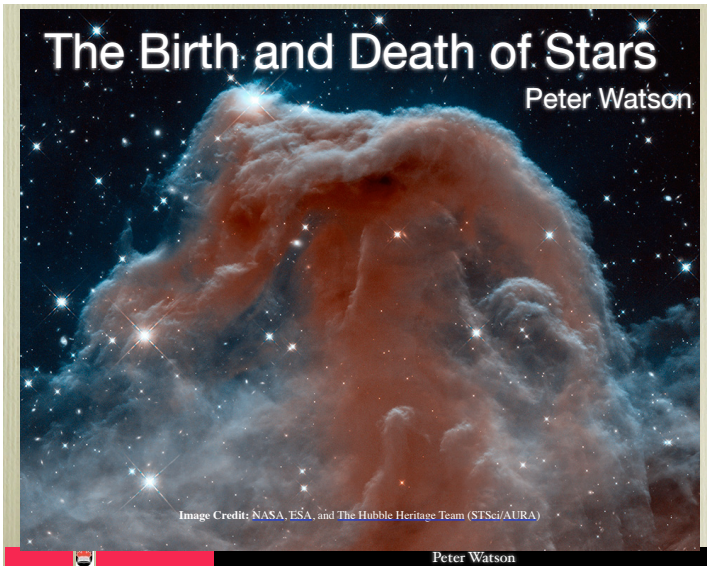
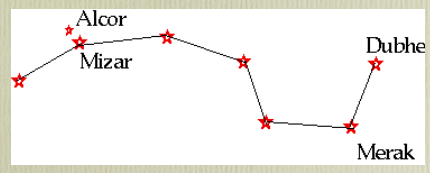
The Birth and Death of Stars

Peter Watson



Preamble...how do we name the stars?

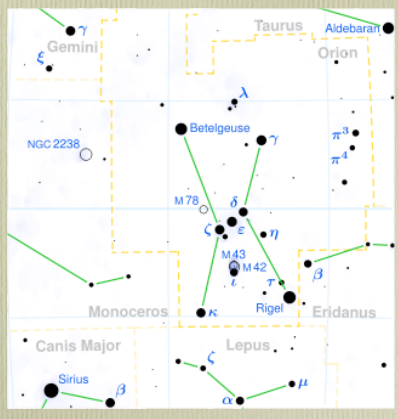
- The brightest stars have names that derive from (usually) Arabic: e.g. Ursa Major



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!



- Later: stars named with Greek letters, in order of brightness
- α-Orionis = Betelgeuse
- β-Orionis = Rigel

So what is the system?

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

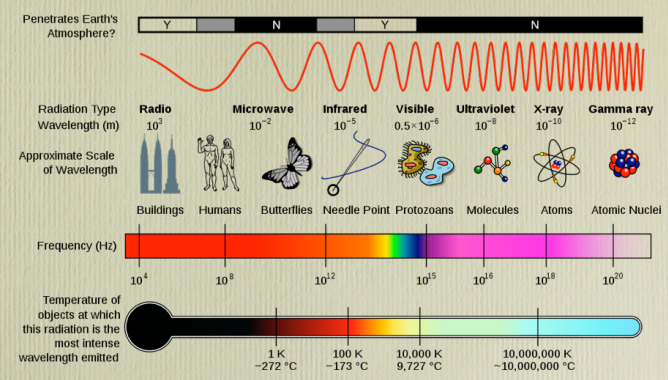
e.g Sirius (Dog Star) is also

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

And the most important thing we learn from playing with fire

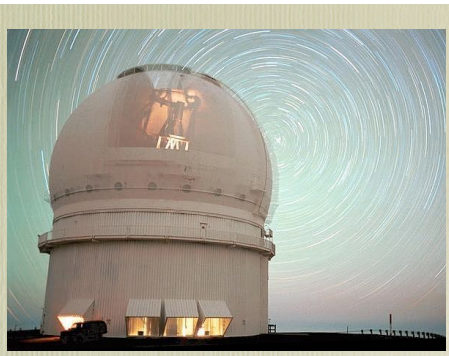
- What's hot and what's not: roughly
- red is 800°C
- orange is 1500°C
- yellow is 2000°C
- blue is 15000°C
- X-rays are 1 million °C



We can use all the wavelengths but we have to be clever!

- Radio at Sea-level
- Large dishes, many hooked together (VLA)

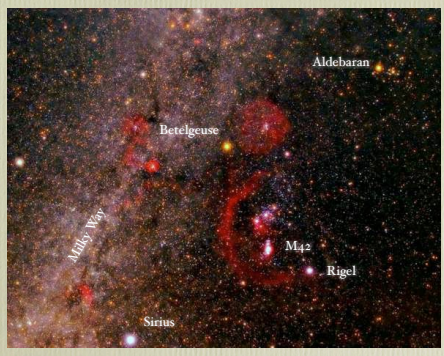
Canada-France Hawaii telescope



- Infra-red absorbed by atmosphere
- so go mountain top, since H_20 is worst offender

and above all, the Hubble which sees in the UV and IR and is above everything!

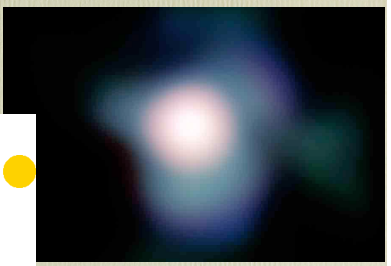
- Around Orion
- Sirius; fairly dim star that is very close
- Rigel: blue supergiant: really 1000 times brighter than Sirius

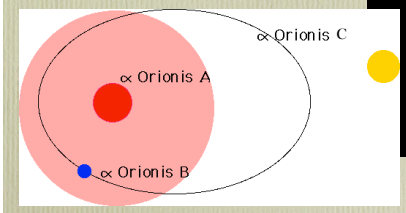


Betelgeuse: red supergiant, 10000 times larger than the sun

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

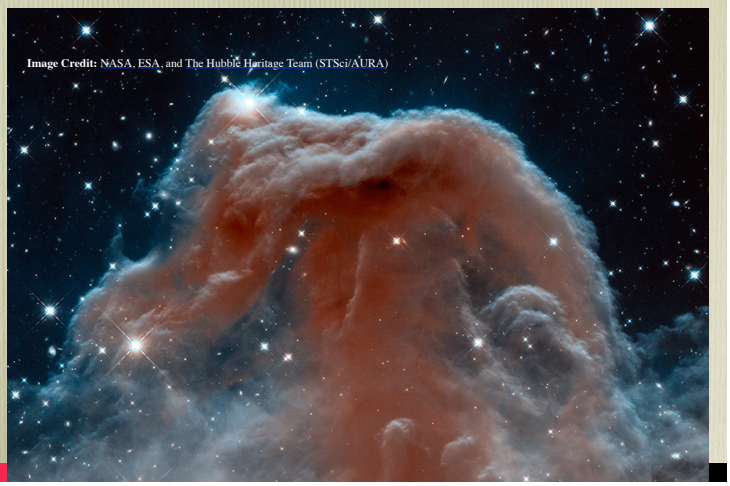
In fact it may be 3 stars!





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

The Horsehead Nebula (part of M42) in Infrared from Hubble



Sun is a typical star

- Will talk about stars having a mass of e.g. 10 M_{sun}
- Jupiter ~ M_{sun} /1000
- Smallest stars (brown dwarfs) ~ M_{sun} /100

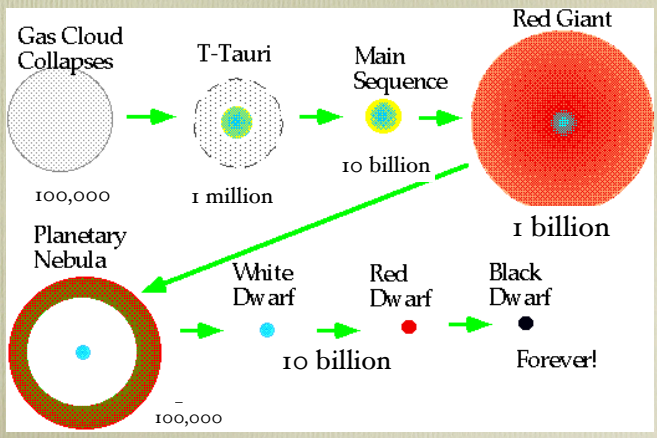
Stars: some numbers

- Distance: we use the "parsec" (don't ask!): 1 pc~ thirty trillion km
- Closest star (α Centauri) is at ~1.3 pc. Sirius is at about 5 pc.
- Time: One million years (1 Myr) is fairly short

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

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



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

Credit & Copyright: T. Rector (U. Alaska Anchorage), Gemini Obs., AURA, NSF

Star Nurseries

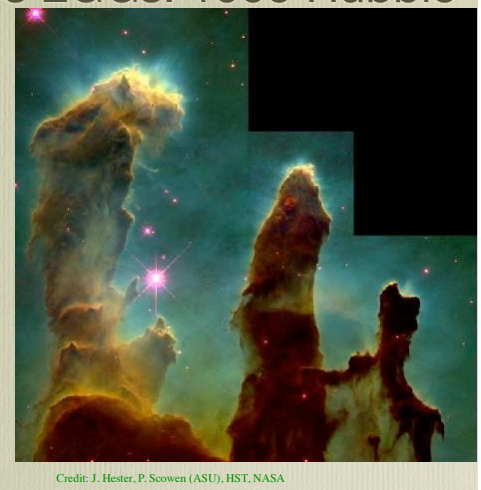
- How much better is Hubble?
- Not quite fair, but this shows two pictures of the same region of the sky
- M16 aka the Eagle nebula: large star forming region

Eagle Nebula: 1980's

- still on film
- red is hydrogen gas, heated up by young stars

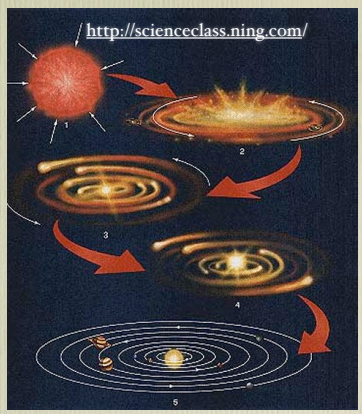
The Eagle's EGGs: 1995 Hubble

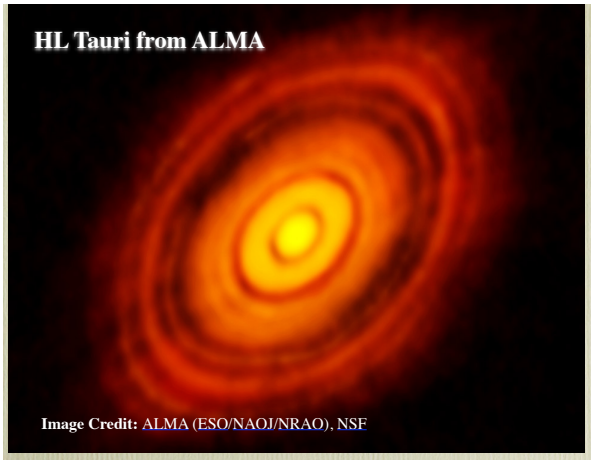
- Evaporating Gaseous Globules (EGGs).
- Very dense parts of the Eagle nebula form new stars which promptly blow away the surrounding dust and illuminate the columns



Credit: J. Hester, P. Scowen (ASU), HST, NASA

- A spinning gas cloud starts to collapse.
- The central part collapses to the sun.
- Outer parts condense into planets

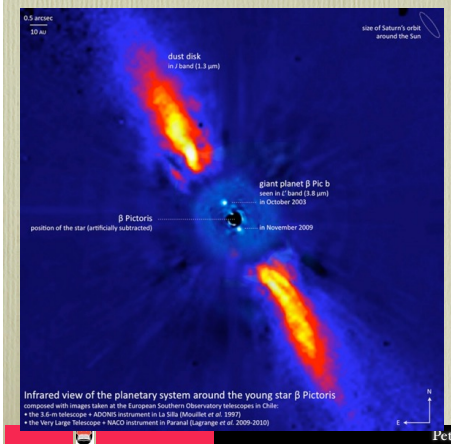




Star has just got going:
we can see the disc of hot gas forming planets

PW

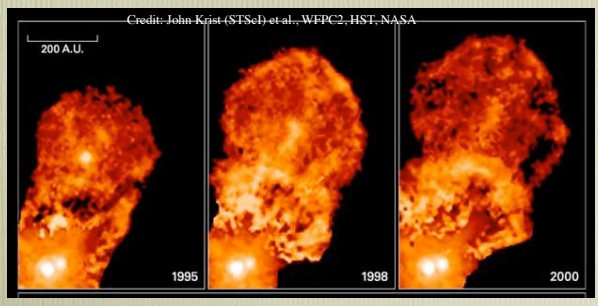
An (amost) new-born star: β-Pictoris



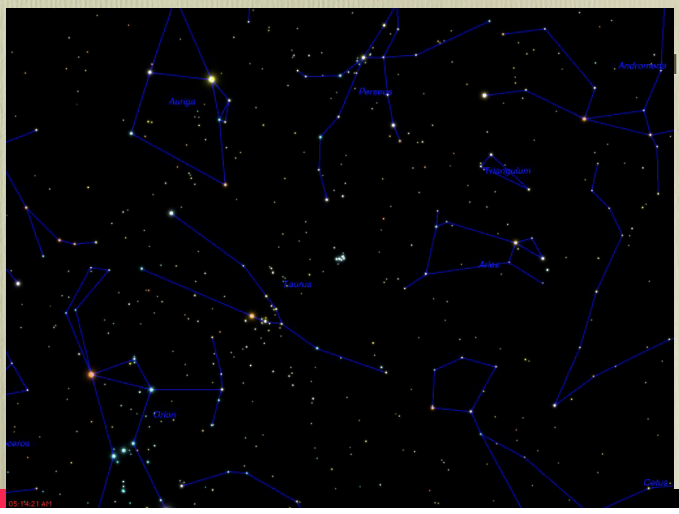
- still surrounded by dust
- But it's had time to form at least one giant planet
- so are planets common?

Teenagers

- XZ Tauri: 2 very young unstable stars, separated by about Sun-Pluto distance, emitting vast cloud of gas
- (pictures taken over 5 years)

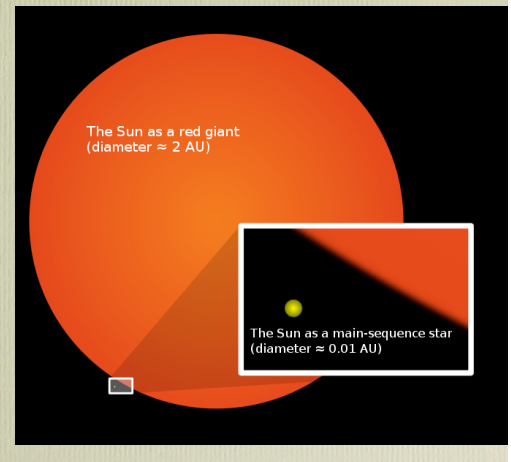


The Pleiades



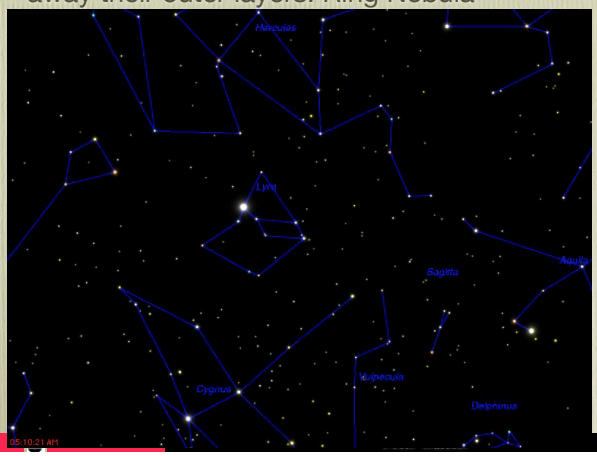
Adulthood is dull

- Don't we know it!
- Finally star will run low on fuel and expand
- Becomes red giant



The Death of Stars

If stars are small, (like the sun, they puff away their outer layers: Ring Nebula

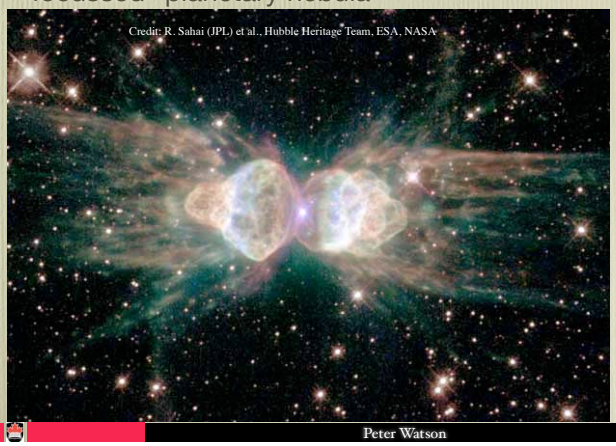


- "Planetary nebula"
- Central star is a white dwarf (50000°C)
- Hot blue gas at centre
- Coolest red gas along the outer boundary.

- This will happen to the sun, in 5.5 billion years.
- The star blows away its outer layers, so almost all the older ones we knew look like this.

Peter Watson

- Mz3: The Ant Nebula.
- Probably magnetic field is creating a "focussed" planetary nebula

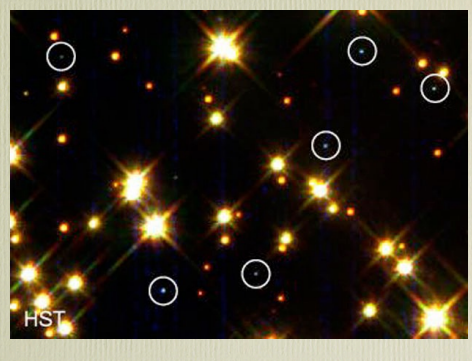


Peter Watson

White dwarfs

- Outer shell dissipates, remnant star has about the same mass as sun but size of earth (~10000 km)
- Density: ~1 million: ~ 100,000 times as dense as lead.

This shows some in M4 (a dense cluster of stars). Small, so cool very slowly.

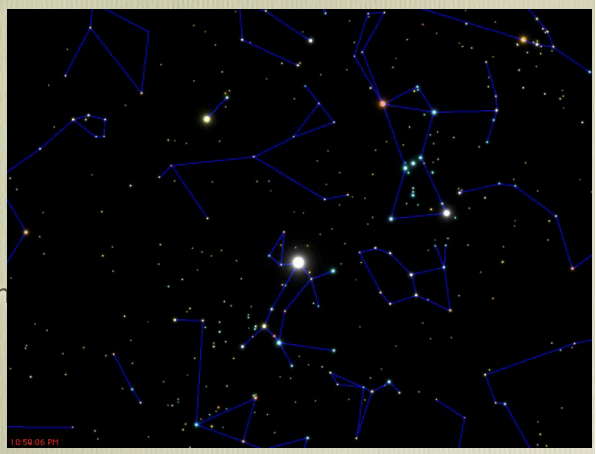


Peter Watson

Sirius

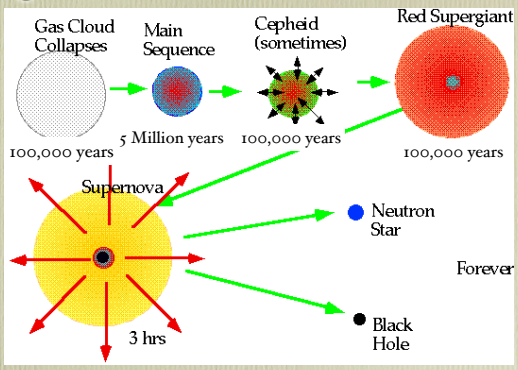
Brightest star in the sky

Has an almost invisible companion white dwarf



Peter Watson

Big stars work much faster:



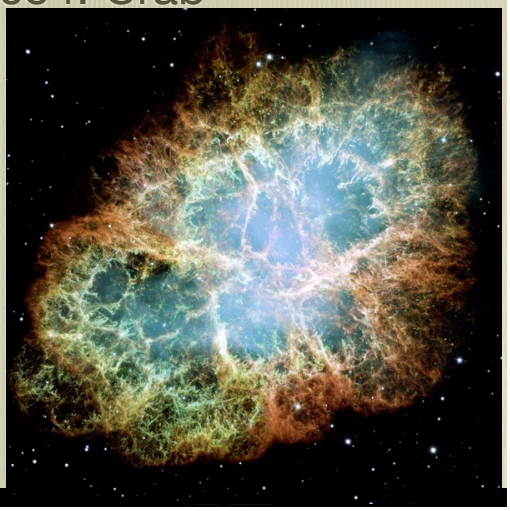
Live fast, Die Young!
Lifetime can be just 10 million years
How do they die?

If Stars are large....

- we get supernovae
- 6 visible in Milky Way over last 1000 years
- SN 1006: Brightest Supernova.
- Can see remnants of the expanding shockwave

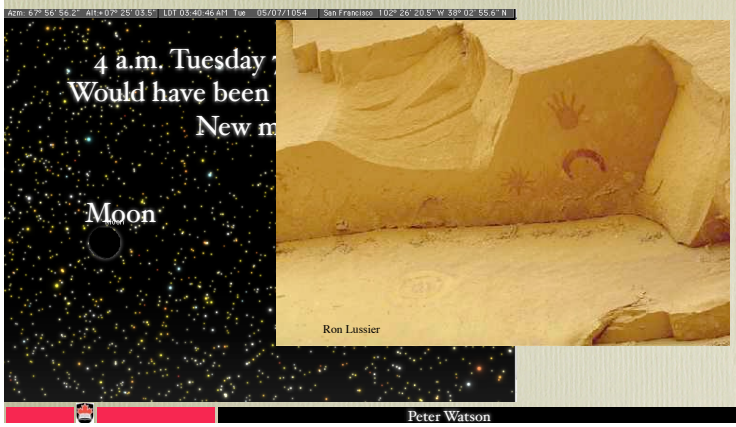
1054: Crab

- X-rays (in blue)
- + Optical
- Tangled appearance due to trapped magnetic field

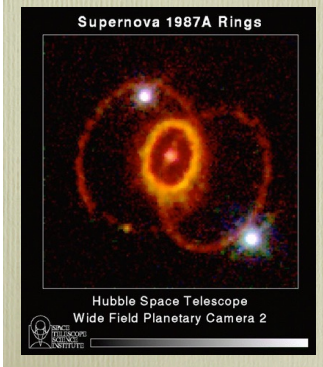


Recorded by Chinese astronomers as "guest star"

May have been recorded by Chaco Indians in New Mexico



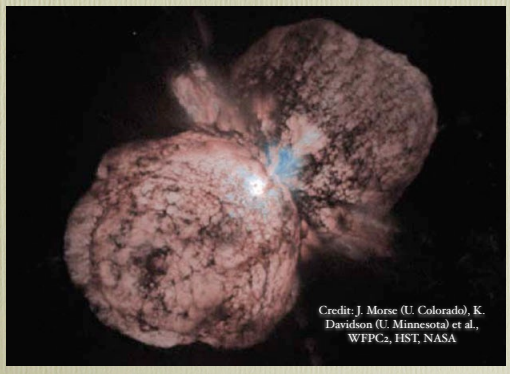
- Most recent close one was SN1987a
- Must have blown up earlier, leaving ring of material, now illuminated by new shock wave



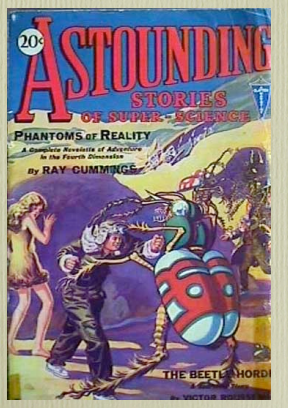
Credit: P. Challis, R. Kirshner (CfA), and B. Sugerman (STScI), NASA

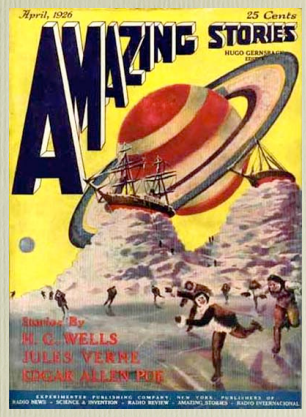
We would like to catch supernovae before they explode

Eta Carinae blew off a lot of material 150 years ago: probably pre-collapse now



ET, phone home
Are we alone in the universe?

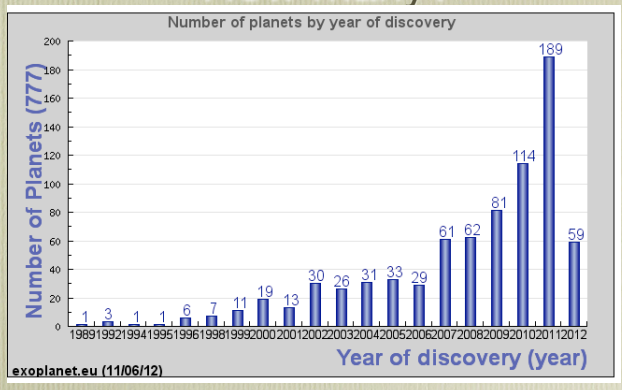




Now we (can see) lots of other solar systems

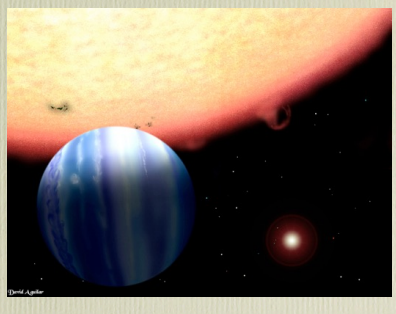
Picture by Etienne Rollin

How many?

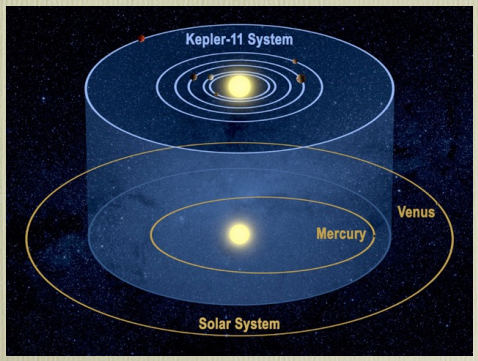


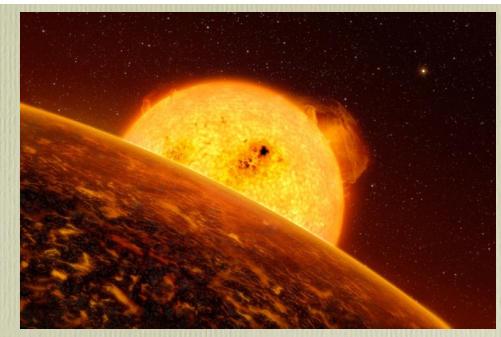
Note: even this is an underestimate:
Kepler has 2321 candidates, ~~61~~ 74 confirmed

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



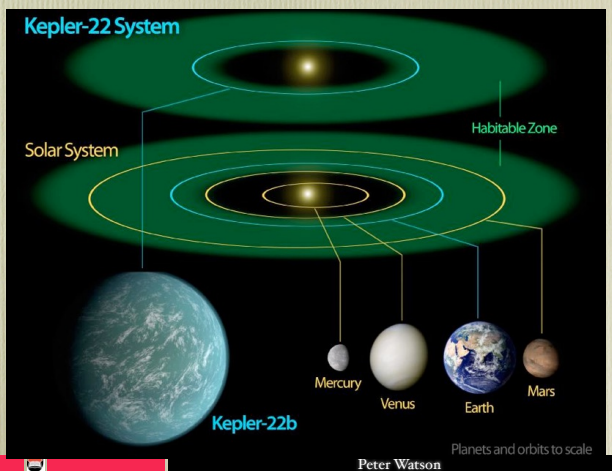
Kepler 11 has at least 6 planets





- CoRoT-7b
- mass ~ five Earth, radius~ 1.7 Earth
- year lasts ~20 hours
- FAR too hot (1500°)

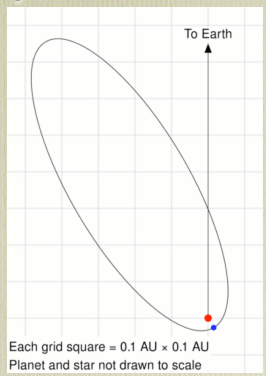
- Kepler 22b: first earth-sized planet in Goldlilocks zone (not too hot, not to cold!)



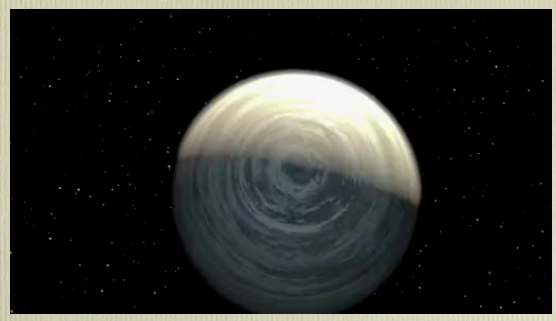
So planetary systems are common: do they look like ours?

Not really

- Lot of stars have hot Jupiters
- Some don't know they should be in circular orbits!
- HD80606b goes from 500°C to 1200°C in 6 hours
- Lots go backwards

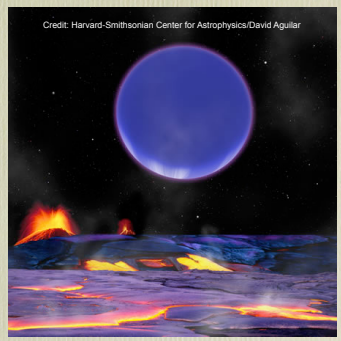


- Planets in orbit round binary (double-star) systems: Kepler 16b



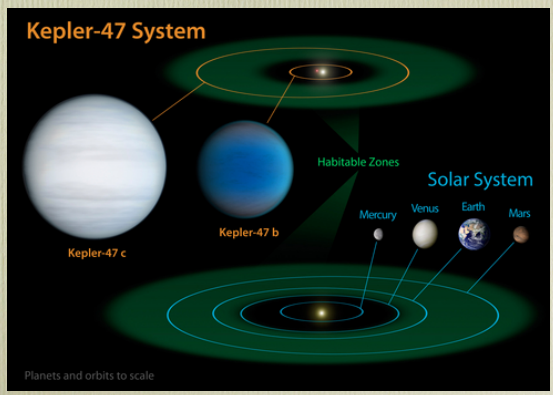
Kepler 36

- ~Earth sized planet + ~Neptune sized planet
- Every 97 days approach to ~1.5 million km



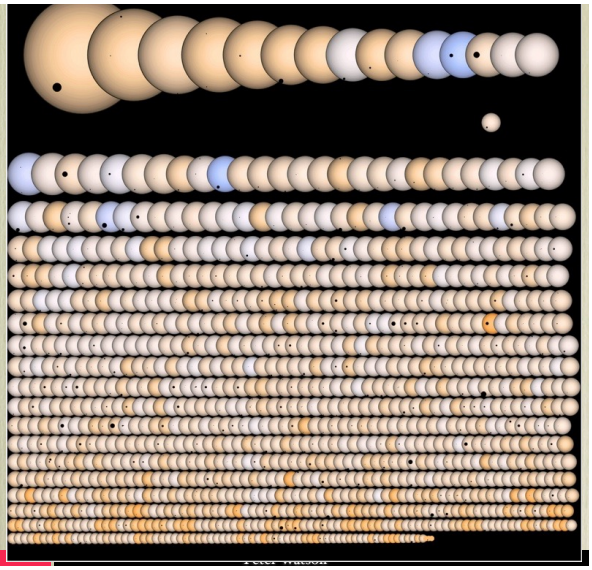
Kepler-47

- First Binary Star 2-Planet System



Kepler has found lots!

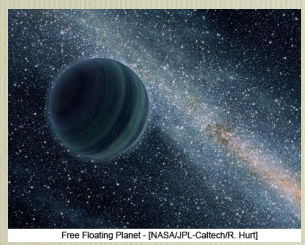
nearly 2300 confirmed and candidates



Conclusions

- 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

- There may be many planets that don't orbit stars
- A real αστήρ πλανήτης *(astēr planētēs)*, meaning "wandering star"
- Except we have defined planets to be in orbit round stars!



Free Floating Planet - [NASA/JPL-Caltech/R. Hurt]

Sources: most pics from

APOD (Astronomy Picture of the Day)

NASA

European Space Observatory

David Malmin

If you want to play games with the data, try http://exoplanets.org/plot/

http://exoplanet.eu/index.php

- BBC Future allows you to play with the Drake equation

And next time we'll look at

Physics as a Creation Myth

Today in History

- from "Britain Today"
- in 1612 Galileo became the first to observe the planet Neptune..