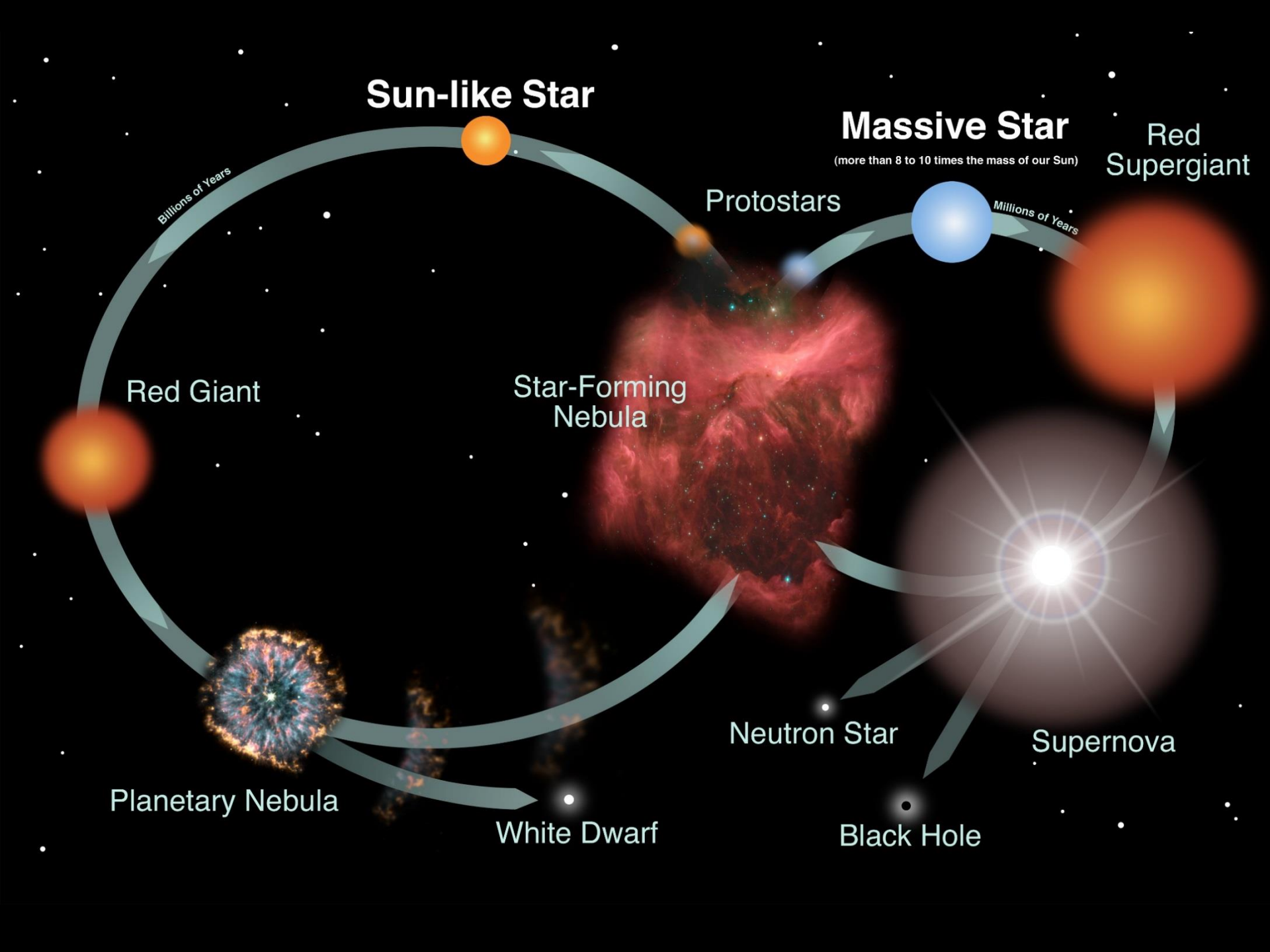
ASTR/GEOL-2040: Search for life in the Universe: Lecture 35

- Revisit star life
- Kepler
- Tidally locked, binaries

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590
and Wednesdays 11-12 in D230)


Sun-like Star
Massive Star
(more than 8 to 10 times the mass of our Sun)
Red Supergiant
Protostars
Billions of Years
Millions of Years
Red Giant
Star-Forming Nebula
Neutron Star
Supernova
Planetary Nebula
White Dwarf
Black Hole

Older stars: iron fraction?

A. More than younger stars

B. The same

C. Less

Analogy: who has more high tech?

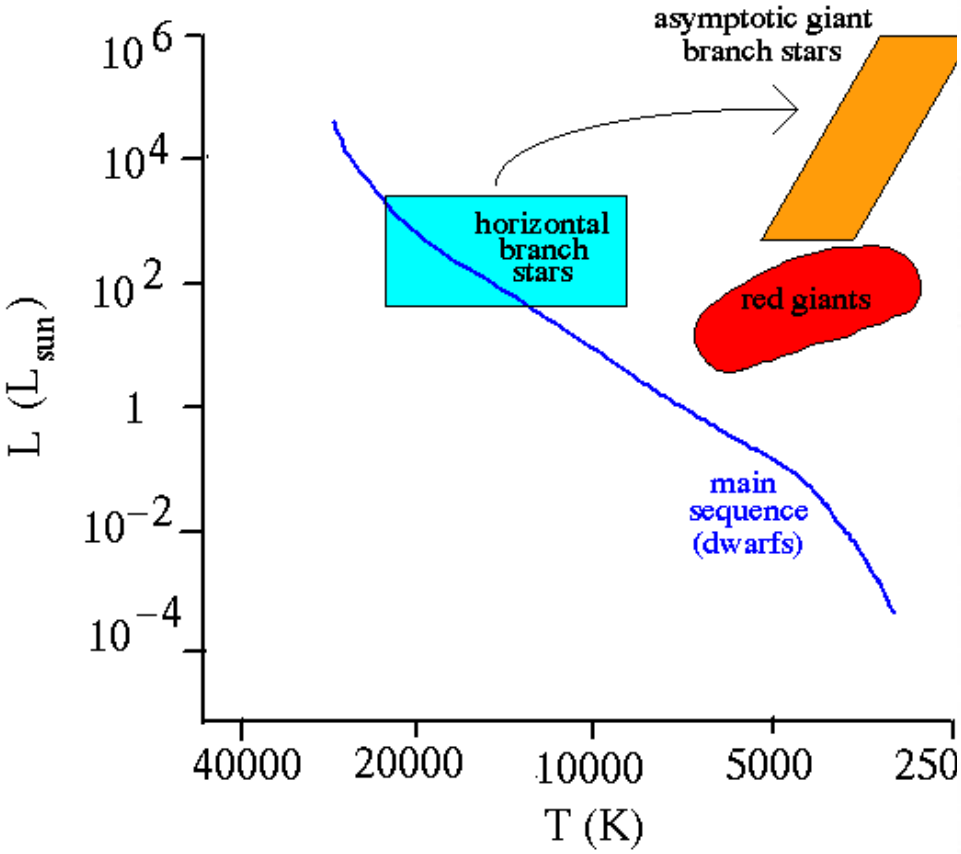
A. You

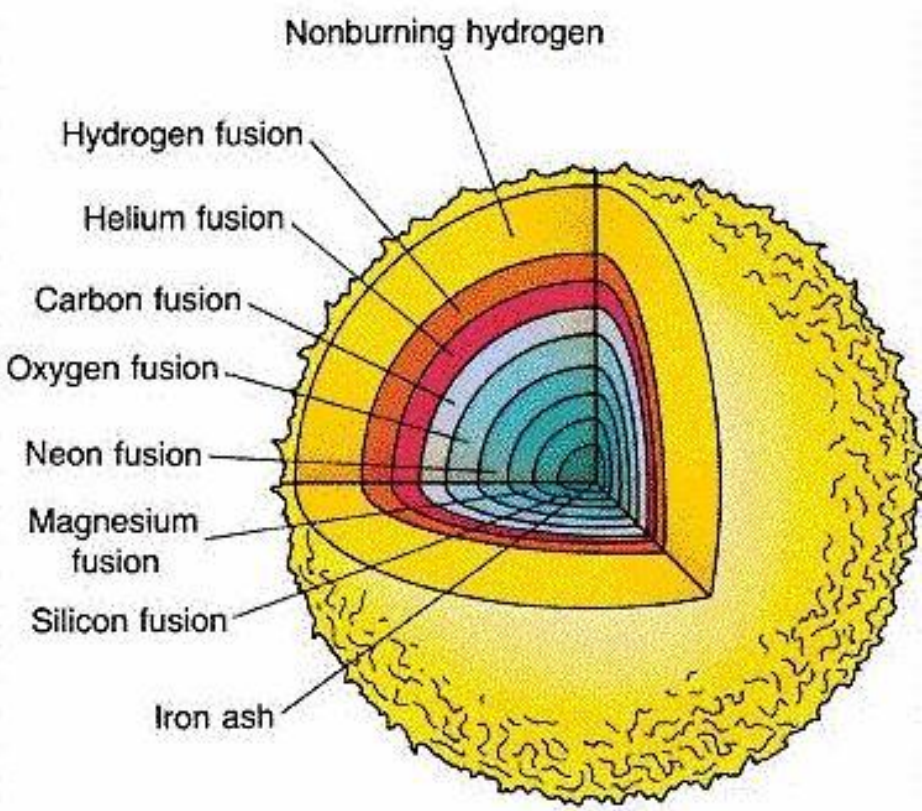
B. Your father/mother

C. Your grandfather/grandmother

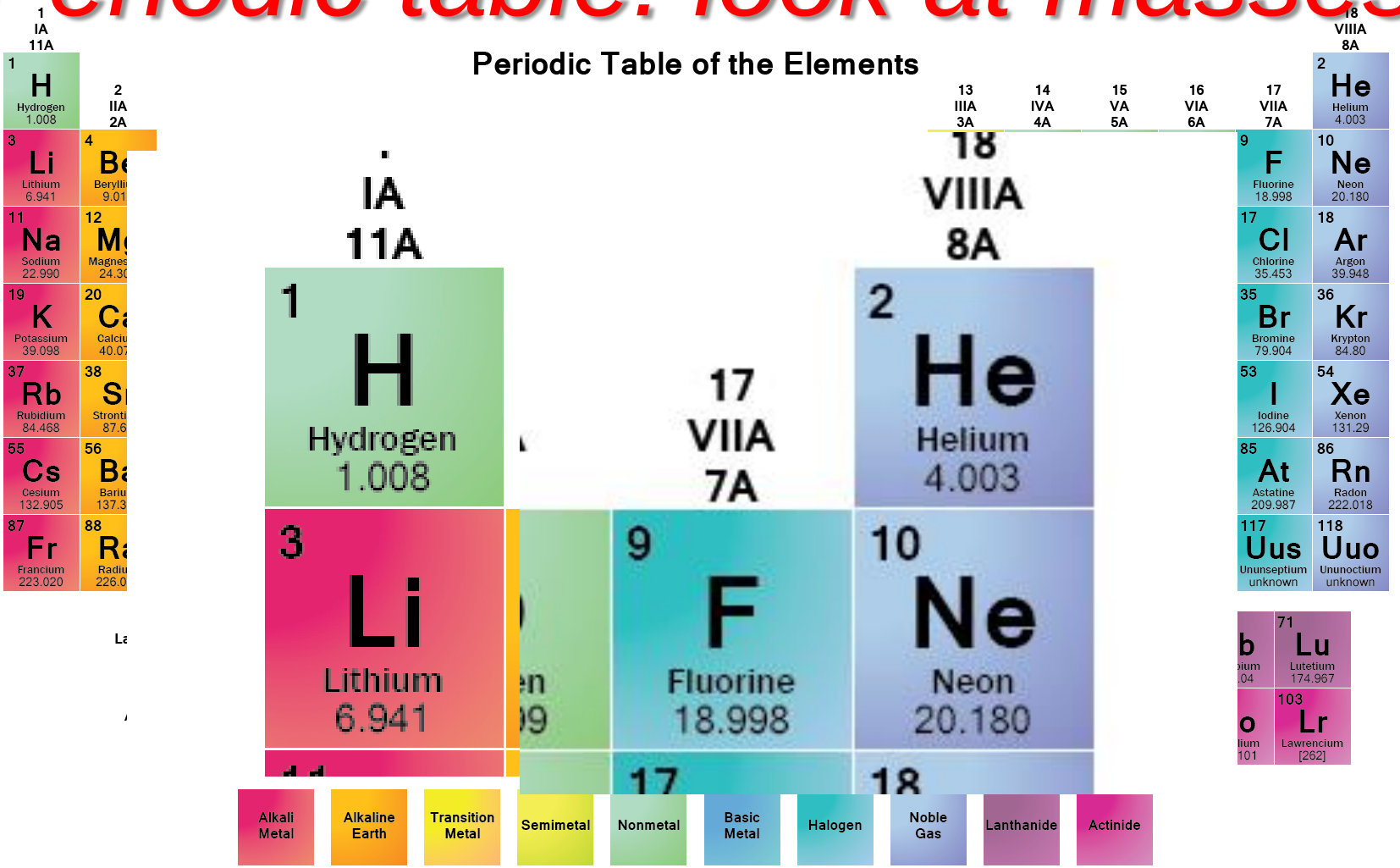
Organic matter in the Universe

- Carbon comes from nuclear fusion in stars



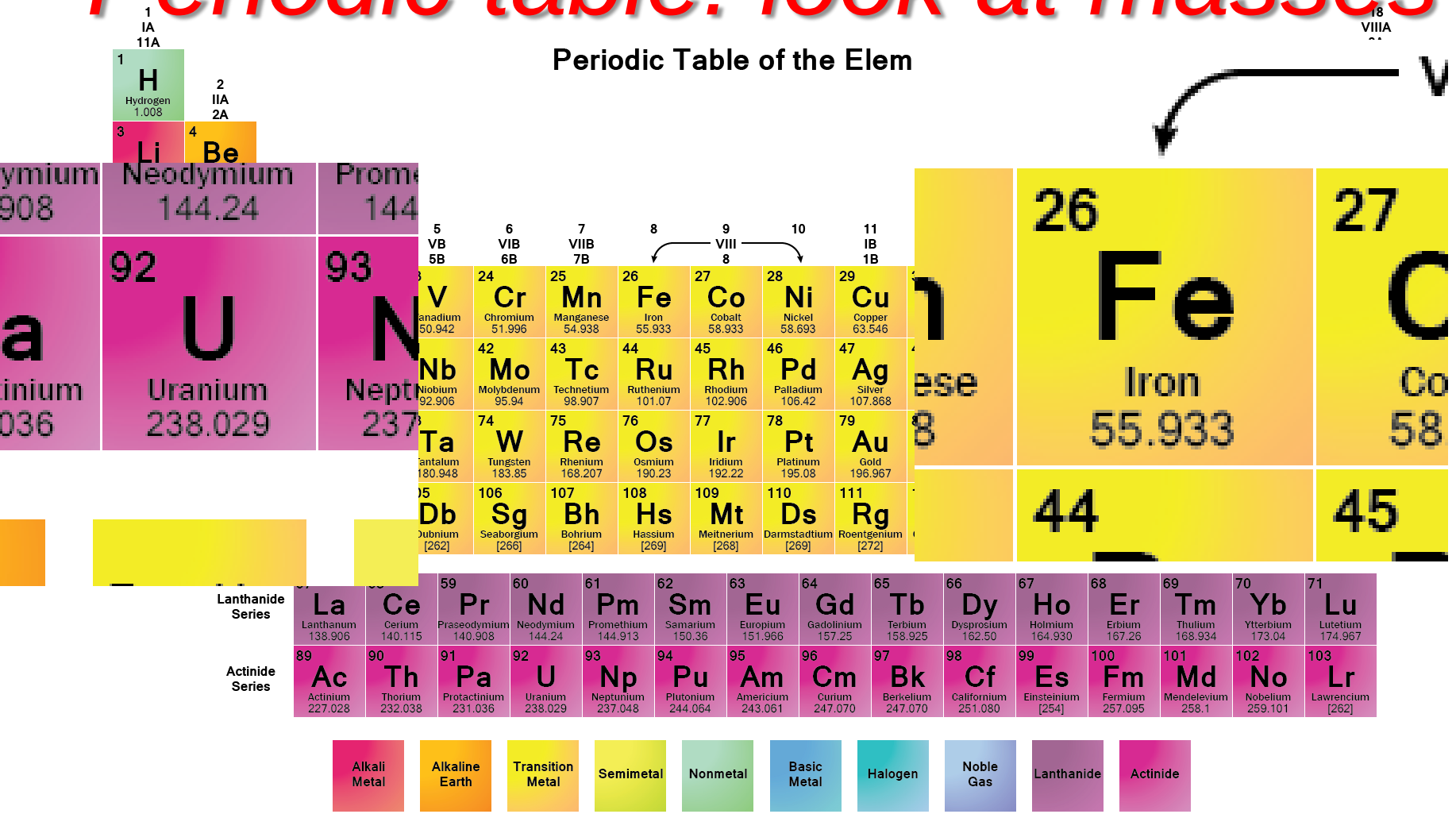


Periodic table: look at masses



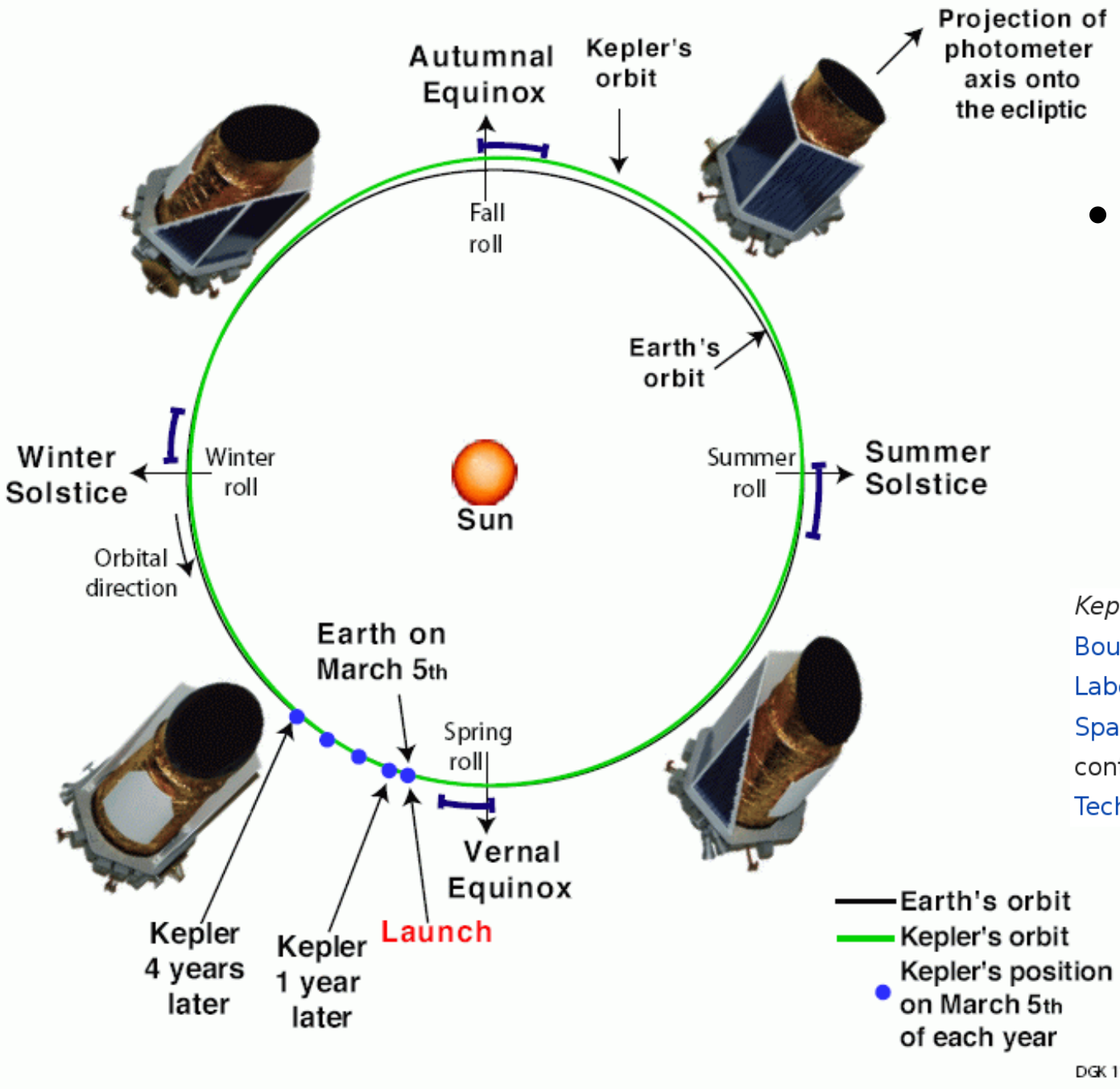
- 4 x 1.008 = 4.032; excess mass: 0.029
- 0.029 x 1.66×10^{-27} kg * c^2 = 4.33×10^{-12} J

Periodic table: look at masses



- 55.933/56 = 0.9988, and 238.029/238 = 1.0001
- Uranium has more mass per nucleus than Fe

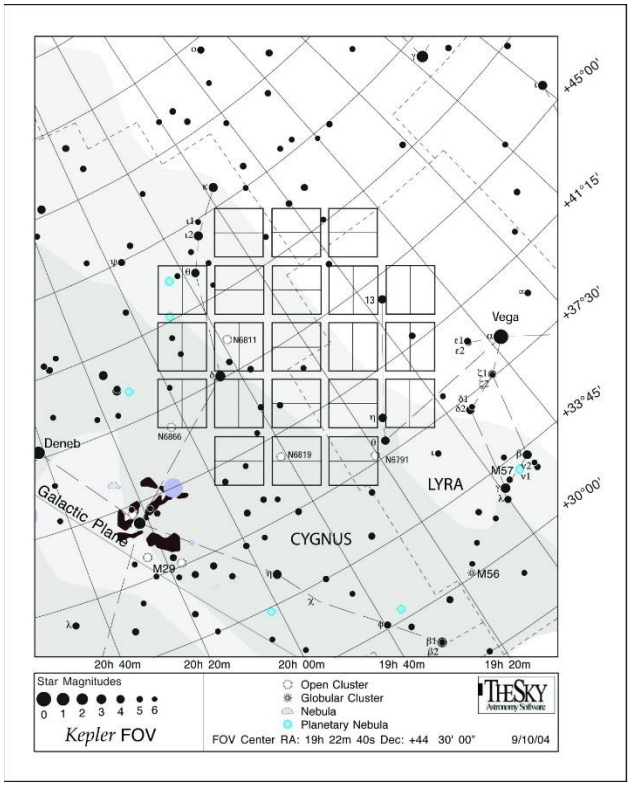
Kepler, the spacecraft



- Trailing the Earth

Kepler is operated out of Boulder, Colorado, by the Laboratory for Atmospheric and Space Physics (LASP) under contract to Ball Aerospace & Technologies. The spacecraft's

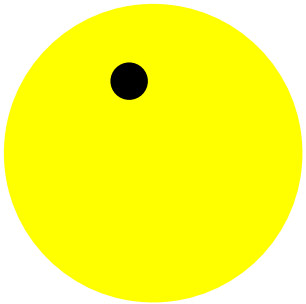
115 square degree



- Small fraction of sky
- $(115*\pi/180)^{1/2}=0.04$
- $0.04/4\pi=0.003=0.3\%$
- 156,000 stars
- ***2740 exoplanets***

Planet in transit

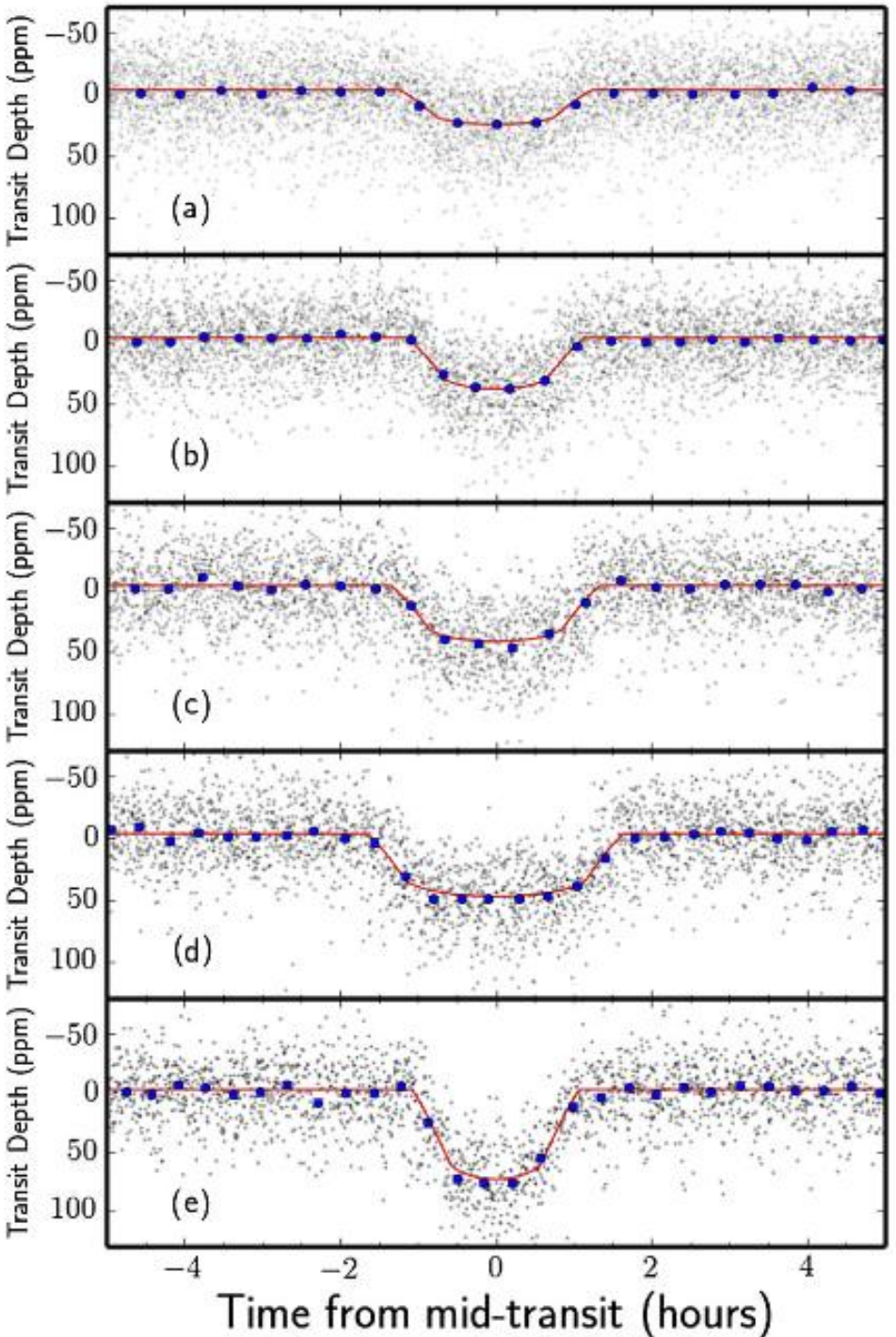
- Actually 5 planets
- ~ 10^{-4} (=area fraction)



A. $r/R = 0.01$

B. $r/R = 10^{-4}$

C. $r/R = 10^{-8}$



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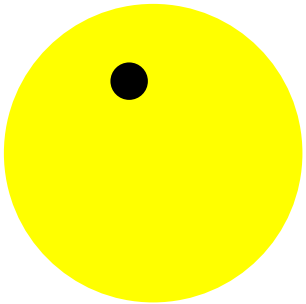
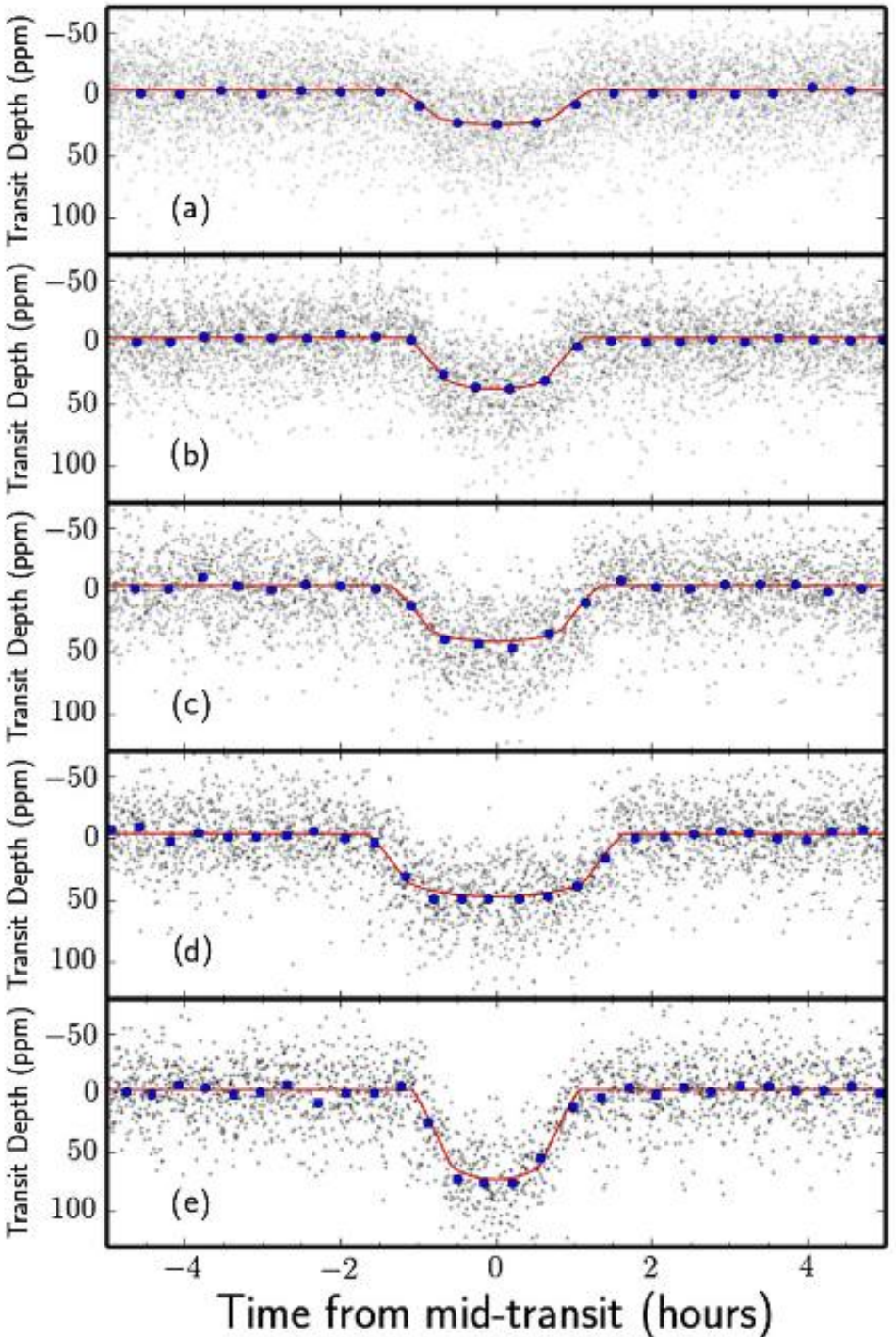


$$\frac{\Delta I}{I} = \frac{\pi r^2}{\pi R^2} = \left(\frac{r}{R}\right)^2$$

$$r / R = \left(10^{-4}\right)^{1/2} = 10^{-2}$$



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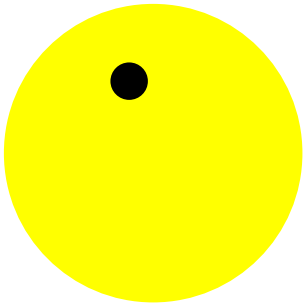

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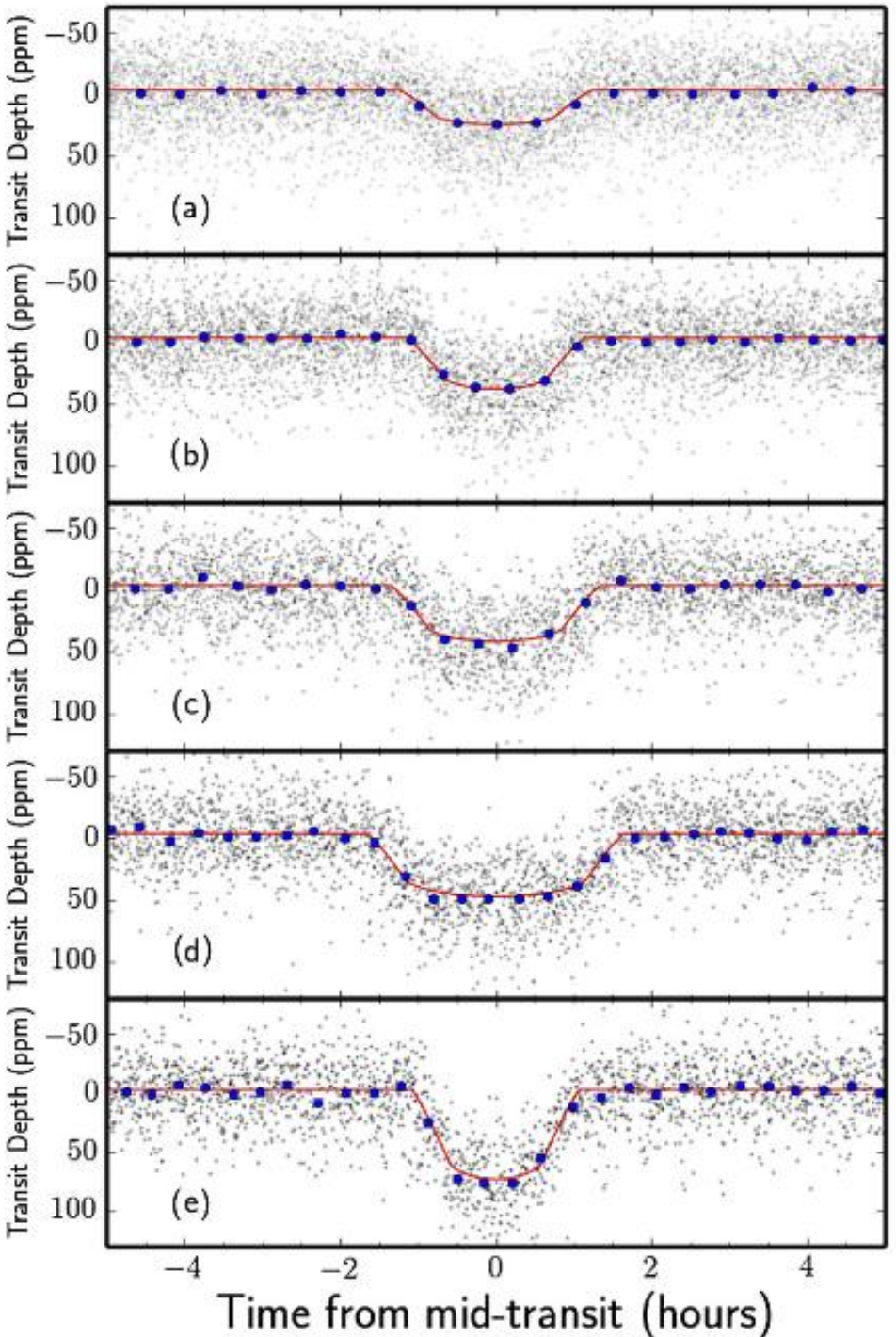
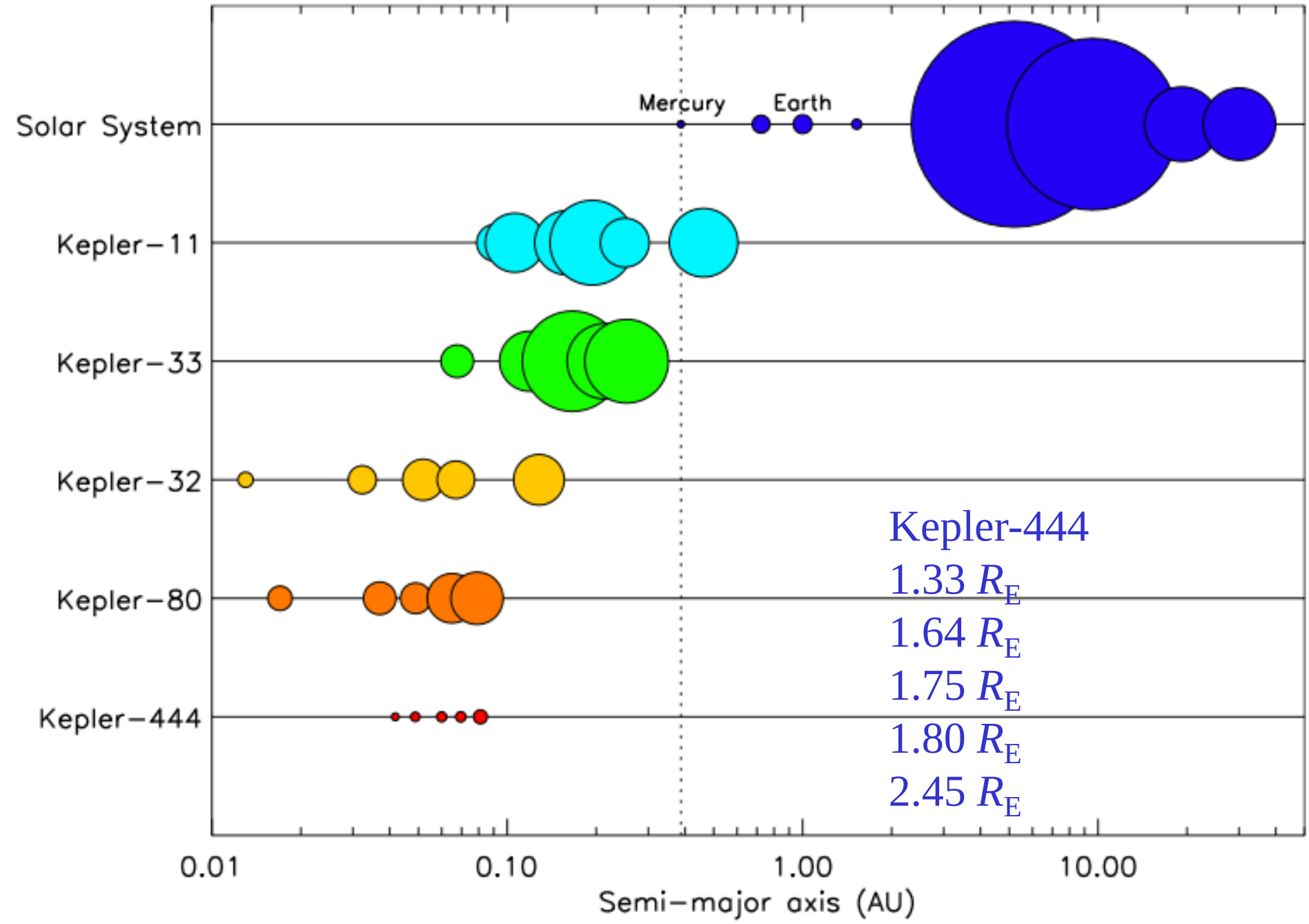
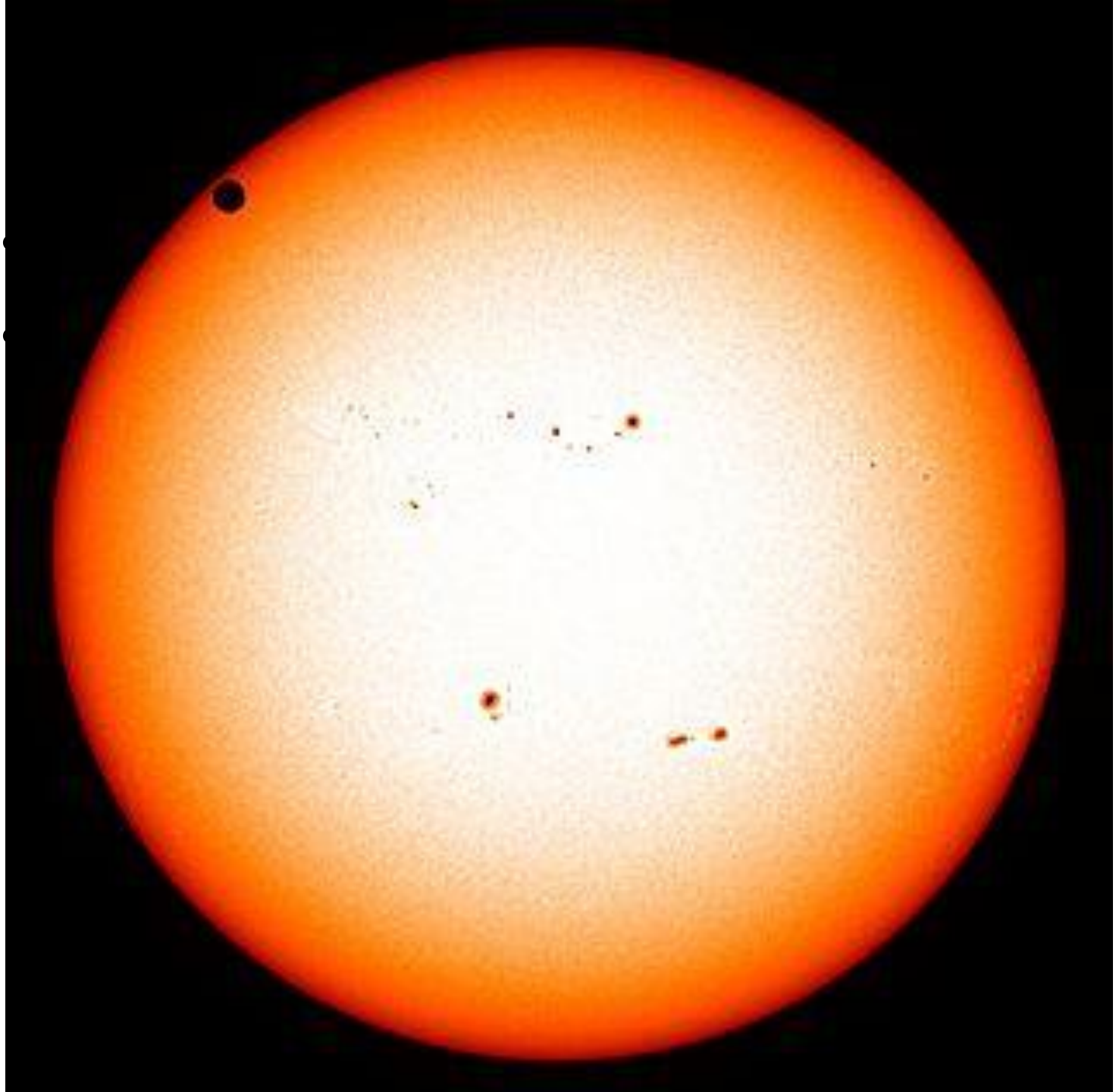



Solar System
Mercury
Earth
Kepler−11
Kepler−33
Kepler−32
Kepler−80
Kepler−444
Kepler-444
1.33 R_E
1.64 R_E
1.75 R_E
1.80 R_E
2.45 R_E
0.01
0.10
1.00
10.00
Semi−major axis (AU)

How low can we go?

- Kepler goal 10^{-5}
- Instrumental difficulties
- Other problems?



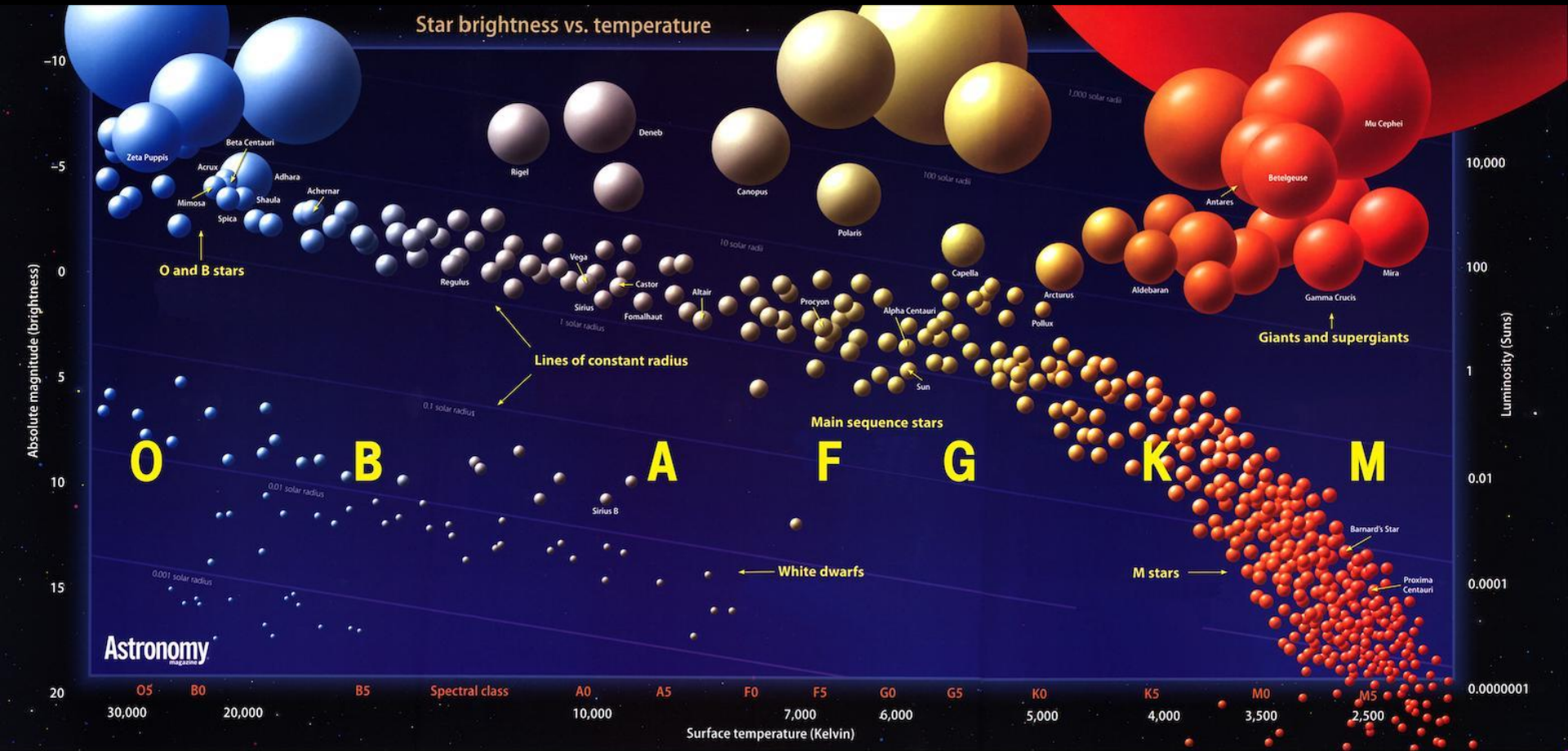
Stellar surface variable

- Starspots (random, but modulated)
- Flares (random, much stronger)
- Stellar activity cycles

→What's one astronomer's noise is anothers one's signal

Again which stars?

- Need long-term stability?
- Fraction of heavy elements?



Based on life span & abundance: which class of star is most likely to habor life?

A. A star
B. F star
C. G star
D. K star
E. M star

Enough time for life?

Spectal Type	M/Msun	Life span [Gyr]	Percentage
O	60	0.0005	0.001
B	6	0.05	0.1
A	2	1	1
F	1.5	2	2
G	1	10	7
K	0.7	20	15
M	0.2	600	75

- Life might not emerge on O, B, and A stars
- But they make up small percentage

Based on life span & abundance: which class of star is most likely to habor life?

A. A star
B. F star
C. G star
D. K star
E. M star

Worlds with liquid surface water

What if star is dimer than the Sun?

A. Need to be closer (<< 1 AU)
B. Farther
C. Brightness doesn't matter

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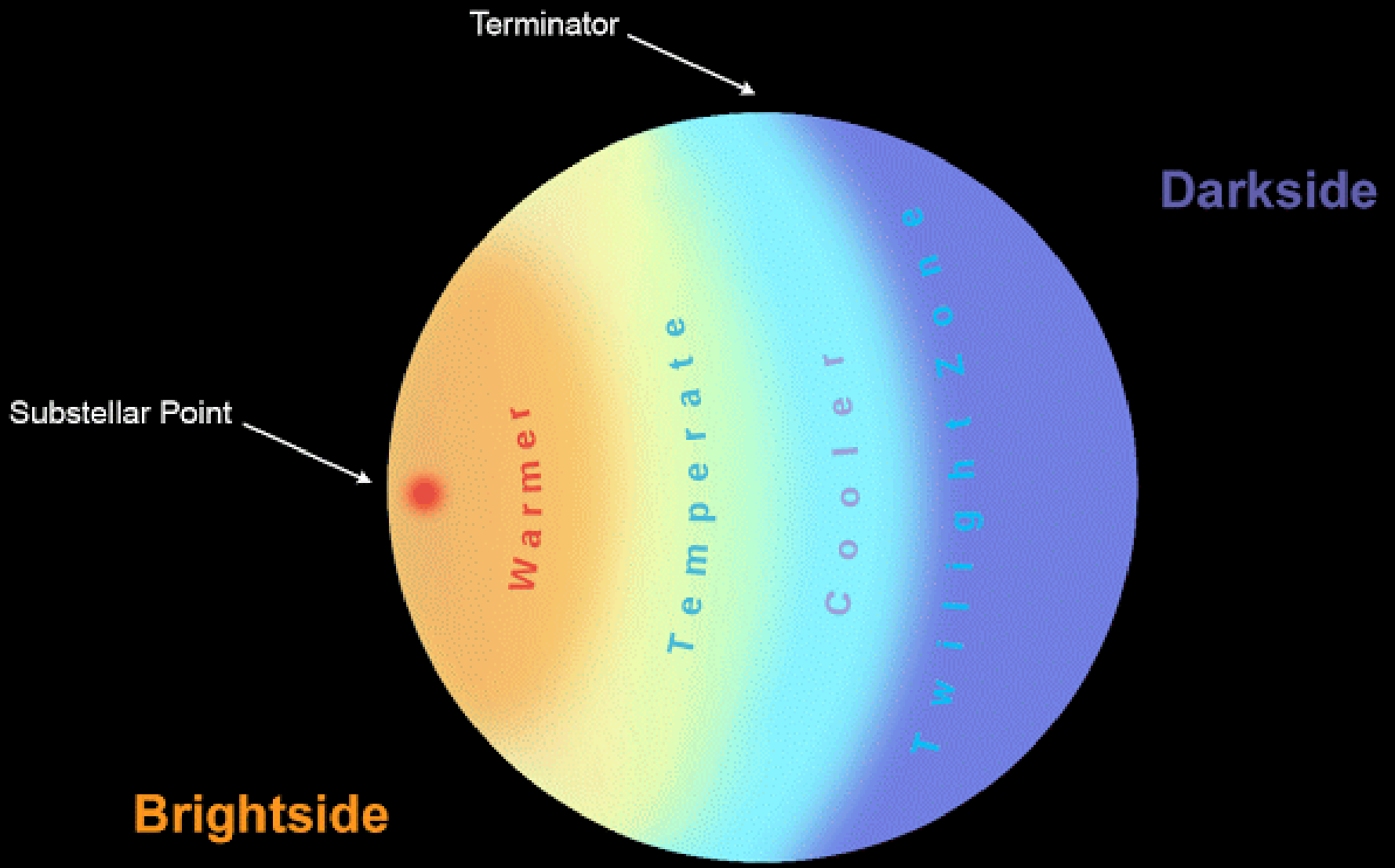
Problems with M dwarfs

(Dwarf = main sequence stars)

- M dwarfs have frequent flares
  - At least in their first 1 Gyr
- Closer planet: synchronous rotation
- What does this mean for life?

- Discuss?
- (and what about effect of atmosphere)


Terminator
Darkside
Substellar Point
Warmer
Temperate
Cooler
Twilight Zone
Brightside


TIDALLY LOCKED
WORLDS

Most stars are binaries

- Triple system (2 stars + planet) often not stable
- a: wide separation, each star with planet
- b: Stars close together: planet orbits 2 stars

Where to go from here

- James Webb (JWST) → atmosph.
- Search for Planets EClipsing ULtracOOL stars → SPECULOOS
- Target for many planetary studes
- And certainly SciFi

Next time

- Other planet detection methods
- TRAPPIST-1
  - http://www.trappist.one/
- Starshade

- Longstaff: 339 – 341