

How PIZZA relates to EXTRA-TERRESTRIALS (ET)

A look at how PLANETS form, and
how COMMON PLANETS are.

By Rick Kang

Who's Rick Kang?

1. Education/Public Outreach Coordinator – Oregon Astrophysics Outreach – I visit hundreds of classes/year, all around Oregon, Kindergarten through University levels.
info at <http://oregonsky.org/>
2. Summer Tourguide at UO's Pine Mountain Observatory east of Bend, you can visit Fri/Sat evenings, June-Sept. <http://pmo.uoregon.edu>

Visit Pine Mountain Fri/Sat evenings June-Sept. Great camping!



What are STARS? How do they form?



What are STARS? How do they form?

- Gravity pulls together GAS and DUST within a NEBULA .
- The matter ACCRETES, pulling in even more material.
- Accretion and compression lead to two major effects:



HEATING from COMPRESSION,

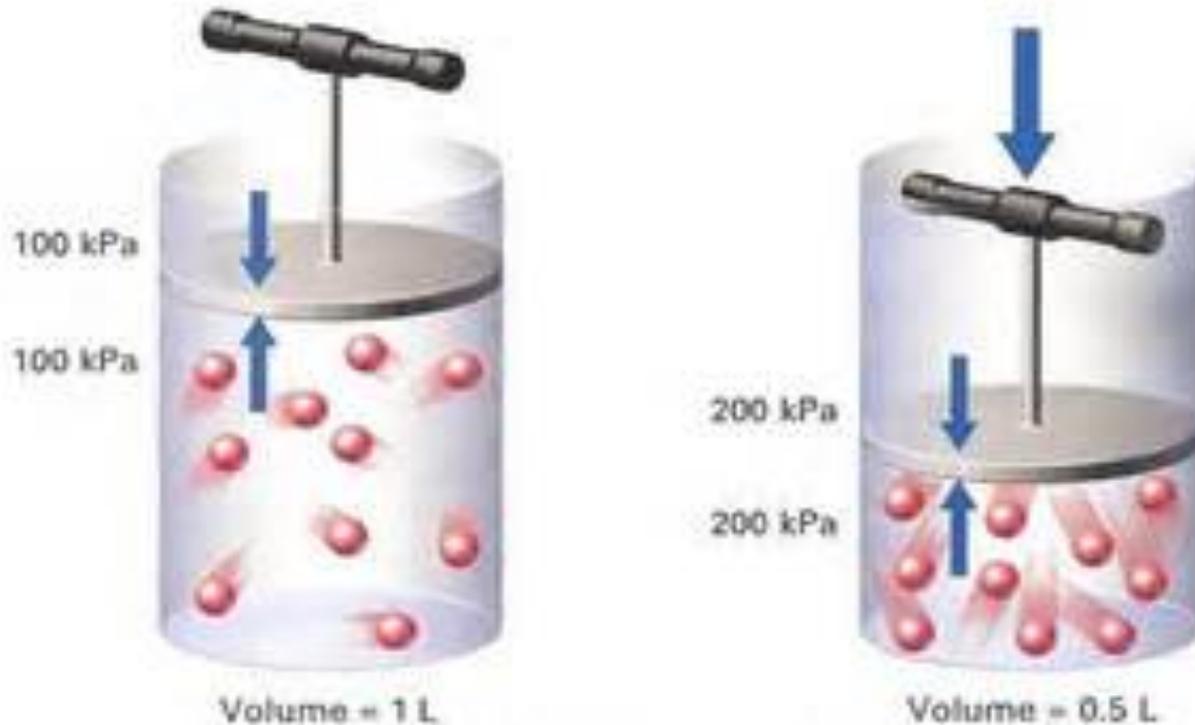
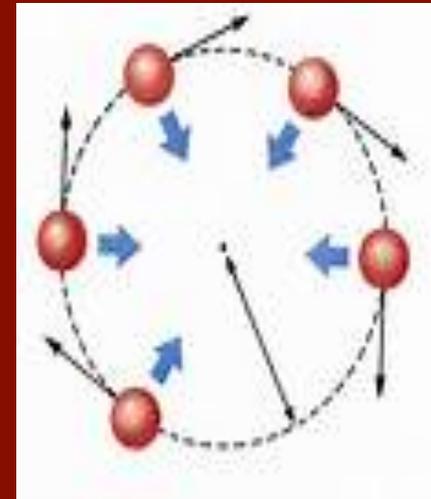


Figure 14.6 A piston can be used to force a gas in a cylinder into a smaller volume. When the volume is decreased, the pressure the gas exerts is increased.

ROTATION (spin)
due to **OFFSET COLLISIONS**
like **DANCERS LINKING ARMS**



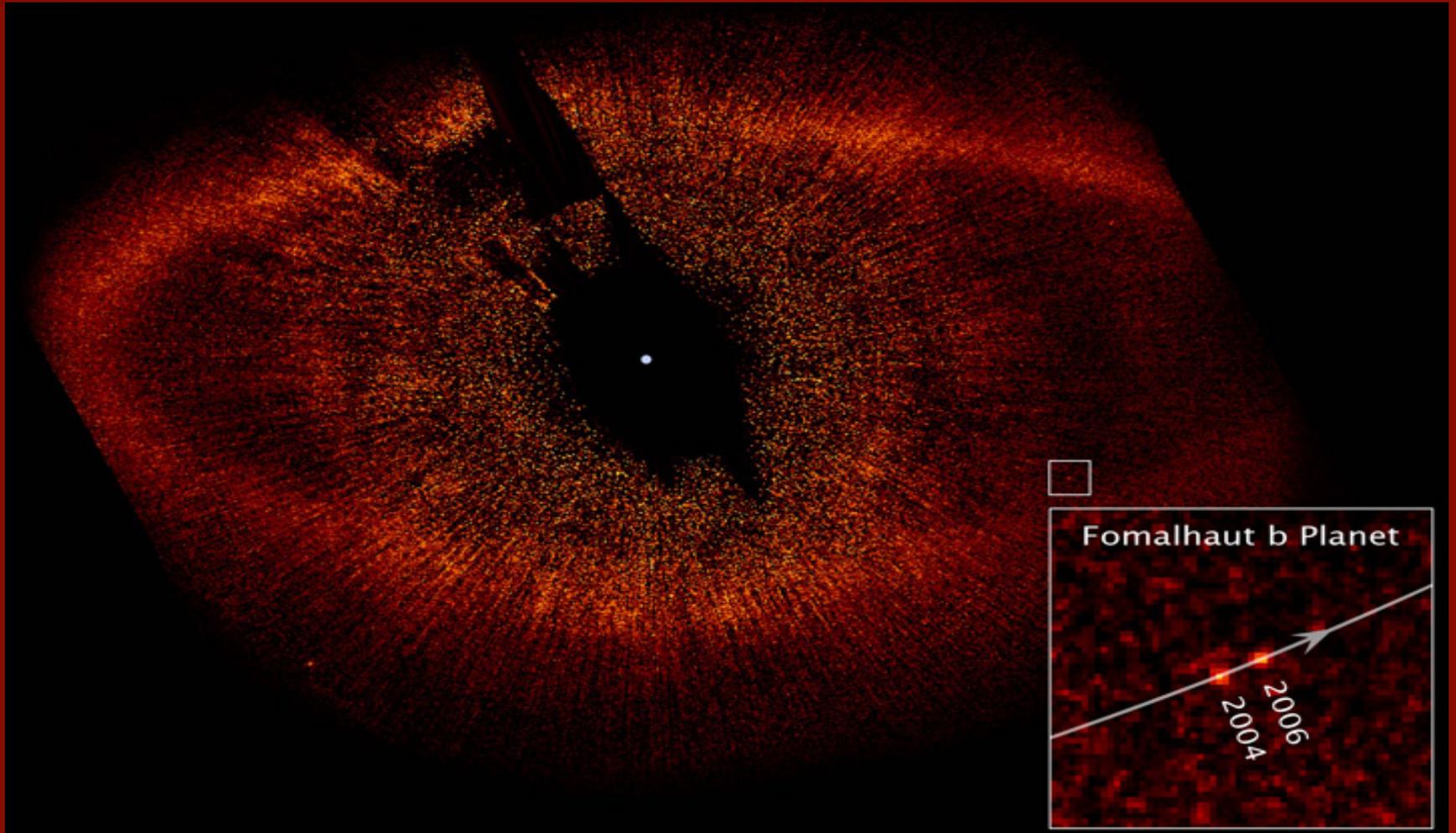
**Rotation leads to
DISK FORMATION
due to Centrifugal Force,
like tossing PIZZA dough!**



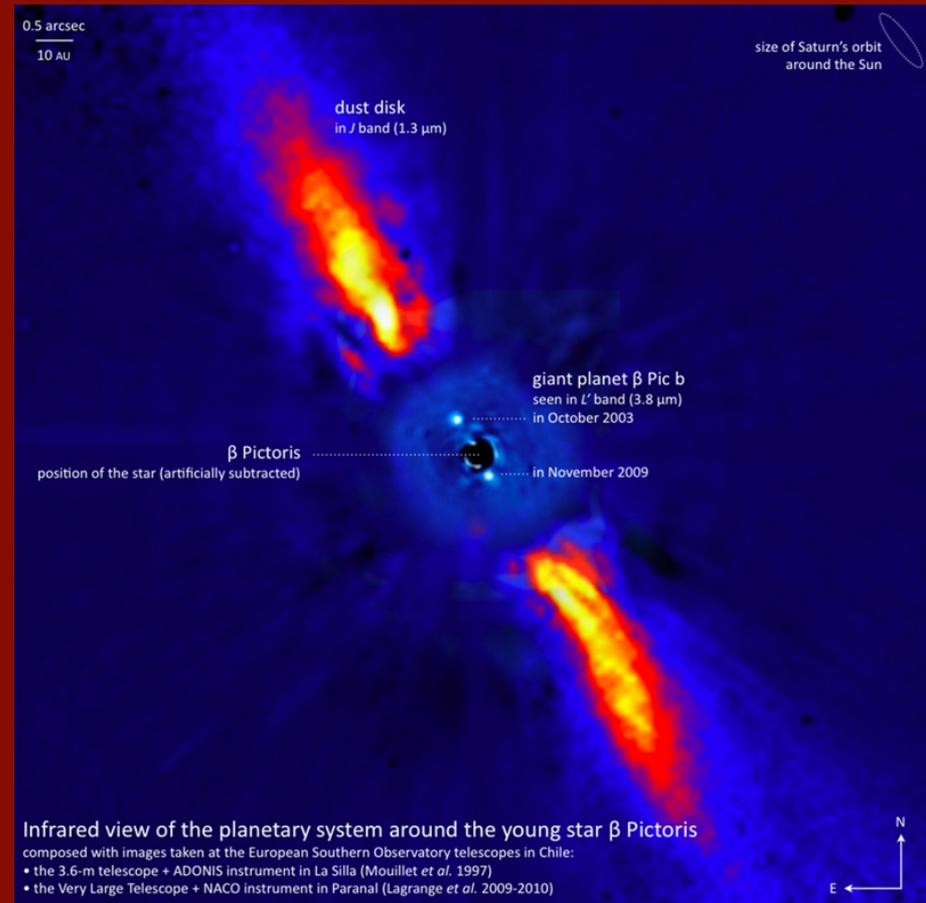
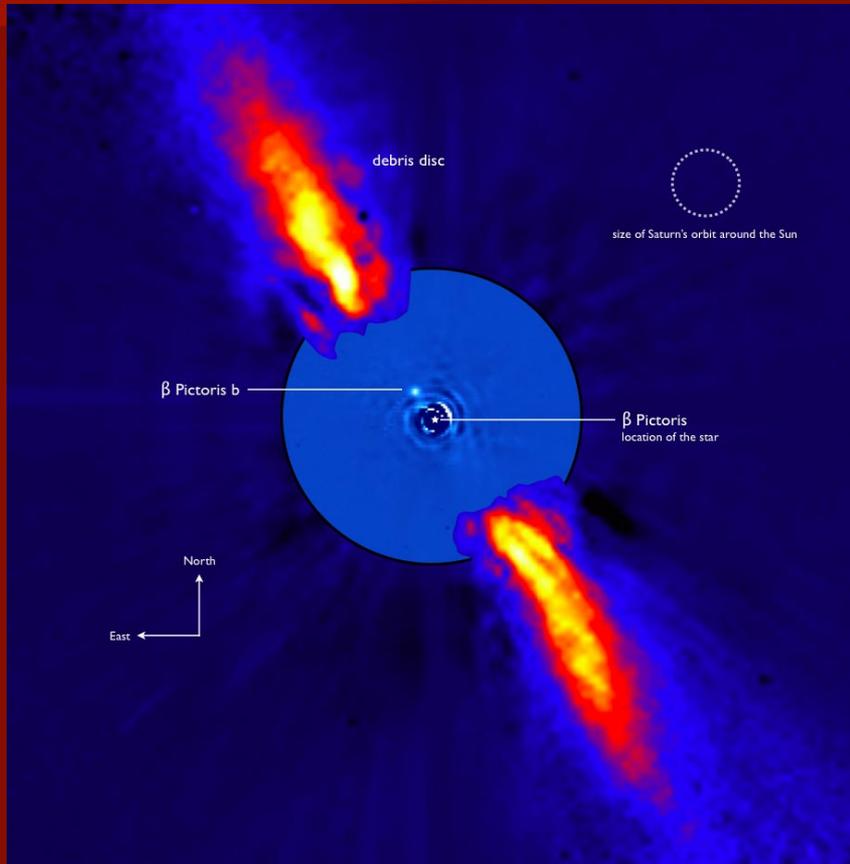
We end up with a rotating
extremely hot sphere of
PLASMA, a **DISTANT SUN**, a
STAR, surrounded by a disk!



The star, Fomalhaut, surrounded by it's STAR PIZZA disk & maybe a planet in the disk?



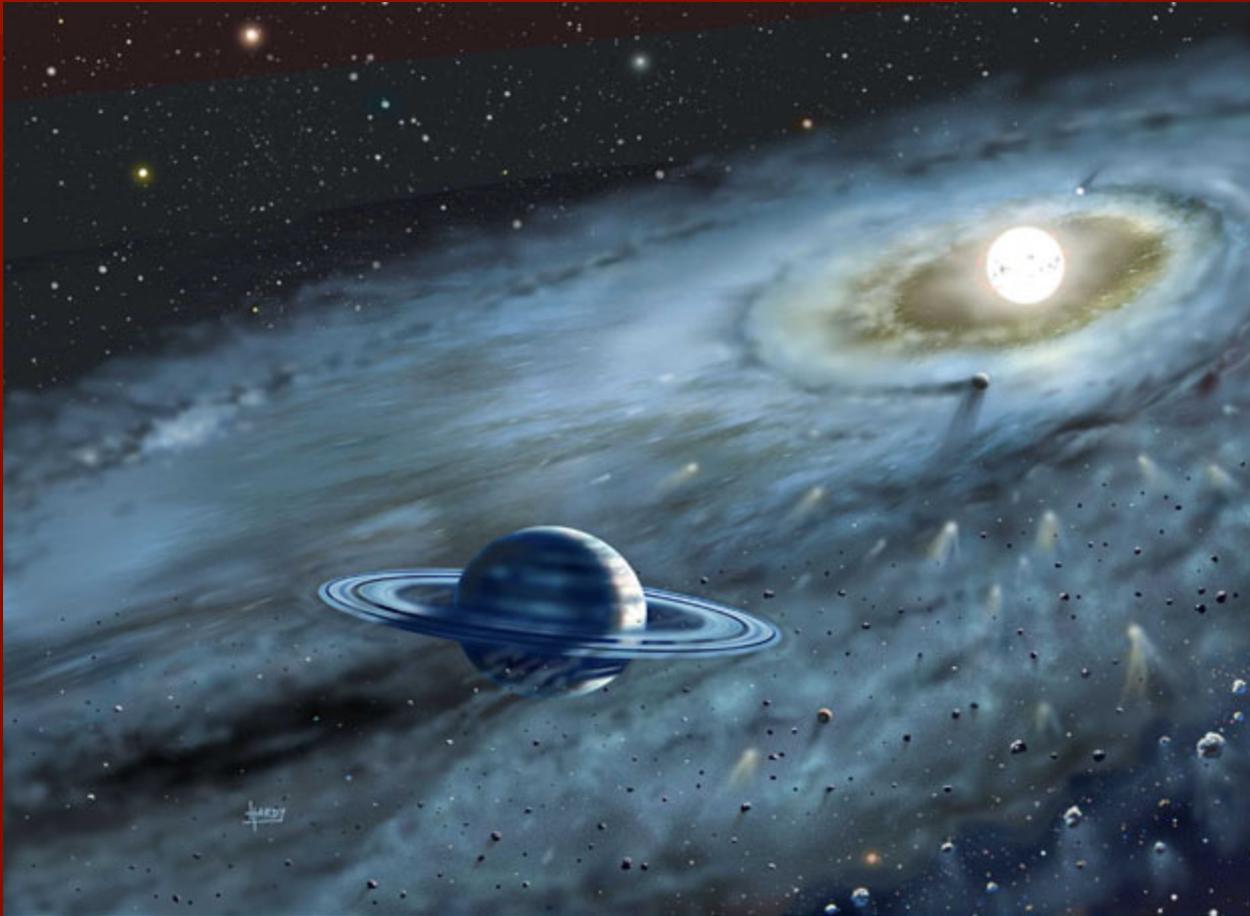
Well known disc of star, Beta Pictoris, possibly also harbors planets?



Many young stars are surrounded by large disks of dust and gas (“Star Pizza”)

- **What probably happens to the material in the DISK?**

More ACCRETION, into Planets!

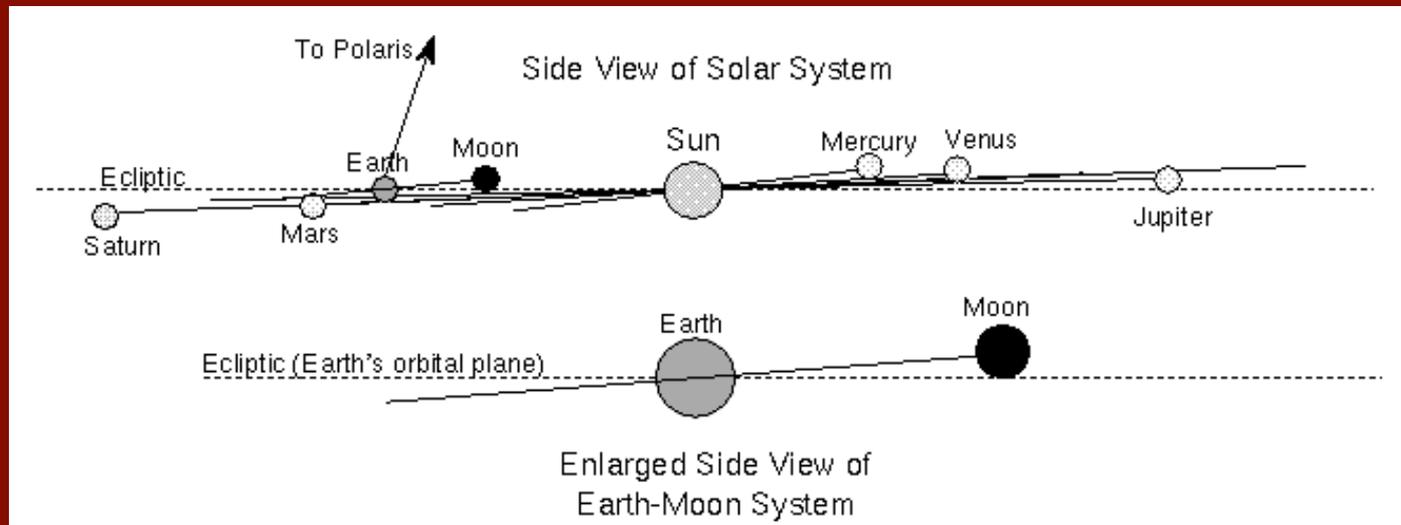
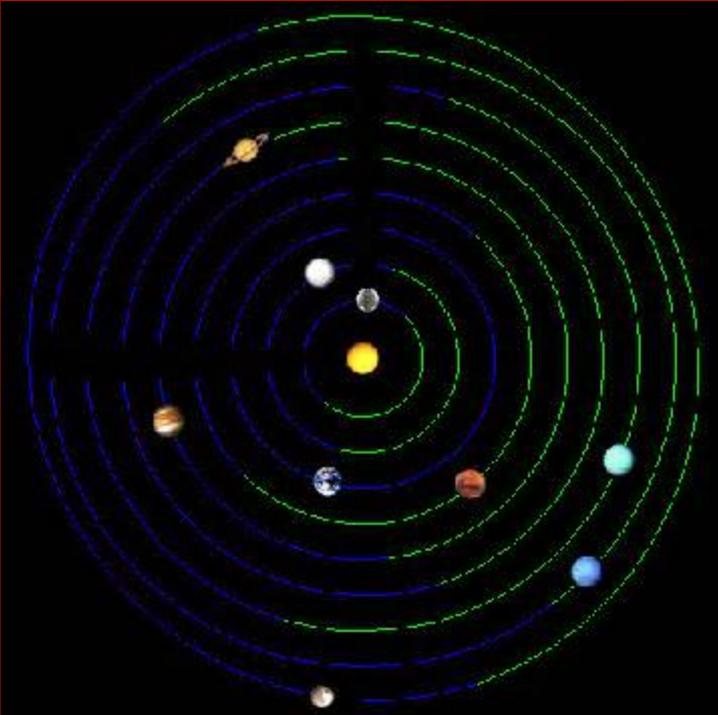


**If that's how our Solar System's
Planets formed, how would you
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If that's how our Solar System's Planets formed, how would you expect them to ORBIT?

- All would orbit in **SAME DIRECTION** around **SUN** and
- **PLANES** of **ORBITS** would be aligned (**CO-PLANAR**)
- Are these criteria met? **YES!**

Solar System top down & sideways views (not to scale!)



How many Stars have disks?

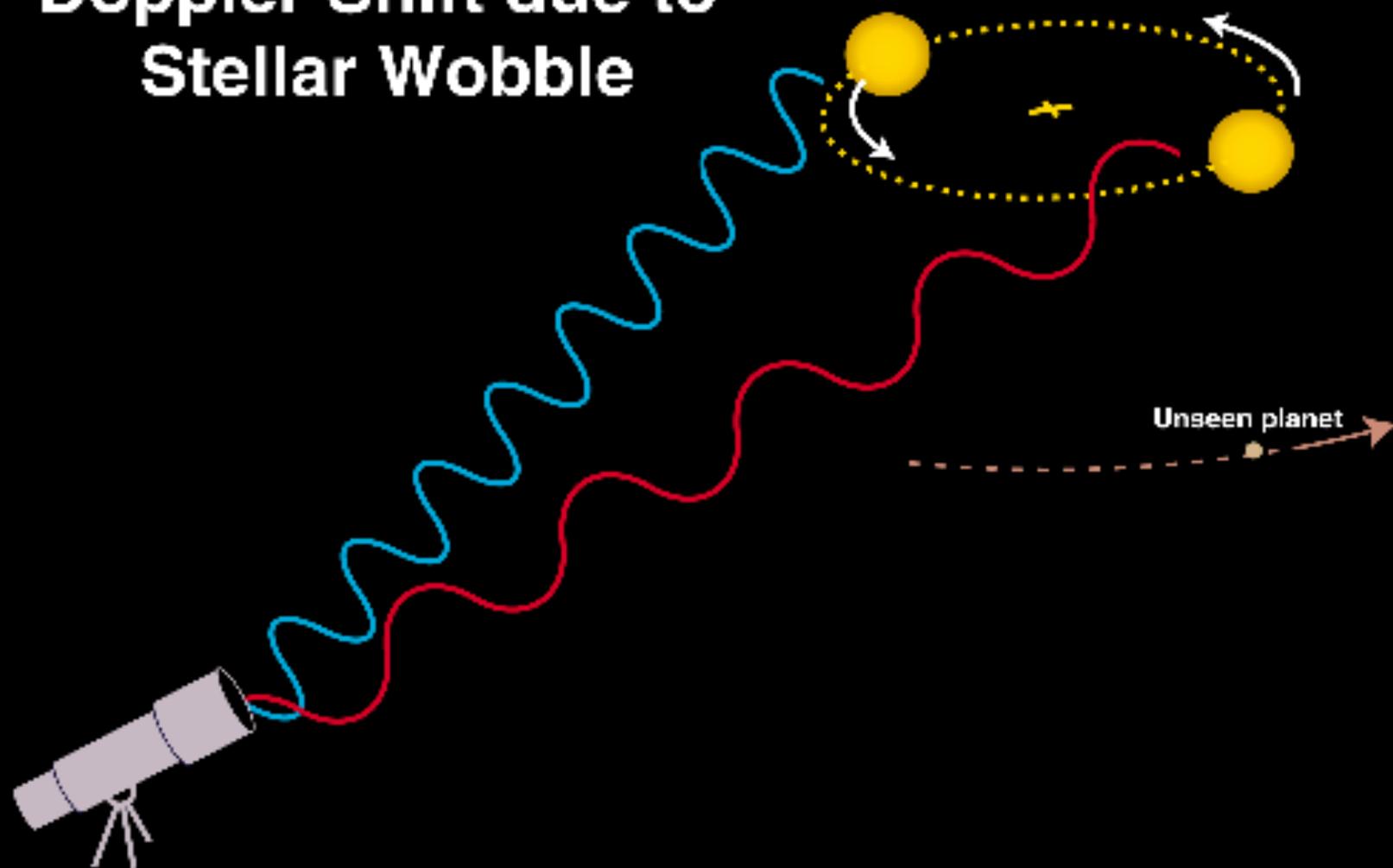
How many Stars have disks?

- **MOST** of the **YOUNG STARS** we observe **HAVE DISKS!**
- We've observed thousands of examples (mostly w/Infrared sensors)
- **Statistics IMPLY:**

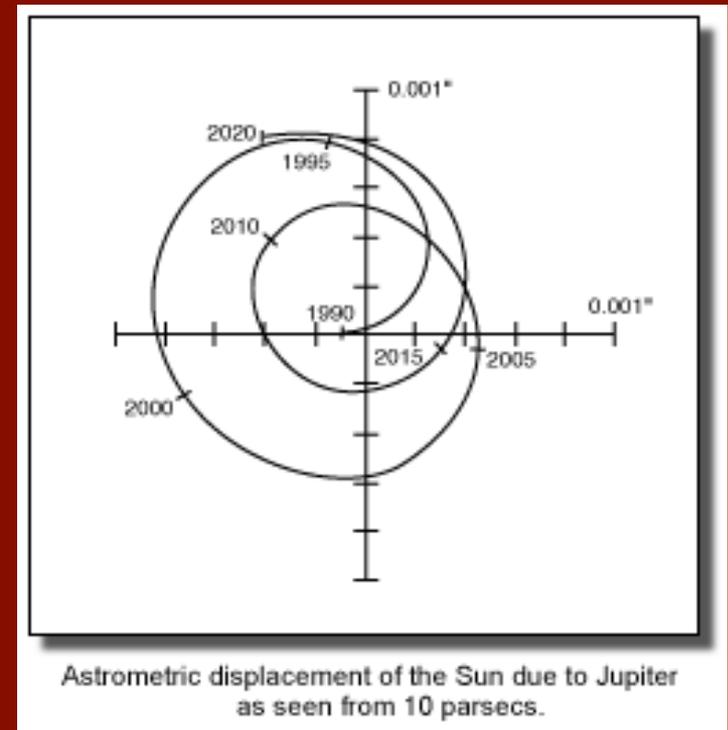
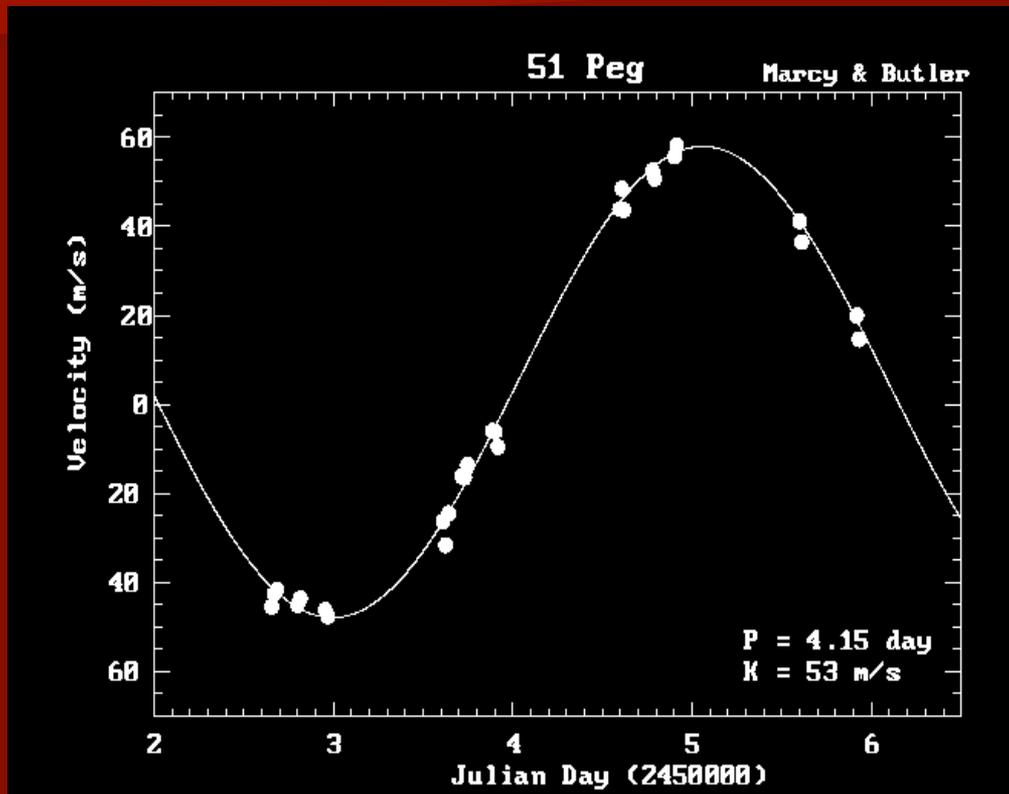
Most Stars must have PLANETS orbiting the Stars!

- Additional statistical EVIDENCE:
 1. We've detected exoplanets by observing **WOBBLE** of star in response to tug of orbiting Planet. (Doppler Shift)
 2. We've detected exoplanets by observing dimming of starlight as Planet **TRANSITS** in front of Star (Kepler Mission-photometry)

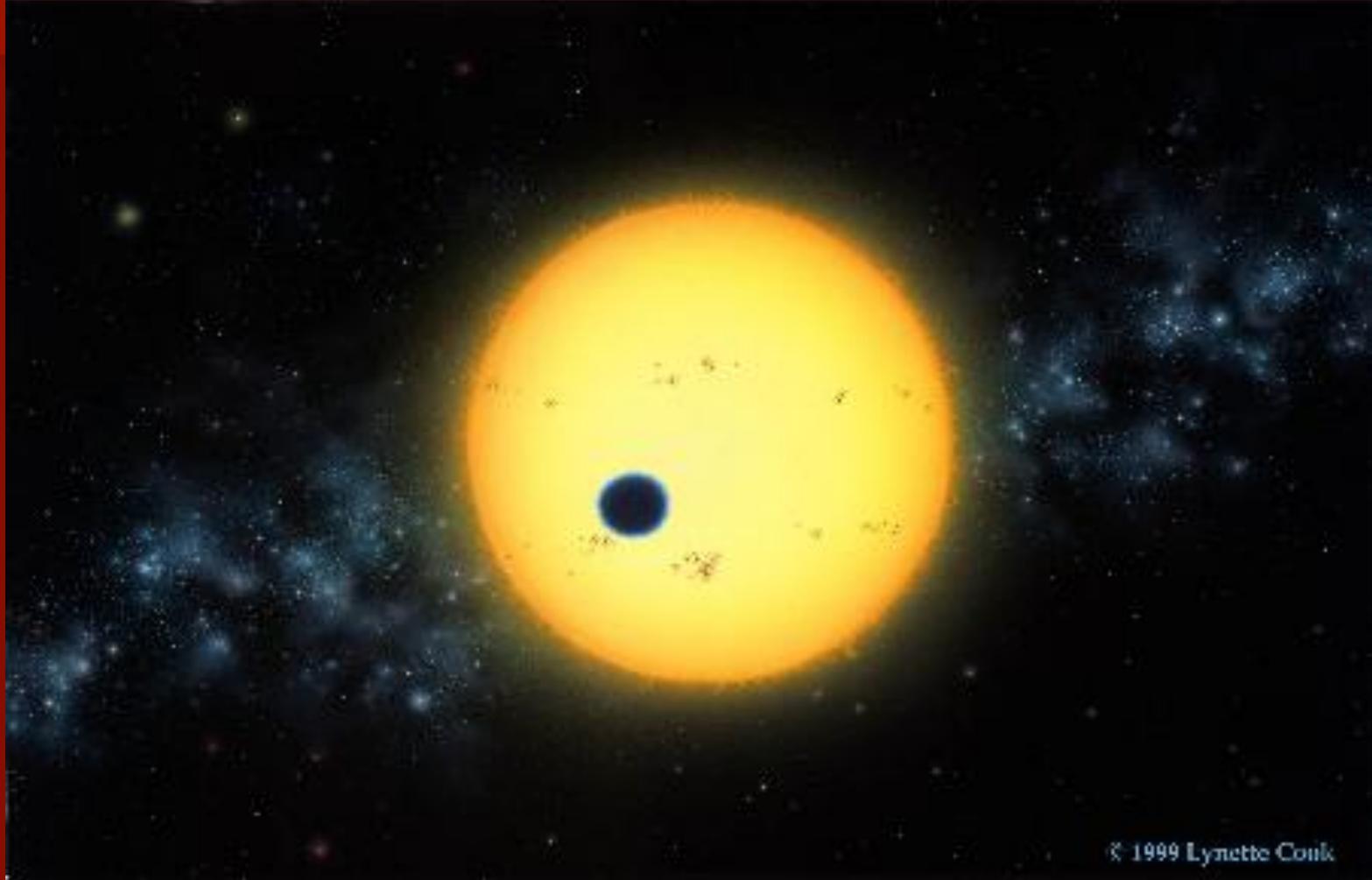
Doppler Shift due to Stellar Wobble

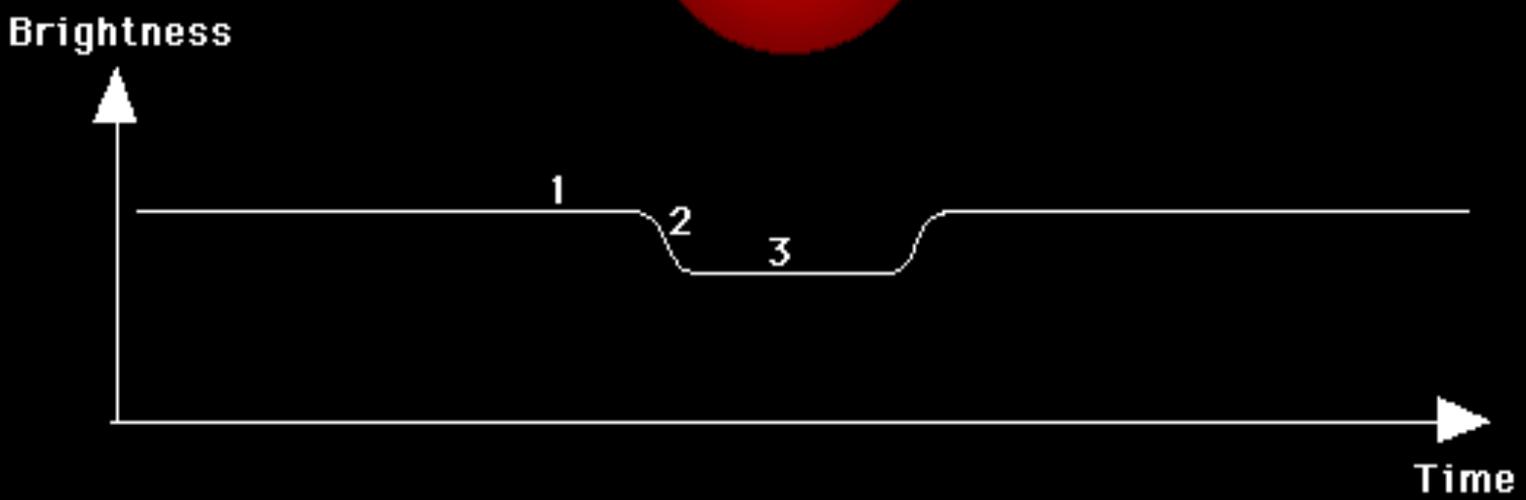
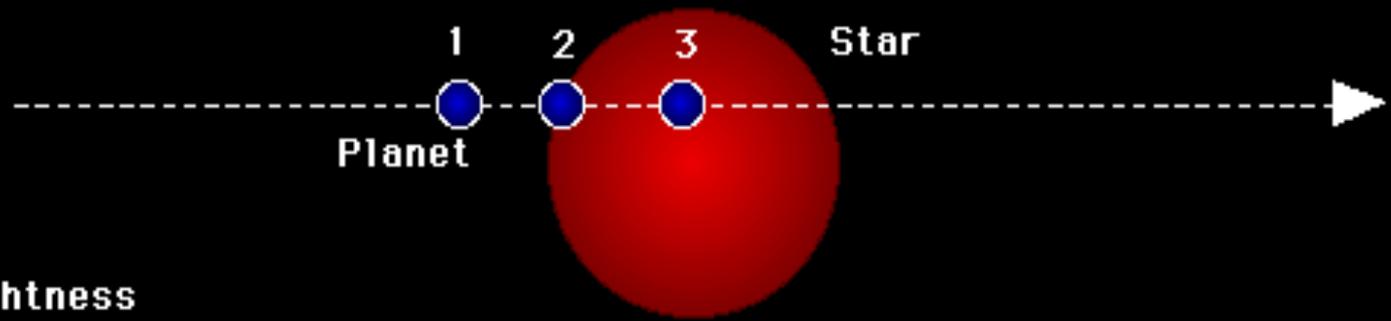


First exoplanet, Our wobble

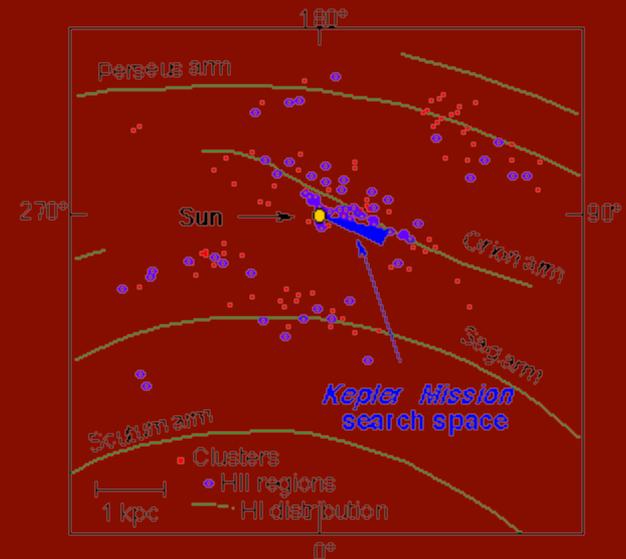
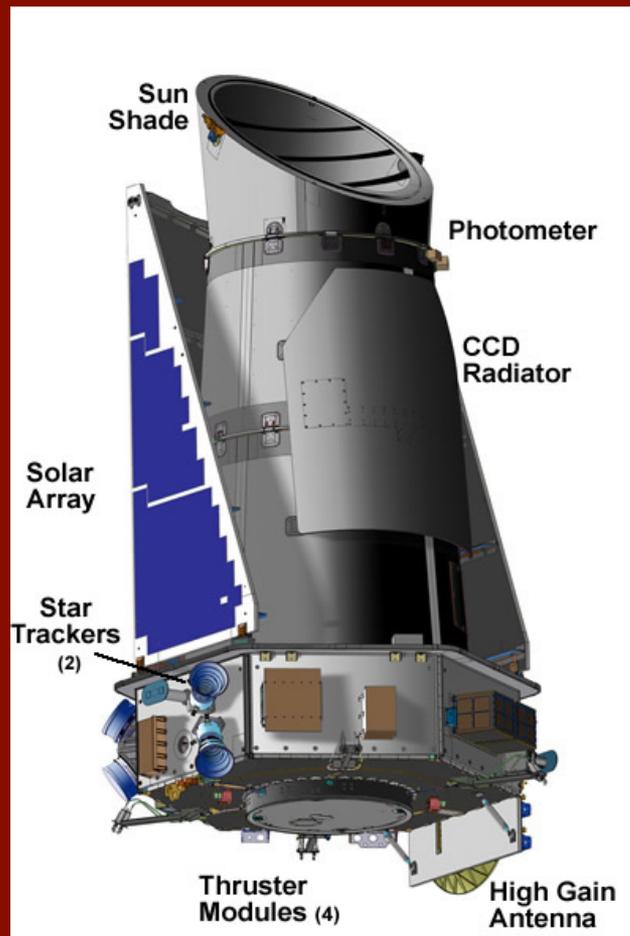


Painting of Planet TRANSITING

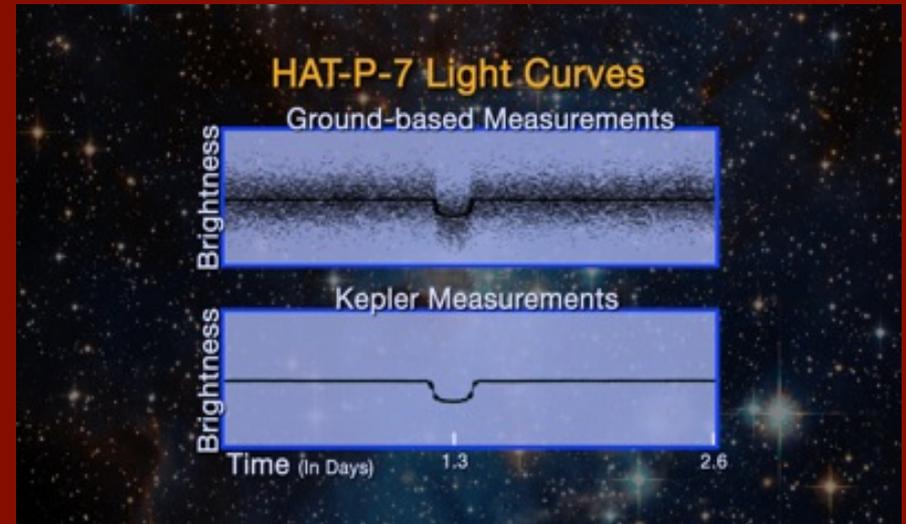
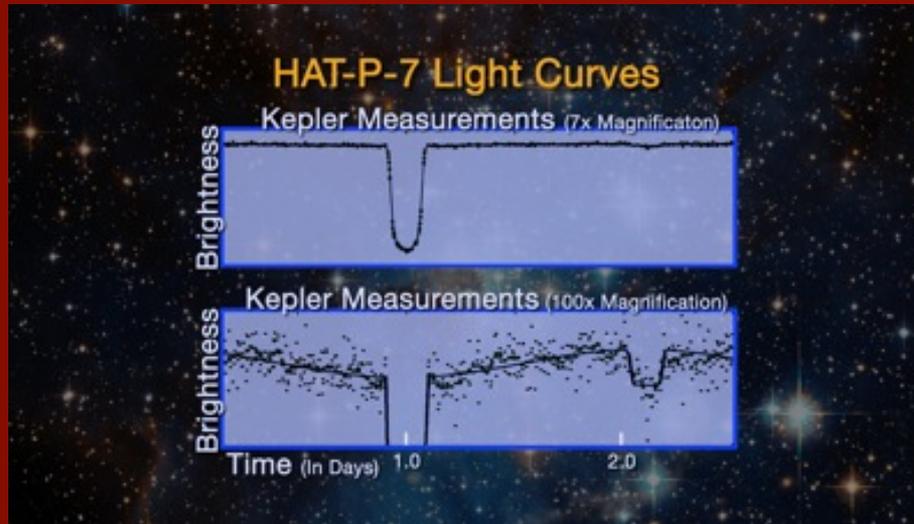




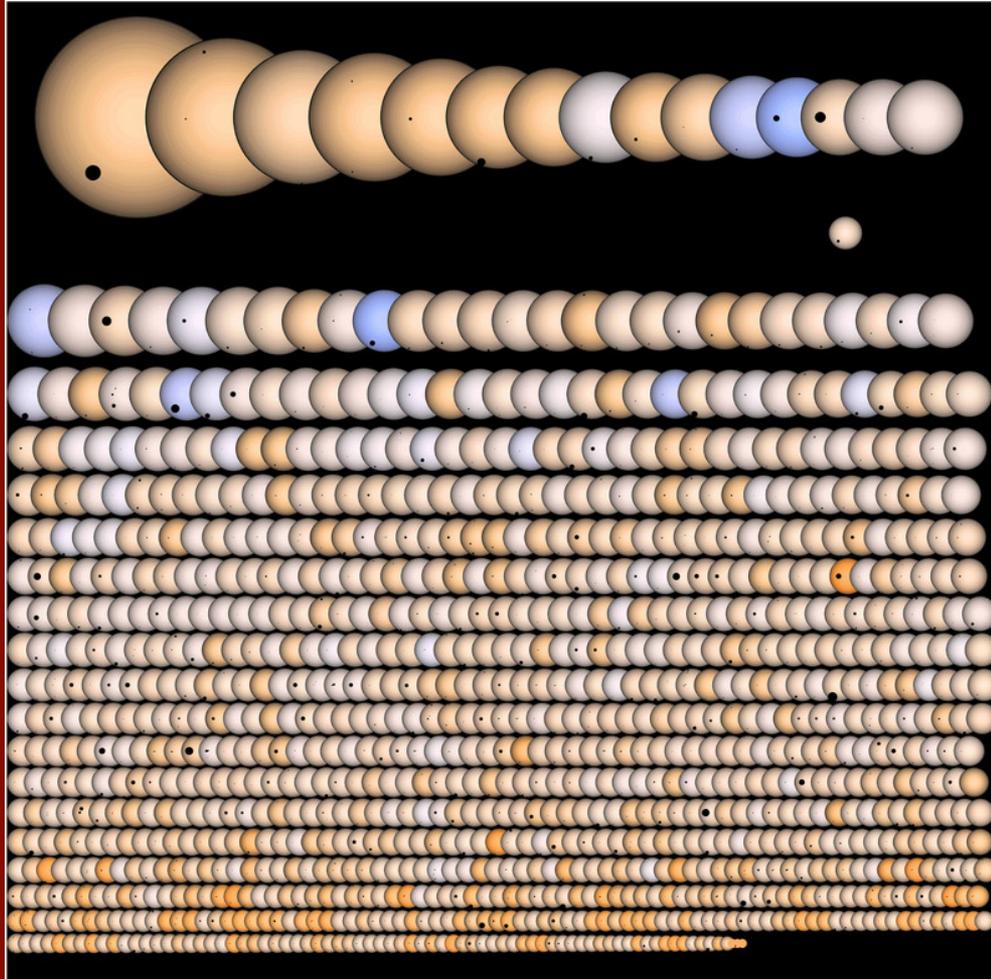
Along came Kepler in 2009. Searching for Earth-like Planets orbiting within Habitable Zone of Sun-like stars



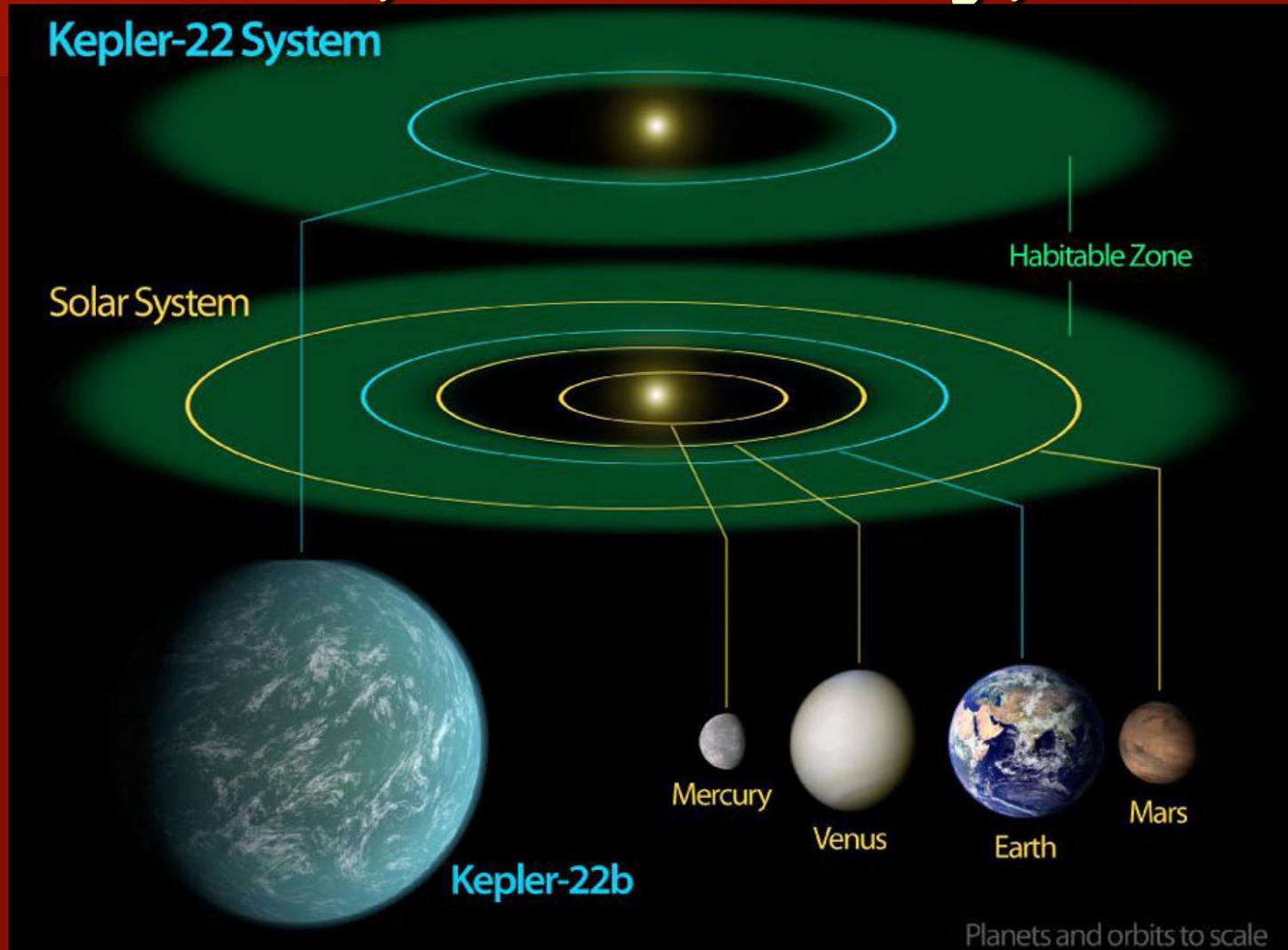
**“light curves” of transits
observed by Kepler, can detect
extremely small dimmings!**



March, 2011 data release: Kepler finds 1,235 stars with Planets



Most similar to Earth so far, Dec. 2011, 600 LY away, 2xDiam



But, wait, we DON'T necessarily need an EARTH-LIKE Planet to sustain life!

- Lots of **EXTREMOPHILES** on Earth do fine where we'd never survive! (undersea smoker vents harbor life, and Mono Lake cells that eat arsenic!)



H-N-O-C organic chemistry is **ABUNDANT** in **UNIVERSE!**

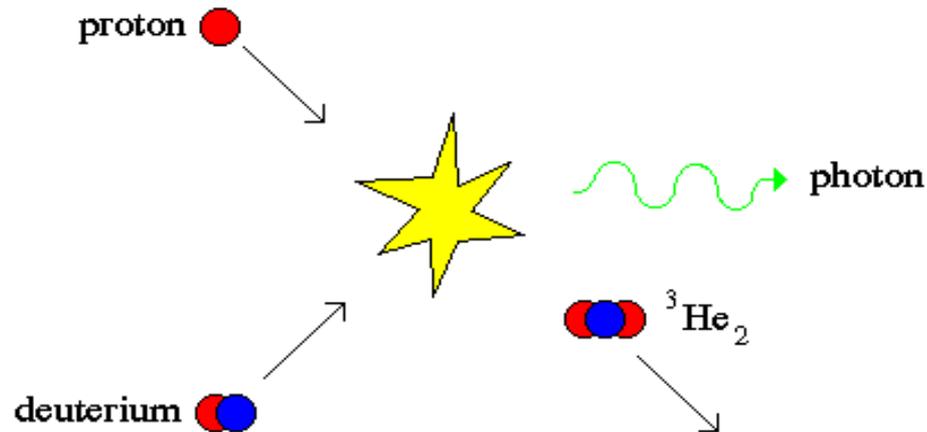
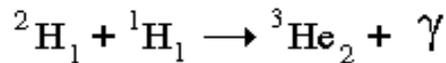
- Zillions of gallons of **WATER** in nebulas and in several Planets' atmospheres

Stars CREATE

1. **Chemical Elements** via Nucleosynthesis
2. **Planets** via Star Pizza
3. Fusion process supplies plenty of **Energy** to Planets' surfaces

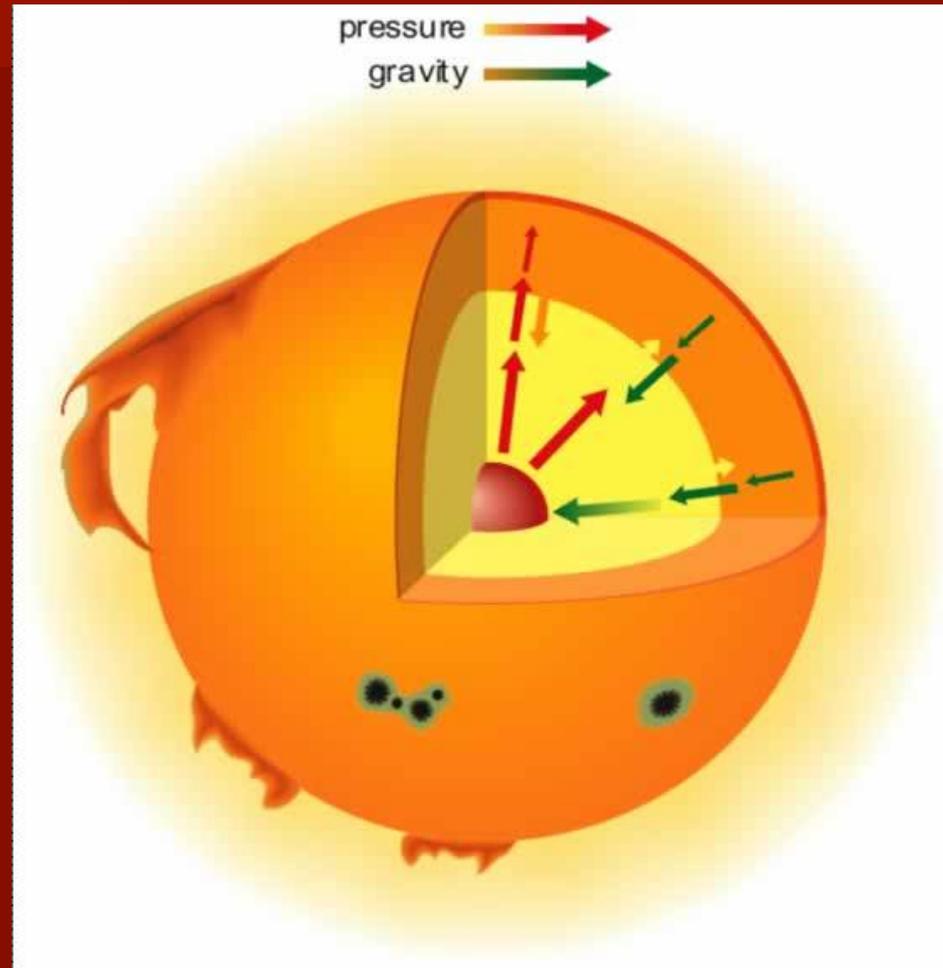
Nucleosynthesis: FUSING new Chemical Elements

proton-proton chain: stage 3



the 3rd stage to the proton chain used the deuterium from stage 1 and another proton to produce tritium (an isotope of helium) and energy in the form of another gamma-ray – isotopes are protons and neutrons combined to produce a nucleus, but usually missing a proton or neutron needed to make a complete element – isotopes tend to decay in short times

Lots of energy



**STARS PROVIDE:
Planets, Chemicals, Energy:
The Ingredients for LIFE!**



Many BILLION stars in each GALAXY

- Billions of Galaxies in Universe.
- If every Star just has ONE planet, consider how many PLANETS there are, many with the right Chemistry for our form of life.

**Hubble Ultra Deep Field –
tiny fraction of square degree of
sky, each dot is a GALAXY!**



The NUMBERS GAME is OVERWHELMINGLY IN FAVOR of OTHER LIFE EXISTING!

- When will we/they make contact?
- What will we/they say?
- What will we get to learn?

- Stay tuned! Maybe we'll share pizza with ET someday soon.

Arecibo Radio Telescope



Allen Radio Telescope NE Calif.



Drake Equation - # of Intelligent Civilizations in MW

$$N = N_* f_p n_e f_l f_i f_c f_L$$

N_* = The number of stars in the Milky Way Galaxy.

f_p = The fraction of those stars that have planetary systems around them.

n_e = The average number of planets in a given planetary system that are suitable for the development of life.

f_l = The fraction of those planets on which life actually arises.

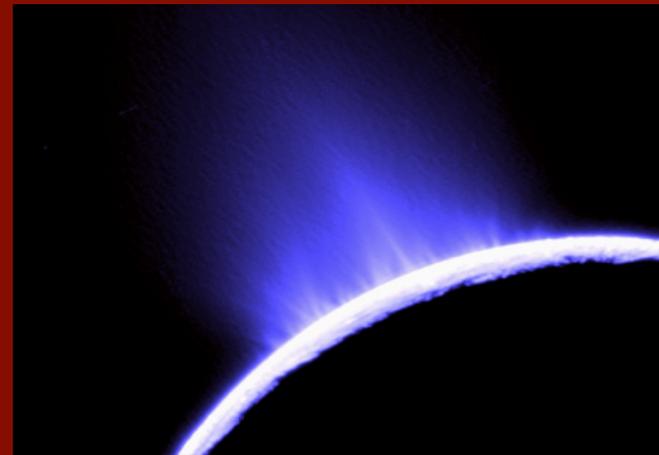
f_i = The fraction of those planets with life on which intelligent life appears.

f_c = The fraction of those planets with intelligent life that develop a technological civilization.

f_L = The fraction of the life of a planet that a technological civilization survives.

N , the solution, is the number of advanced technological civilizations in the Milky Way galaxy.

Sites for potential life in Solar System: Mars, Europa, Titan, Enceladus



ET

