Announcements

- Nothing due on Friday
- Test 2 on Friday!!
  - Solar System material (Ch7-14)
  - All review materials posted (with solutions)
  - Equation page updated
  - Email me if you want to reserve one of my few calculators for Friday
- Polling: `rembold-class.ddns.net`

Review Question!

Our Sun is powered by:

A. Fusion

B. Fission

C. Gravitational Collapse

D. Solar Power

Review Question!

Our Sun is powered by:

A. Fusion
B. Fission
C. Gravitational Collapse
D. Solar Power

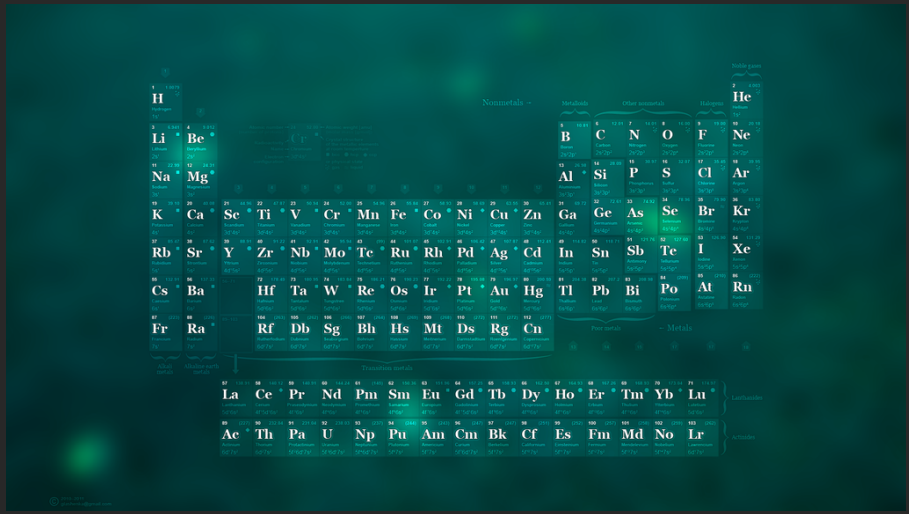
Fusion Power!

- The interior of the Sun is very dense, very hot, and very Hydrogen
- Packs lots of protons close together and moving real fast
- When protons get close enough:
  - Bang! Fusion happens!
  - Energy is given off!
  - The cycle continues...

The Sun is a Mass. . .

https://www.youtube.com/watch?v=me06I9GDM_k

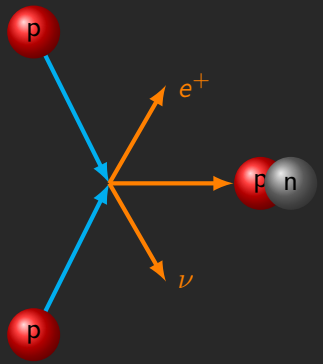
Fusion vs Fission: The Periodic Table



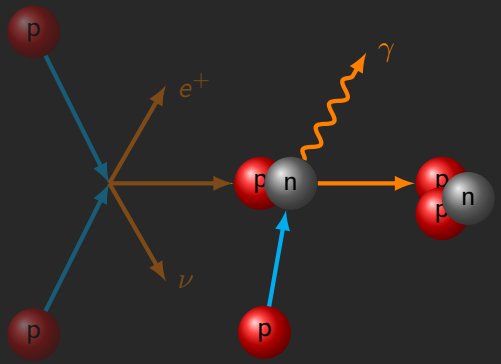
Fusion vs Fission: The Periodic Table

Fusion vs Fission: The Periodic Table

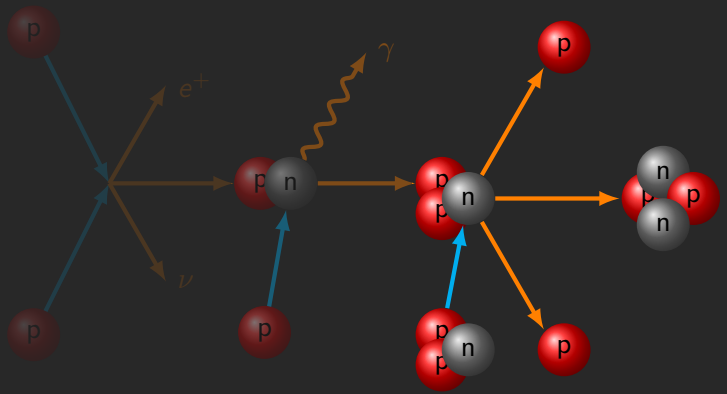
Powering Your Sun: A 3 Step Process



Powering Your Sun: A 3 Step Process



Powering Your Sun: A 3 Step Process



$$4\left({}^{1}_{1}\mathrm{H}\right) \rightarrow {}^{4}_{2}\mathrm{He} + 2e^{+} + 2\nu + \gamma$$

Taking things slow. . .

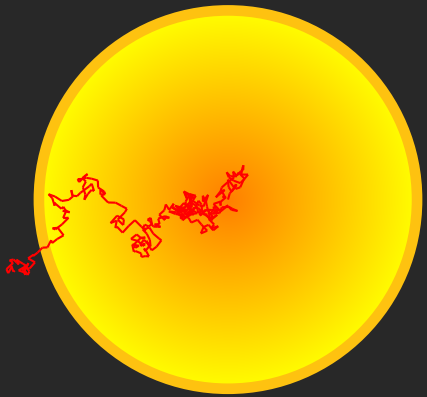
- The full 3 step reaction is actually quite slow!
- First Step:
  - The tricky one
  - Need both to get really close AND need the proton to decay into a neutron
  - Takes over a billion years!
- Second Step:
  - Quite fast
  - About 1 second
- Third Step:
  - Slow again, but 1000$\times$ faster than Step 1
  - About a million years
- The sheer number of protons is what maintains such a high energy output!

The Photon Trail...

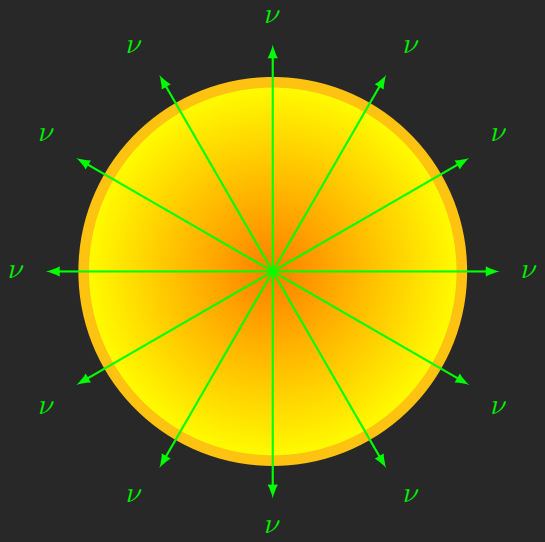
- Our mechanism for fusion releases much of the energy in gamma rays
- But Gamma Rays are not the majority of what we see coming out of the Sun! (Thankfully!)
- Something else must be happening enroute
  - Not much between us and the Sun, so most likely in the Sun itself

. . . a crooked path

- Gas below photosphere is very dense and ionized
  - Photons interact with charged particles
  - "Scattered" by nuclei and electrons
  - Results in a "random walk" to the surface
- Energy produced in the core thus takes many thousands of years to reach the surface
- The photons we see on Earth tell us about the *photosphere*
- We do *not* get to see into the core



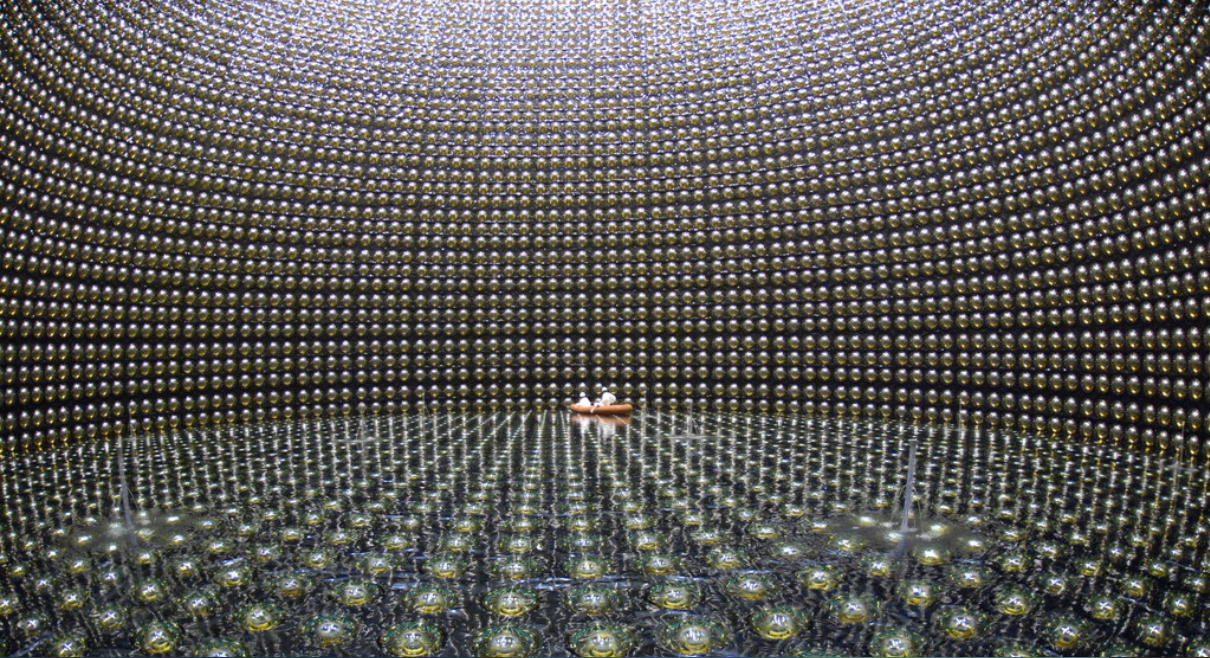
Nature's Atomic Hermits



- Neutrinos are notoriously inactive
  - They generally don't interact with anything
- This makes them very tricky to detect
- But they COULD show us the core of the Sun!

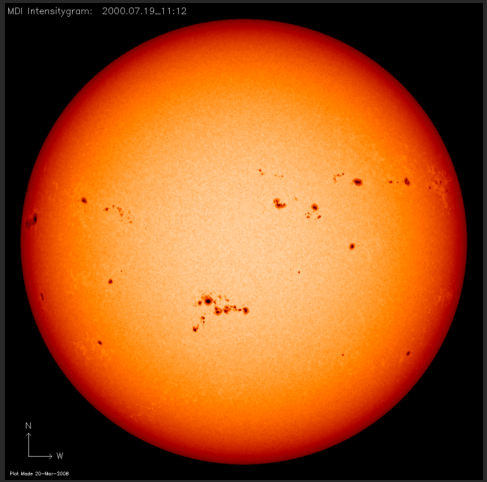
Catch a Neutrino by its tail. . .

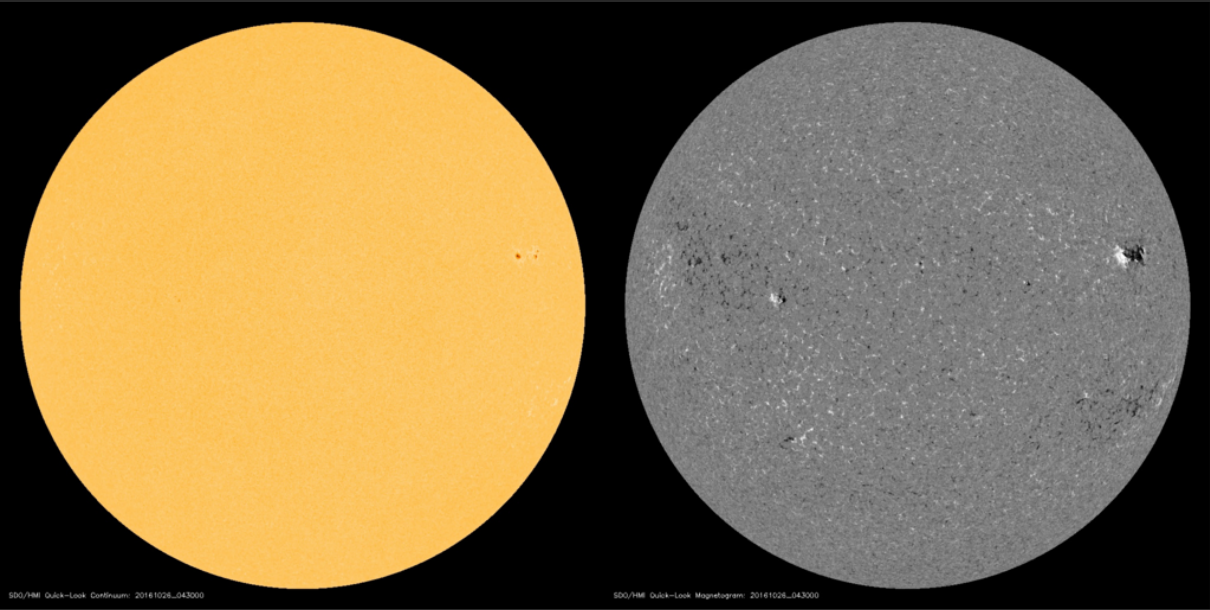
- Find an isolated area
  - Generally underground, away from other radiation
- Build a BIG detector
  - A neutrino interacting is a rare event, the bigger the detector, the better your chances
- Variety of detection methods
  - Checking huge vats of chlorine for traces of argon caused by a neutrino interaction
  - Looking for traces of light from Cherenkov radiation, when a charged particle travels fast than light *in that medium*, usually water or ice (Antarctica)



Can't Change Your Spots (But the Sun can!)

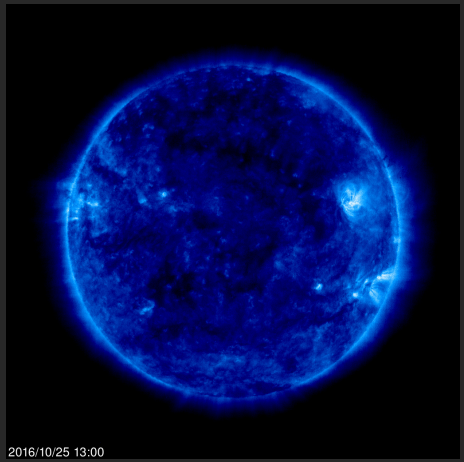
- Sunspots are dark patches on the surface of the photosphere
- Darker because they are cooler ($\approx 4000\,\mathrm{K}$)
- Something must keep the cool gas from mixing with the surrounding hotter gas!




SDO/HMI Quick-Look Continuum: 20161026_043000
SDO/HMI Quick-Look Magnetogram: 20161026_043000

The Sun's Magnetic Fields

- Sunspots give us a way to see parts of the Sun's magnetic field!
- Often come in pairs, one for each magnetic pole
- Seem to be loops where the magnetic field can connect



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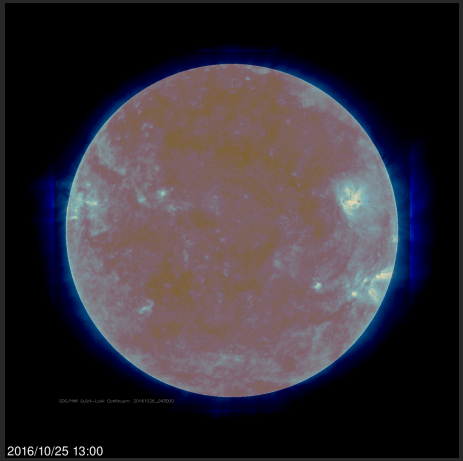

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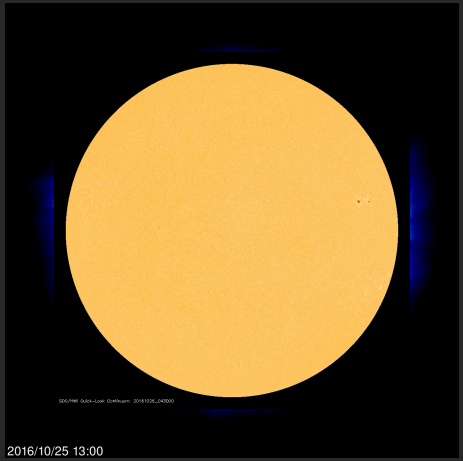
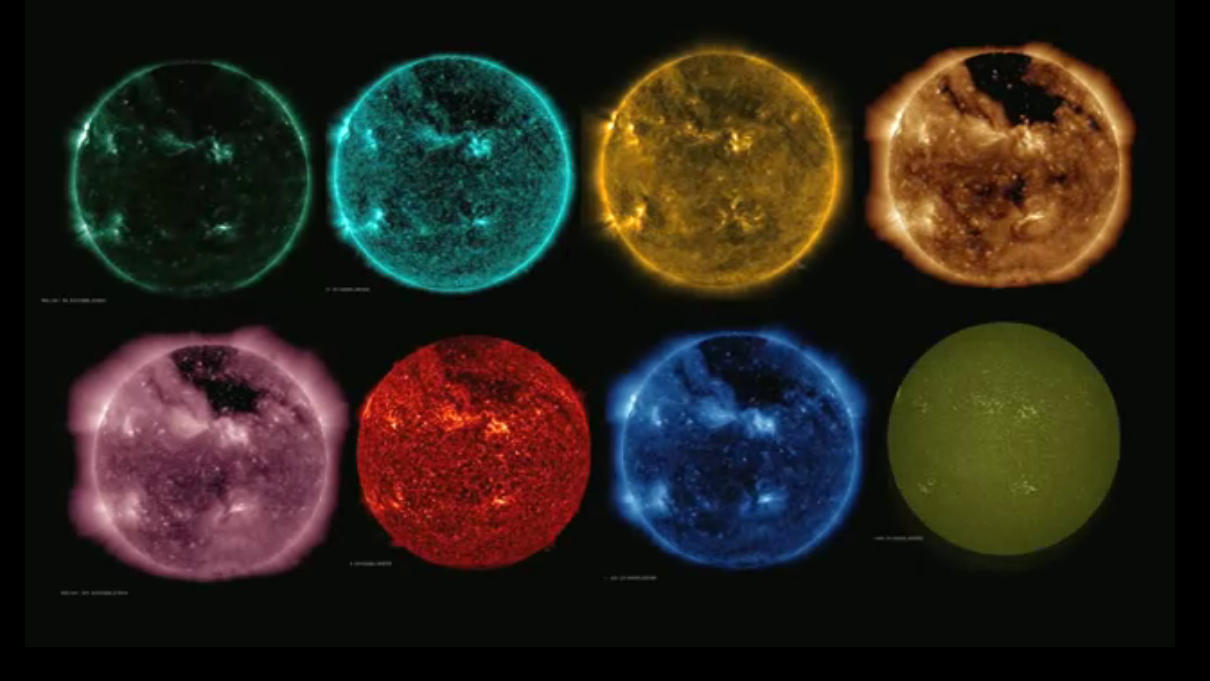


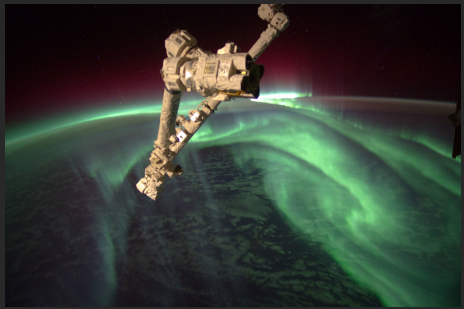


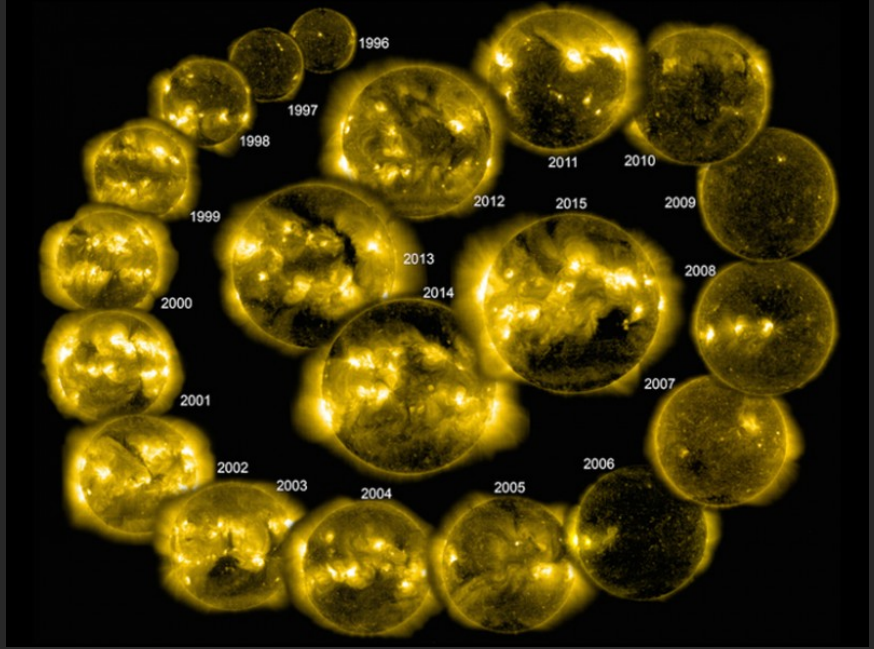
Flareon

- Most flares occur near sunspots, implying a connection to the magnetic field
- Unlike the Earth, the equator of the Sun rotates faster than the poles!
  - Think tradewinds on Earth, but the entire Sun is a gas
- Gases tend to drag the magnetic field with them
- Things can get very tangled, and flares are though to be a way of rearranging magnetic field lines to untangle them

Effects on Earth

- Communications
- Aurora

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