CelebrityLife Activities

Babylon to the Big Bang

BEYOND THE PODIUM

GUEST SPEAKER SERIES

Peter Watson

Carleton University

Start with the Sun:

the most excellent, the greatest and the midmost star,

If we look at it with "white" light, it's a bit dull!

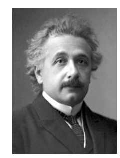
But we can still see a few sunspots

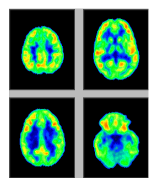
And Mercury!

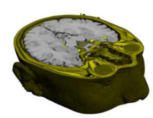
About 5800°C

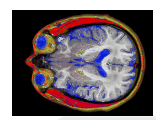
But if we want to find out how the sun works, we need to look at it in different ways

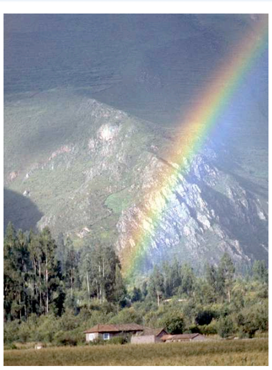
Just like a human!





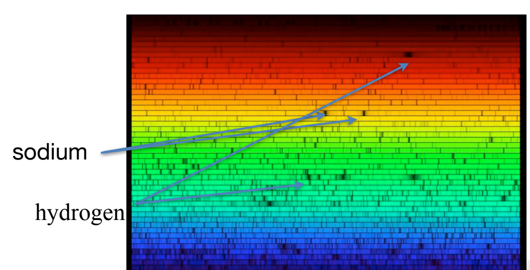






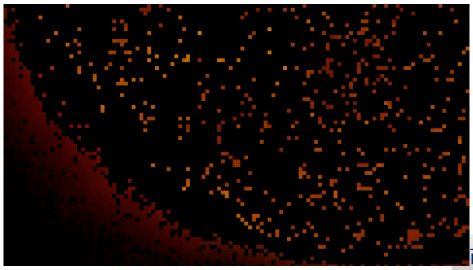
Start by splitting up the light

- We can look at the light from the sun
- Each line is corresponds to a particular element

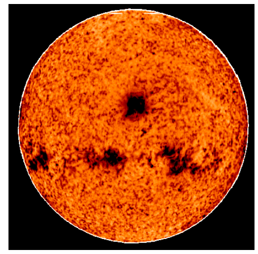


- So we can look at the hydrogen in the sun

- Hydrogen picks up the “prominences” very clearly



But we can look at the sun in different ways, so we can see how structure varies.



This is Helium:

Note the sunspots, where the sun is cooler (~4500°)

a “rösti” picture

BEYOND THE PODIUM

Since you asked: Rösti

A traditional Swiss potato dish that can be served as a crispy side dish or even as a snack. This recipe can also be enhanced with cheese, meat and vegetables if desired to make it into a tasty potato pizza.

Directions

Peel potatoes and shred using a food processor or a box grater. Hand or machine grate potatoes into strips similar to hash browns. If hand grating, grate the potato lengthwise for best results.
Place strips of potatoes into water to wash off excess starch. When finished washing, place shredded potatoes into a dish towel or cloth. Wrap tightly and wring or squeeze out excess water, making sure to remove as much as possible so cooking results are not affected by the excess moisture.
Crack egg into mixing bowl and whisk until smooth.
Add potatoes, ground pepper and salt, mixing all ingredients together well.
On stovetop, add 2 tablespoons of oil to a 10 inch non-stick skillet to be warmed on medium heat setting.
Add potato mixture to the 10 inch non-stick skillet, using a spatula to level the potatoes evenly across the pan. Since the potato mixture does not firm up after cooking only one side, the non-stick skillet will assist with the ease of turning the Rösti over when the first side if finished cooking. Cover pan and cook over medium heat for 6 to 8 minutes or until golden brown on bottom surface of potatoes. Remove cover and cook an additional 5 minutes.
Coat flat baking sheet with oil or cooking spray.
Remove skillet from stovetop. Using protective mitts or hotpads, place a flat baking sheet over the skillet. Hold baking sheet against skillet and turn skillet over so Rösti drops out of skillet onto baking sheet.
Remove bits of potato from skillet and place it back onto burner, adding remaining 1 tablespoon of oil.
Slide Rösti potato cake off baking sheet and into skillet, allowing uncooked surface to begin cooking.
Cook second side in uncovered skillet for 6 to 8 minutes, until golden brown. When finished cooking, tilt skillet and allow potato cake to slide out of skillet onto serving plate. Cut into 4 pie-shaped pieces and serve warm.

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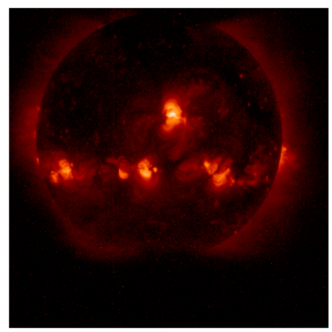


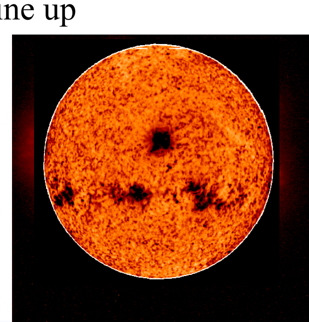
X-rays come from hot gas

Note the hot X-rays come from the cool sunspots

BEYOND THE PODIUM

And this shows the magnetic field

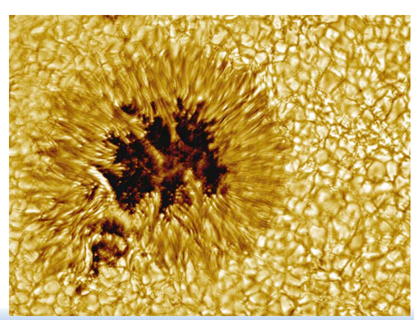
- Note how they all line up



- So the hot X-rays come from the cold sunspots
- And they are tied to the magnetic fields

YOND THE DIUM

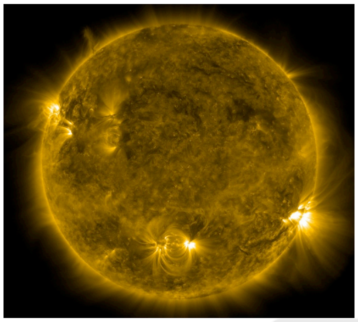
Sunspot close-up

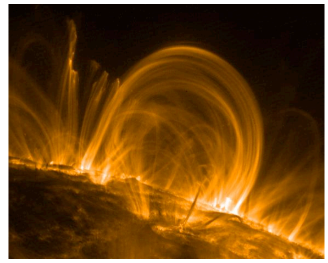


Credit: Vacuum Tower Telescope, NSO, NOAO)

BEYOND THE PODIUM

From the side we can see what the sunspots are





magnetic field is traced out by hot plasma

Loop of hot gas extends into the corona:

About 50000 km high.

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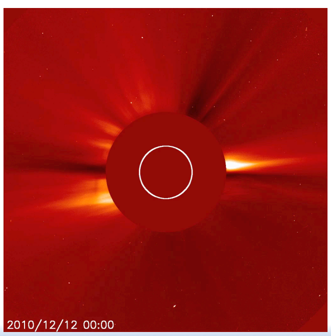
But magnetic fields are dynamic

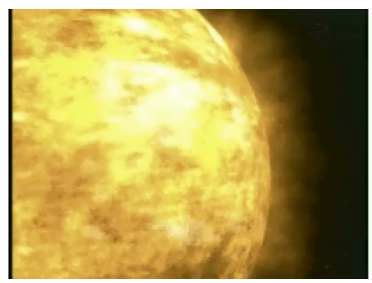


They can expand and squirt out gases or collapse and spray out high energy particles

Solar & Heliospheric Observatory (SOHO)

BEYOND THE PODIUM

Which travel towards the earth



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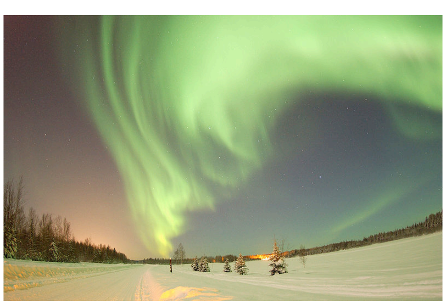
And become aurora



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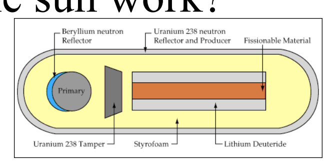
So how does the sun work?

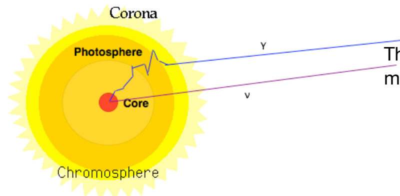
- Sun is ~ 90% hydrogen,
- ~9% Helium
- ~1% everything else
- It "burns" Hydrogen to Helium (almost the same reaction as a hydrogen bomb!)



BEYOND THE PODIUM

Every second the sun converts 4 million tons of matter into energy!

- And this is what keeps us warm!
- How do we know it's true?
- What really goes on in the core is a bit more complicated
- 4 protons become helium + 2 positrons (anti-electrons) + 2 **neutrinos**



The neutrinos produced at the centre make it to earth in 8 minutes

What Are Neutrinos?

- Neutral particles
- Very weakly interacting with matter
- If 100,000,000,000 neutrinos strike the earth, all but 1 will pass right through
- Must have very little mass, if any
- Seem to come in 3 distinct types – electron, muon, tau

One Trillion (roughly) go through your thumbnail each second

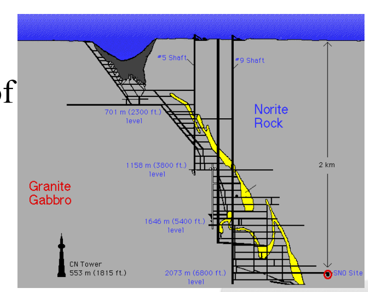
you hadn't noticed?

tsk tsk!

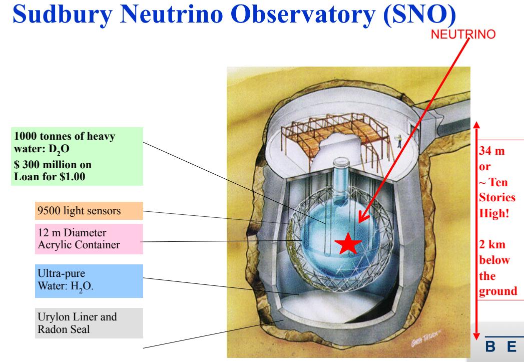
If we could see the neutrinos, we can see the centre of the sun, but they have almost no interactions!

Sudbury Neutrino Observatory

- Let's look at the sun through 2 kilometres of rock!!
- And use 1000 tons of heavy water as our detector



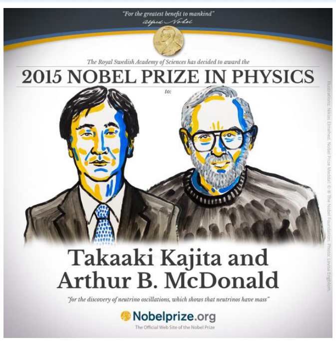
Sudbury Neutrino Observatory (SNO)



Neutrinos really come from the core of the sun, but they change into another kind on the way over

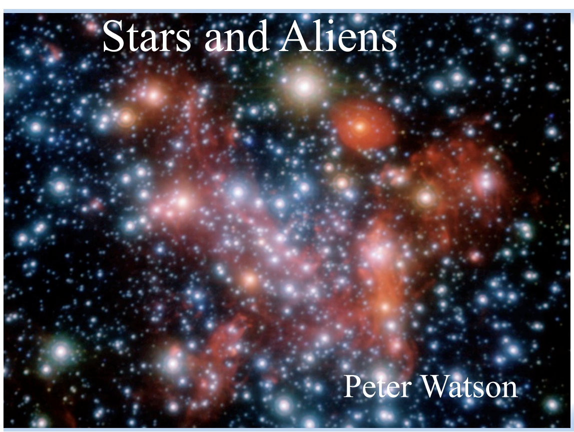
Why?
We Don't Know

Art McDonald,
Queens U
Nobel Prize for Physics 2015



At least I got
chocolate Nob e

but a mouse ate it



Carleton University

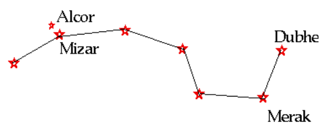
We have always divided the sky up into "patterns" or constellations

- But remember: The stars that make up Orion are random lights in the sky

They do not represent a mythic figure!

A long preamble...how do we name the stars?

- The brightest stars have names that derive from (usually) Arabic: e.g. Ursa Major



There is NO system for naming objects in the heavens
the same object can have several names!

e.g Sirius (Dog Star) is also

α Canis Majoris
α CMa
9 Canis Majoris
9 CMa
HD 48915,
HR 2491
BD −16Â°1591
GCTP 1577.00 A/B,
GJ 244 A/B
LHS 219
ADS 5423
LTT 2638
HIP 32349

Stars: some numbers

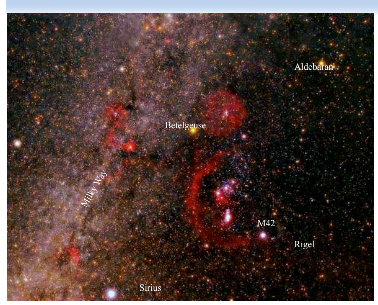
- Mass: will refer to mass of sun as $M_\odot$
- Jupiter ~ $M_\odot$ /1000
- Smallest stars (brown dwarfs) ~ $M_\odot$ /100
- Largest "normal" stars ~ 20 $M_\odot$
- Maybe R136a1 ~ 300$M_\odot$, but any star this size loses material very fast

Mass governs how a star works

- If M ~ $M_\odot$, ⇒ star like the sun
- If M ~ $M_\odot$ /10 ⇒ red dwarf
- If M ~ $M_\odot$ /100 ⇒ Smallest stars (brown dwarfs)
- If M ~ 20 $M_\odot$ ⇒ Supergiant (like Rigel or Betelgeuse)

Stars: some numbers

- Distance: light year is distance traveled by light in 1 yr
- Astronomers usually use the "parsec": 1 pc ~ 4 ly (thirty trillion km).
- Closest star (α Centauri) is at a distance of ~1.3 pc. Sirius is at about 5 pc.



We can see all this around Orion

Sirius; fairly dim star that is very close

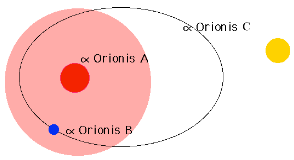
Rigel: blue supergiant: would be 1000 times brighter than Sirius if it were at the same distance

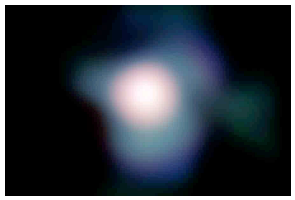
Betelgeuse: red supergiant:

10000 times larger than the sun

Orbits of Mercury, Venus, Earth and Mars would be inside it!

In fact it may be 3 stars!





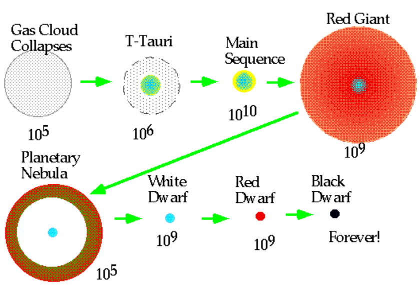
BEYOND THE PODIUM

Stellar evolution once over lightly:

- Stars are born, mature and grow old.
- We call this stellar evolution, which is stupid, since we don't talk about the evolution of a baby into an adult.
- Also note: **ALL** stars go through **ALL** the stages.
- We don't (usually) see them change because a human lifetime is so short compared to stellar

BEYOND THE PODIUM

Stellar evolution once over lightly:



Small stars (like the sun)
Times are approximate in years.

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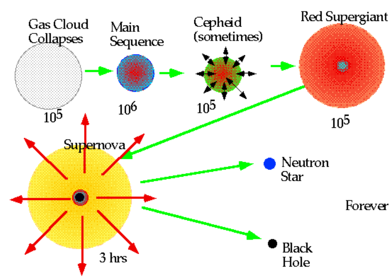
Big stars work much faster:



Live fast, Die Young!

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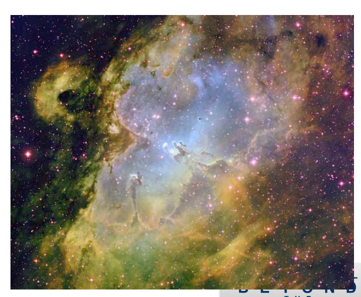
- M42 (Orion's sword) is a vast cloud of gas
- turning into stars as we watch

BEYOND THE PODIUM

Star Nurseries

- Eagle Nebula (M16)
- Cluster of stars just formed in centre of dark shell of dust and gas



BEYOND THE PODIUM

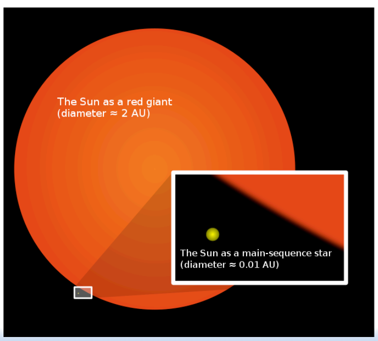
Star Birth: Stars are born from vast clouds of gas and dust

The Eagle's EGGs:

Evaporating Gaseous Globules (EGGs).

Very dense parts of the Eagle nebula form new stars which blow away the dust and illuminate the columns

Adulthood is dull

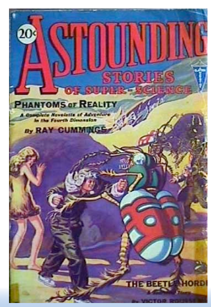


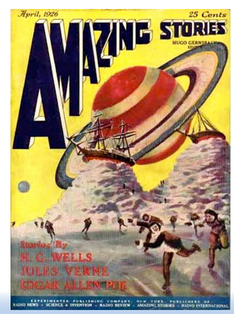
Don't we know it!

Finally star will run low on fuel and expand

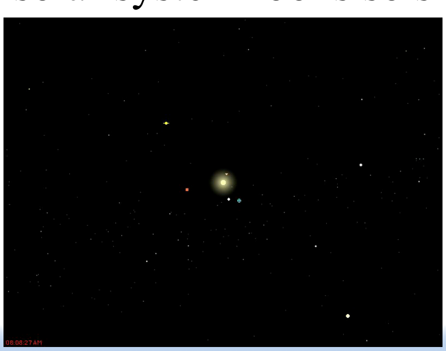
Becomes red giant

ET, phone home
Are we alone in the universe?

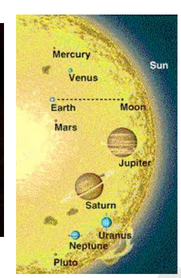




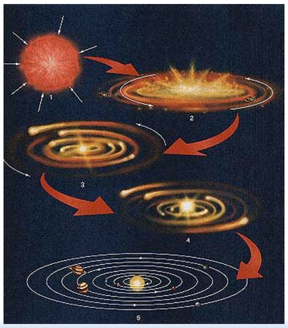
The solar system looks so simple



- How did it get that way....?



Star formation



A rotating gas cloud, compressed by a nearby supernova shock wave, starts to collapse.

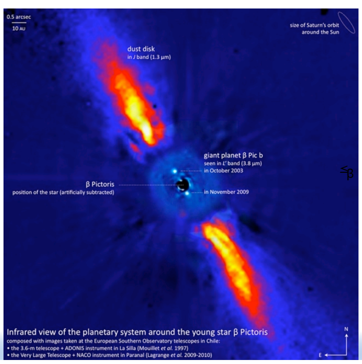
The central part collapses to the star.

http://scienceclass.ning.com/

Exoplanets: other solar systems

- first found around 51 Pegasi in 1995: 5 times as big as Jupiter

If we are lucky, we can see them directly



e.g β-Pictoris

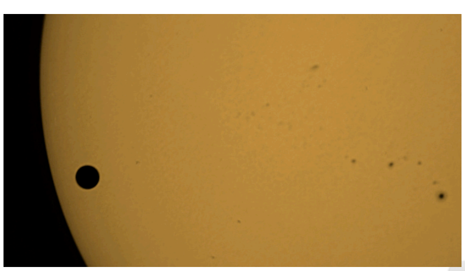
Young star

dust clouds

giant planet

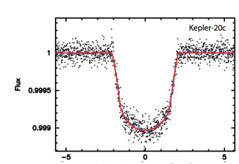
Now we are seeing lots of other solar systems

Like this! (except this is our sun and Venus, June 5)

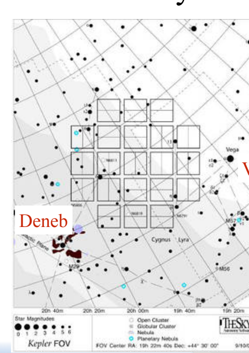


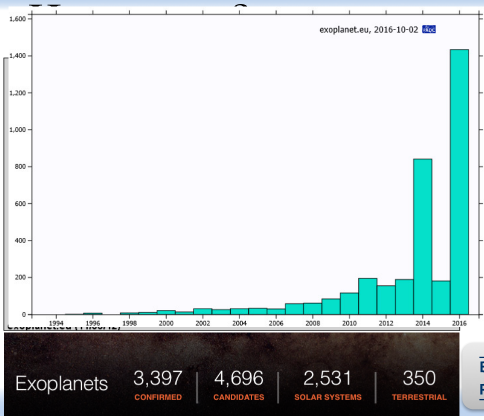
Picture by Etienne Rollin

Kepler observes 150000 stars every 30 mins.

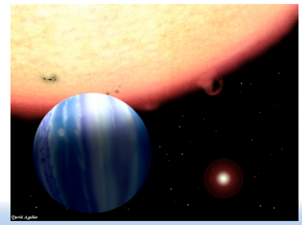


- Note 0.1 % change
- 4 hours
- symmetrical shape

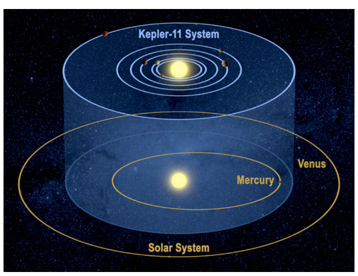




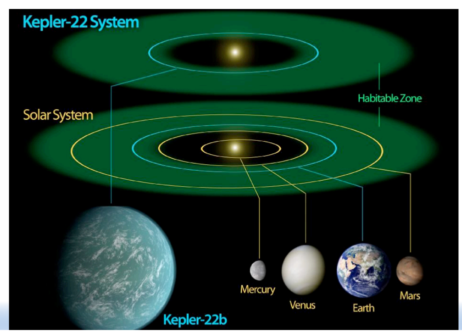
- Orbit has to be aligned with earth
- Need to see several transits
- Does best with large planets, close to star
- “hot jupiters”



Kepler 11 has at least 6 planets



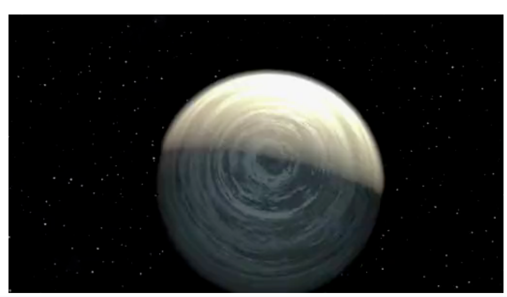
- Kepler 22b: first earth-sized planet in Goldlilocks zone (not too hot, not to cold!)



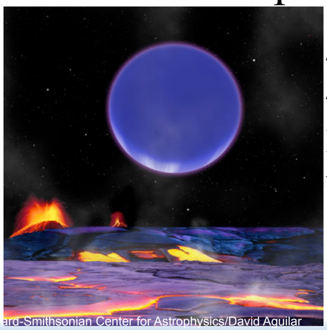
So planetary systems are common: do they look like ours?

Not really

- Planets in orbit round binary (double-star) systems: Kepler 16b

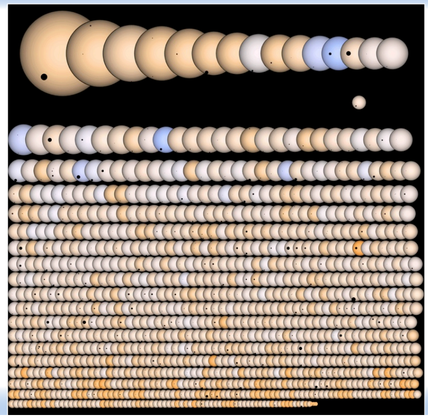


Kepler 36



~Earth sized planet +
~Neptune sized planet

Every 97 days approach to ~1.5 million km



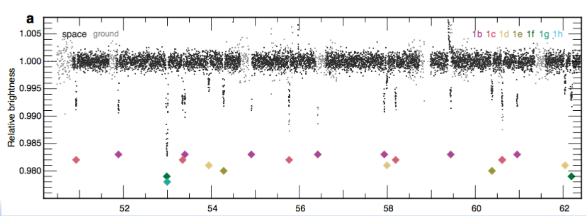
Kepler has found lots!

nearly 2300 confirmed and candidates

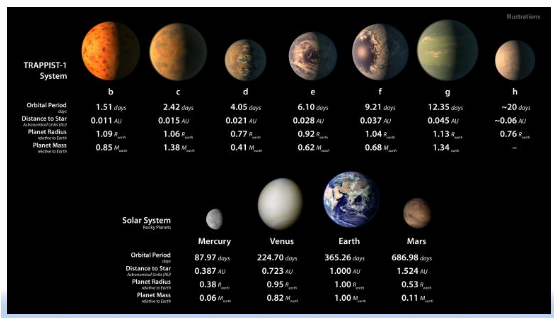
And now.. (Feb 2017)

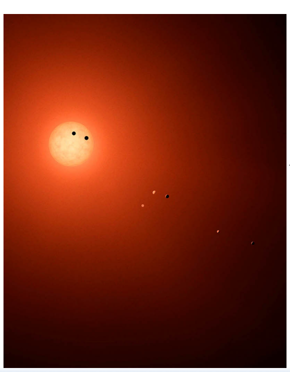
- TRAPPIST-1 system

Transiting Planets and Planetesimals Small Telescope



- 7 planets, all within orbit of Mercury
- Several in Goldilocks zone





Like this!

Star is cool red dwarf

Not what we would expect for life support

Conclusions

- Based on a very small # of stars and short observing time, it seems likely ALL stars have planets
- We haven't had time to observe orbits of longer than a year or so
- Maybe more than 100 billion planets in the Milky Way

Where are they? Enrico Fermi

- How many advanced civilizations are there in our galaxy (50 billion stars)?
- Depends on how many have planets, how many develop life, how many develop intelligent life, how many want to talk to us, how long civilizations last….

BEYOND THE PODIUM

- f_c = (prob. that intelligent life can communicate across space) =5%
- L = (lifetime of intelligent civilization) =3500 yrs
- Total number of civilizations in our galaxy at the moment?

- 42!!!!!!!!!!!!
  - Well, you decide which number I got wrong!

BEYOND THE PODIUM

CelebrityLife Activities

BEYOND THE PODIUM

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