The Death of the Dinosaurs and Mankind?

Holland America Line
A Signature of Excellence

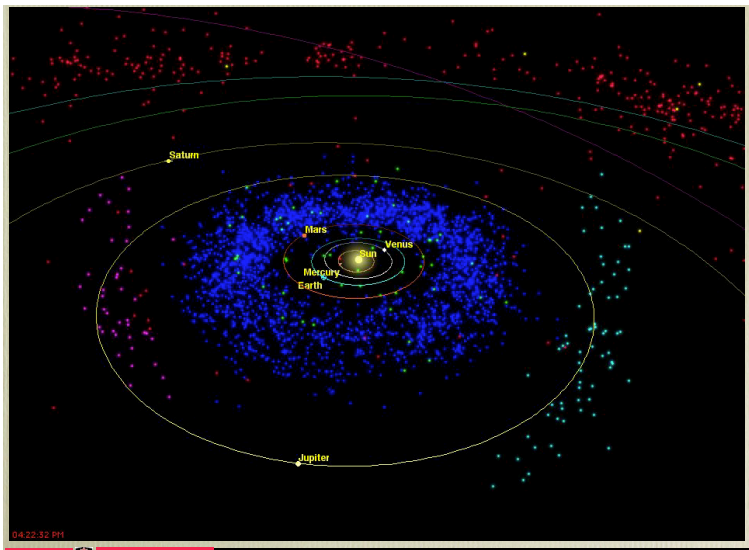
Correction

- 1920's Goddard
- First Liquid Fueled Rocket

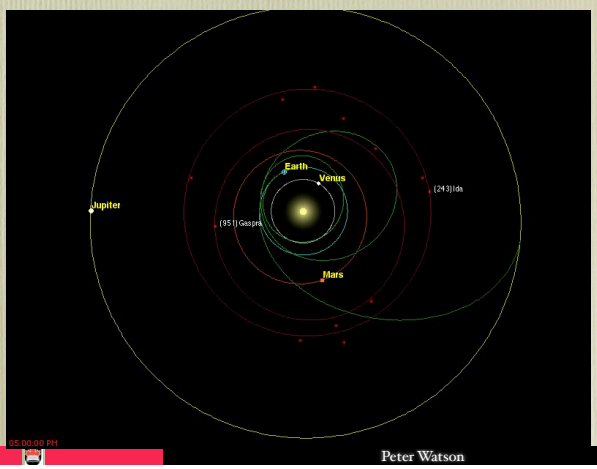
Launched from Auburn Mass.

Asteroids

- Planetoids mainly lie in belt between Jupiter & Mars
- Ceres (~900 km radius) biggest
- Total mass much less than Mercury

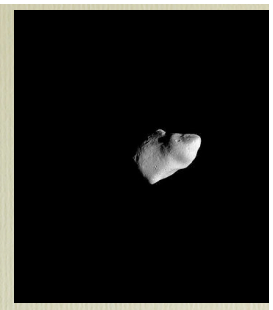


Galileo, the space probe



Galileo took a quick look at 2 asteroids on the way out

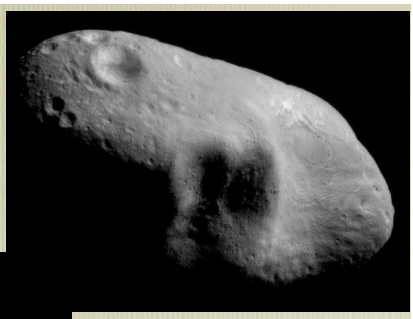
Gaspra



- And Ida and its moon, Dactyl.

Eros (like all the asteroids) is a lump of rock

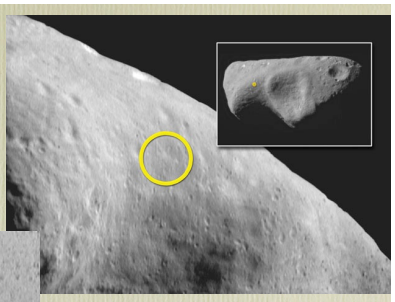
Was used to measure Earth-Sun distance very accurately

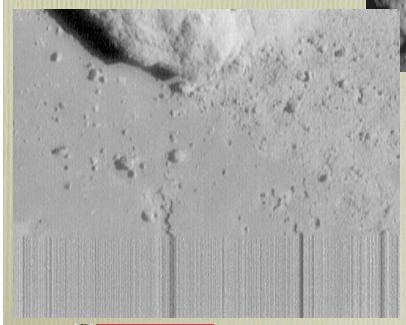


- We can even watch it rotate

And we even landed on it

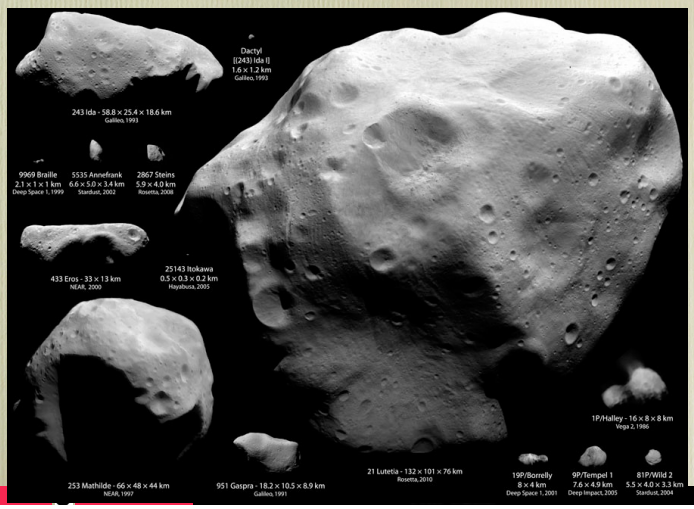
4th object (after the Moon, Mars and Venus) in the universe!



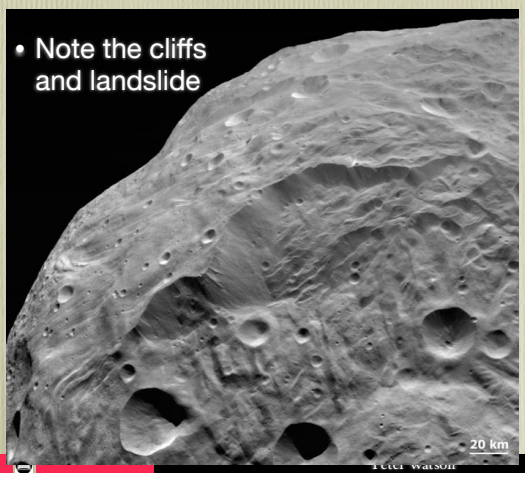


But a bit too hard!

Now we have visited lots of others

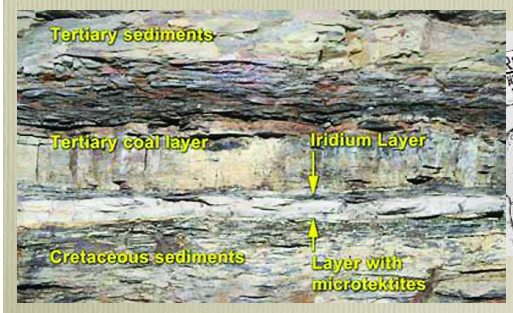


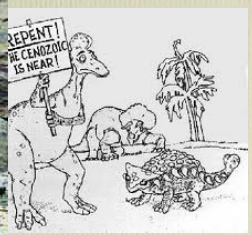
And last year, Vesta



What killed the dinosaurs?

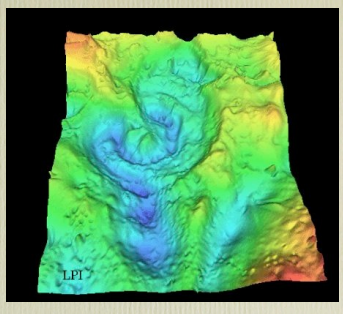
- Dinosaurs vanished in "K-T event" about 69 million years ago
- Iridium-rich layer of clay found all over North America: thickest (1 m) in southern states





- also visible in Alberta (Tyrell museum)

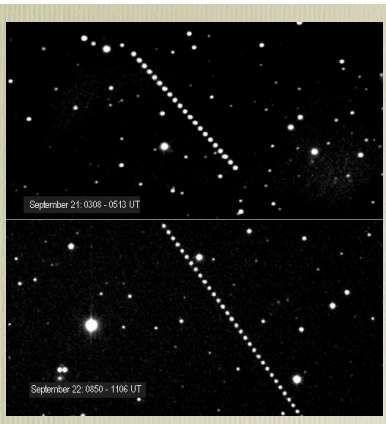
- Alan Hildebrand found a 65 million year old, 112 mile wide ring structure off Yucatan
- Chicxulub crater due to impact of an object of 10-25 km radius
- Suggests that dinosaurs died out due to impact + material ejected into atmosphere



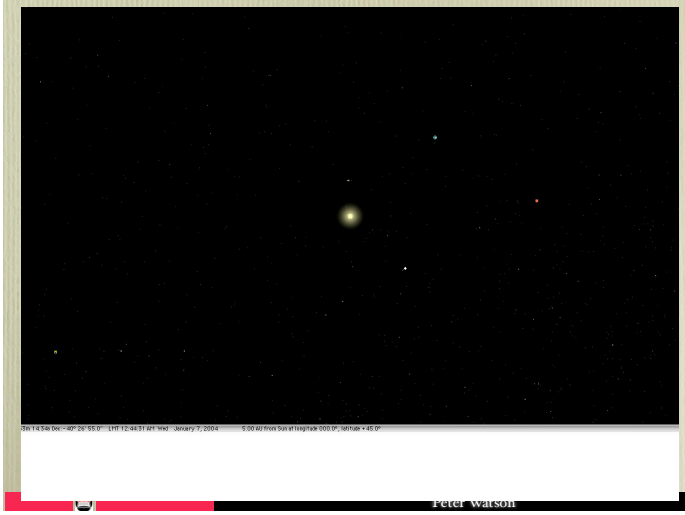
- Manicougan crater in Northern Quebec
- Can only be seen from space.
- ~ 200 Million years old.

Much more important: can it happen again?

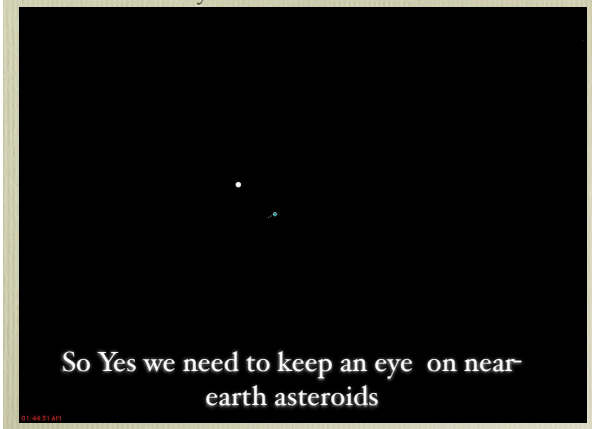
- This is Toutatis
- ~ 1000000 km from earth



How close was Toutatis?

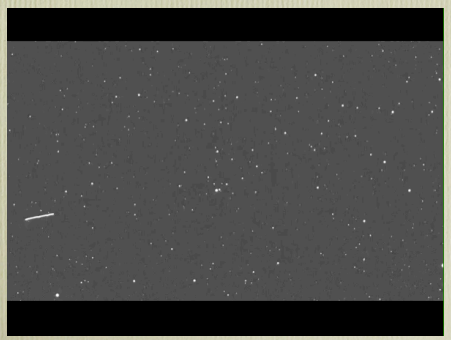


- But actually it wasn't that close!

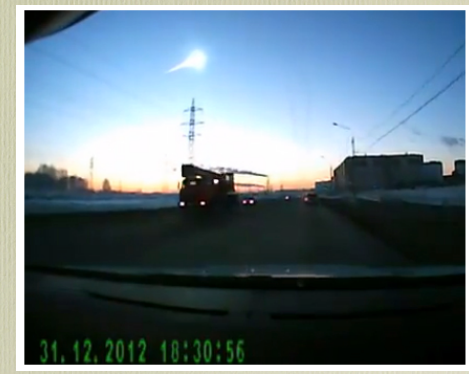


Today's trivia: who was Toutatis?

- How about 2012 DA 14?
- Feb 15th 2013: passes with 27000 km



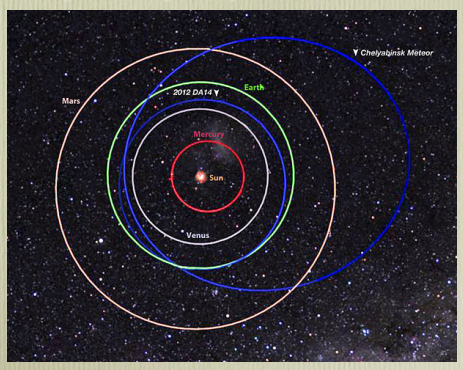
- Chelyabinsk Meteor
- Feb 15th 2013
- 15 m diameter
- Mass of 7000 tons



Andrei Borisovich Korolev

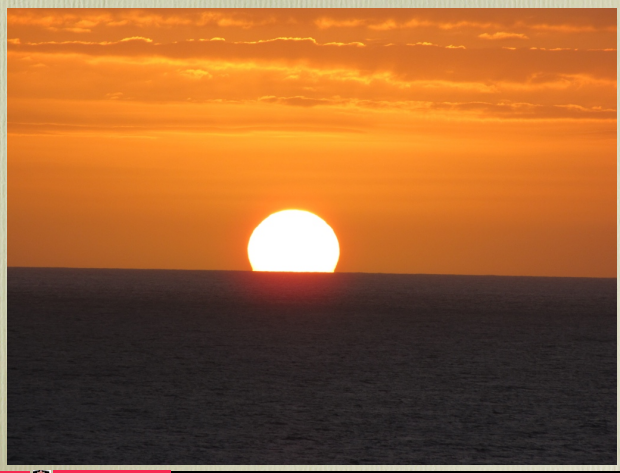
- Were they related?

Nope! Completely different orbits



NASA

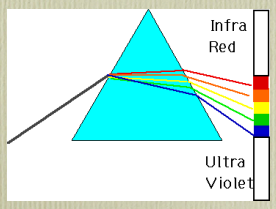
The Sun

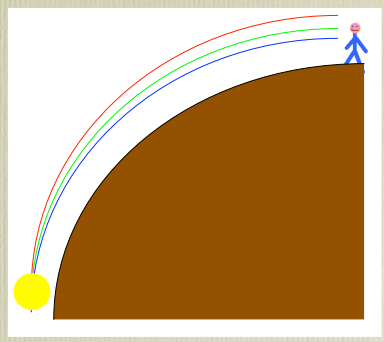


Did you see the green flash?

How does it work?

- Atmosphere works like a prism
- Bends red light least
- blue-green light most



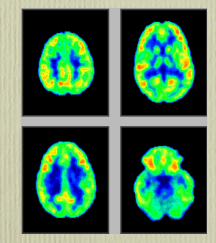


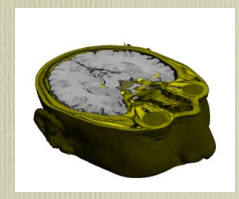
If we look at it with "white" light, it's a bit dull!

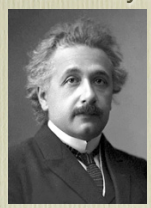
- But we can still see a few sunspots
- And Mercury!
- About 5700°C

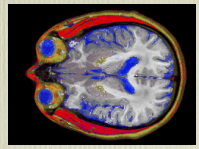
But if we want to find out how the sun works, we need to look at it in different ways

- Just like a human!



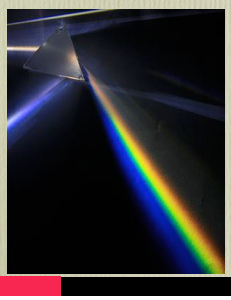




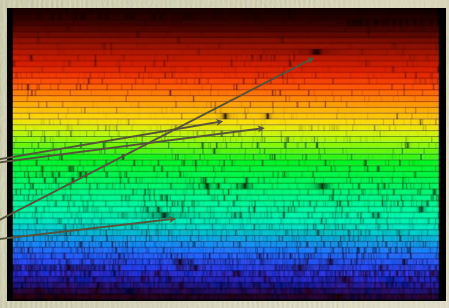


So we need to look at the sun in different ways

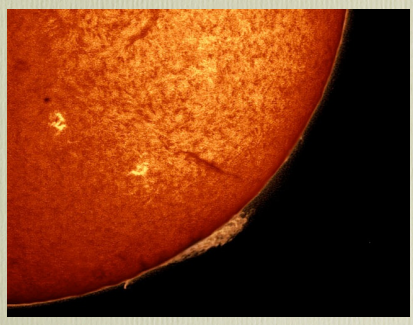
- Start by splitting up the light



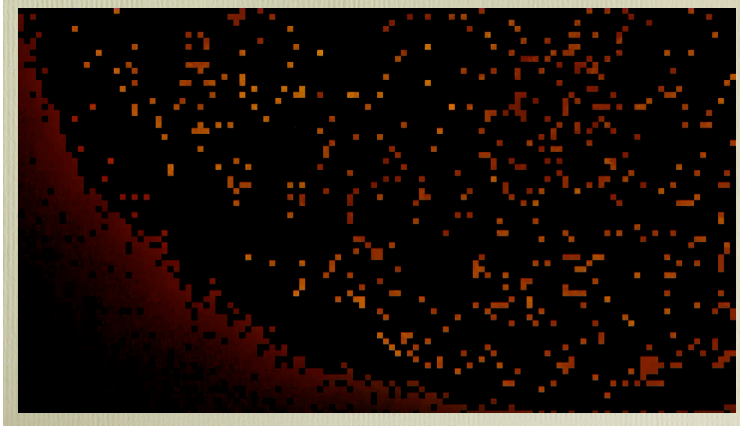
- We can look at the light from the sun
- Each line is corresponds to a particular element
  - e.g sodium
  - and hydrogen



- So we can look at the hydrogen in the sun
- which picks up the “prominences” very clearly

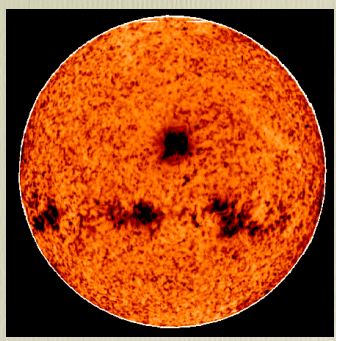


And we can watch a prominence in time-lapse

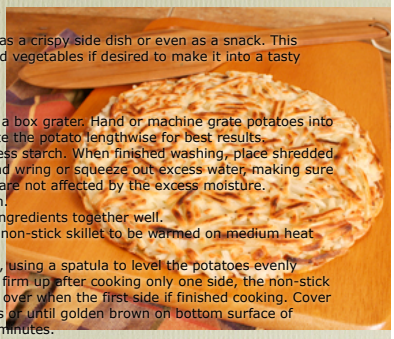


Look at the sun in different ways, to see how structure varies.

- This is Helium:
- Sunspots, are cooler (~4500°)
- a “rösti” picture



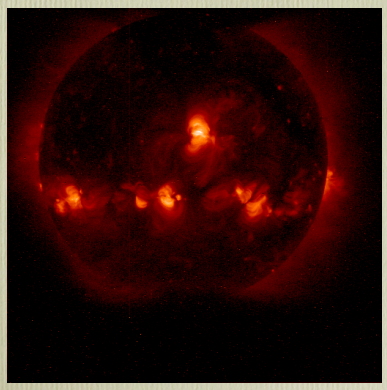
Since you asked: Rösti



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,

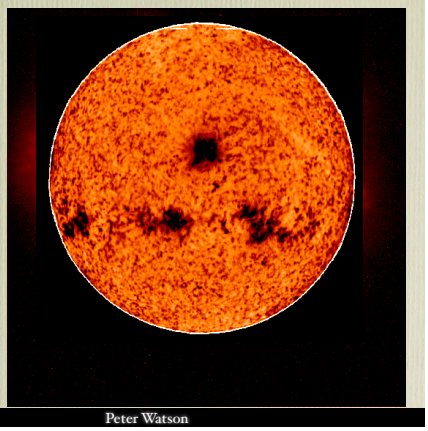
X-rays come from hot gas



And this shows the magnetic field

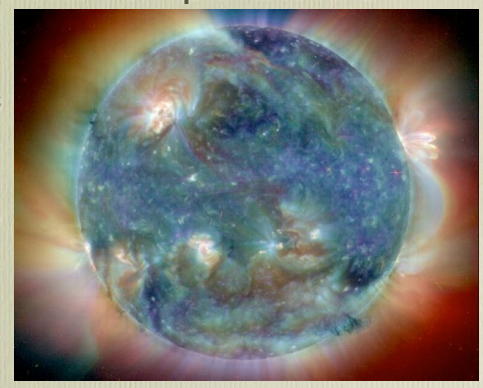
- Note how they all line up

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



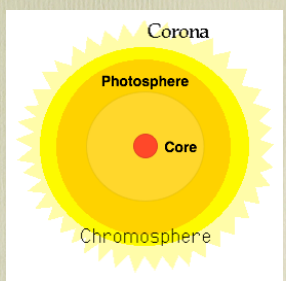
And this looks at the sun at 3 different temperatures

- Red at 2000000 °C
- green at 1500000 °C
- blue at 1000000 °C
- The outer part of the sun is the hottest!

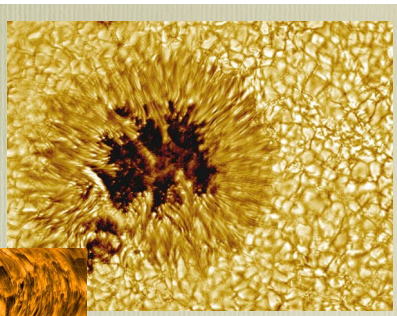


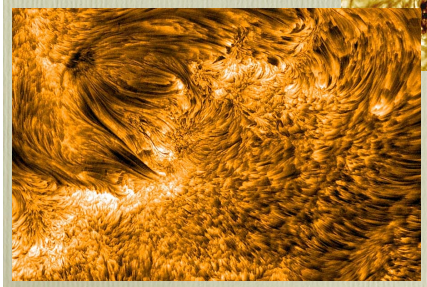
So lets look in a bit more detail

- **Core**: energy is produced here
- **Photosphere** is at a fairly uniform 5800°. Not a surface in any normal sense.
- Energy coming out of interior of sun will take ~ 100,000 years to get to the "surface"
- then it takes 7 minutes to reach earth.



So what are these sunspots? Cool parts in the middle

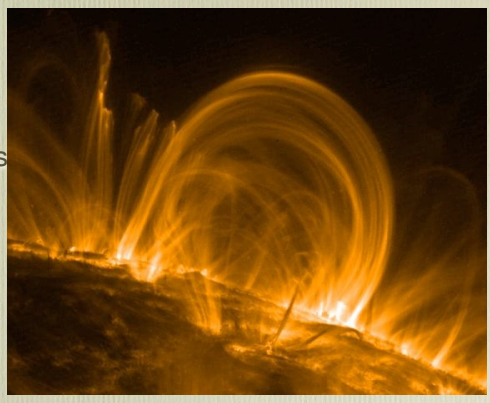




Credit: Vacuum Tower Telescope, NSO, NOAO)

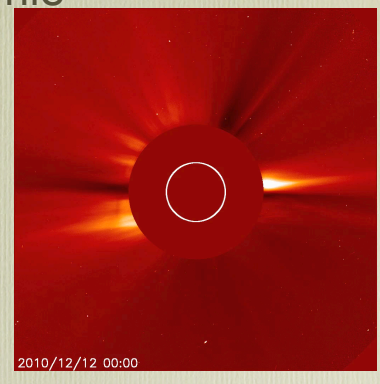
- And round the we can see spicules: "flames" of hydrogen gas

- magnetic field is traced out by loops of hot plasma
- Loops extend into the corona: about 50000 km high.



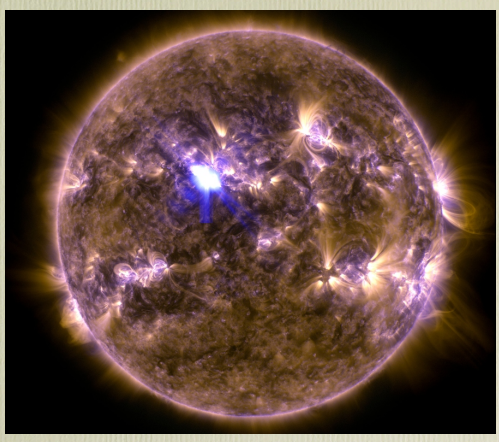
But magnetic fields are dynamic

- They can expand and squirt out gases
- or collapse and spray out high energy particles
- Solar & Heliospheric Observatory (SOHO)

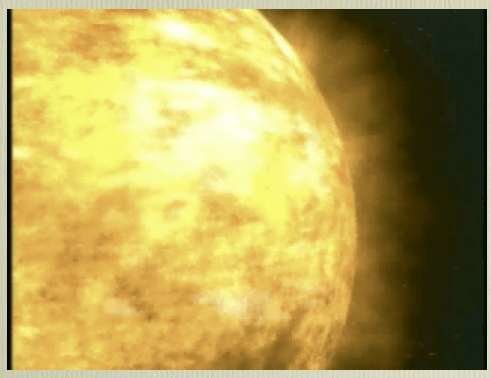


Flare on April 11th 2014

- Strong flare, caused mass ejection and aurora



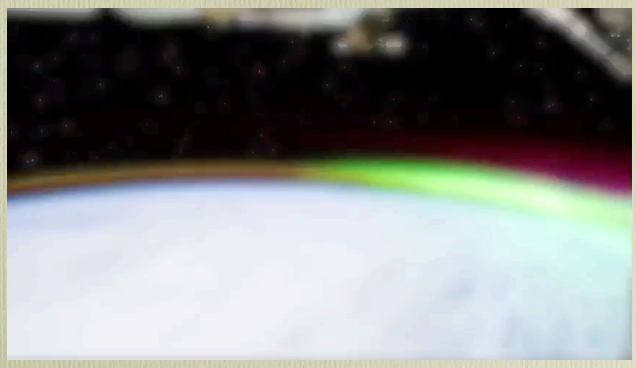
Like this



And become auroras

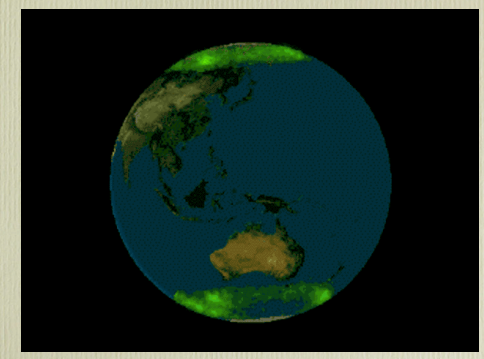
Sudbury Neutrino Observatory

You can fly through it

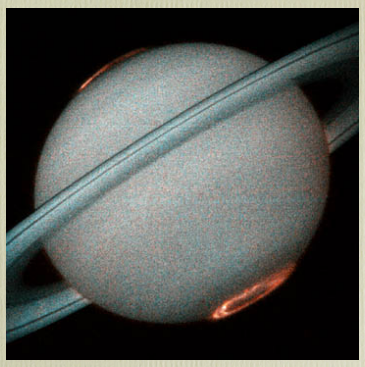


International Space Station movie

- Note we always get simultaneous aurora at N & S poles

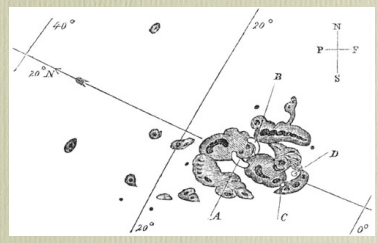


- And we can even see them on other planets



Carrington Event

- Biggest solar storm in (recorded) history
- 28th August-2nd Sept 1859
- Blew out telegraph linkages all over Europe & US



- Aurora seen in Caribbean
- From Sciam

- March 1989
- Quebec blackout: 9 hours,
- communications down everywhere
- aurora in Texas (thought to be first-strike in nuclear war.
- Probably 1/10th of strength of Carrington event
- Hydro Quebec spend B$4.3 to improve protection

If the Carrington event happened today .....

- Nightmare scenario:
- surge protectors don't trip fast enough, all power transformers in North America melt.
- Lead time for construction is 3 years…
- Could we survive a 3-year black-out…?

Hopefully:

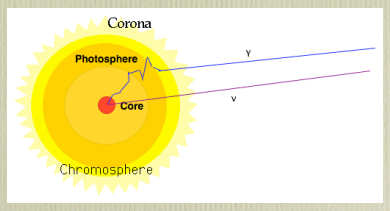
- 12 hours warning of storm would allow power lines to be isolated
- surge protectors would burn out but could be replaced …
- but communications satellites & GPS could well fail

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!)

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 anti-electrons + 2 neutrinos

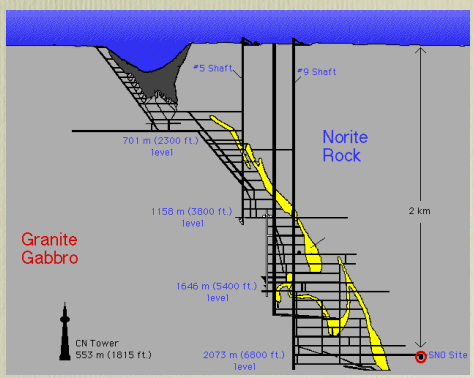


The neutrinos produced at the centre make it to earth in 8 minutes

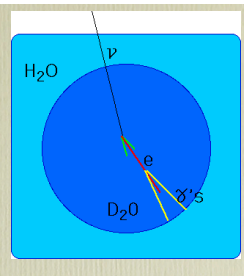
- One Trillion (roughly) go through your thumbnail4 each second
- you hadn't noticed?
- tsk tsk!
- If we could see the neutrinos, we can see the centre of the sun, but they have almost no interactions!

Sudbury Neutrino Observatory

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



- Once every 3 hours a neutrino will hit an atom and produce light



- Which we can detect

And this tells us that neutrinos do really come from the centre of the sun

Except they change into another kind on the way over

- So we understand (more-or-less) how the sun works:
- It is 4.5 billion years old
- "Best before" date is 10 billion years when it runs out of hydrogen fuel
- What happens then?