



- WebWorkK due on Monday
- I'll aim to put out updated grade reports this weekend
- Physics Tea today at 3pm
- Polling: `rembold-class.ddns.net`

The Sky Tonight



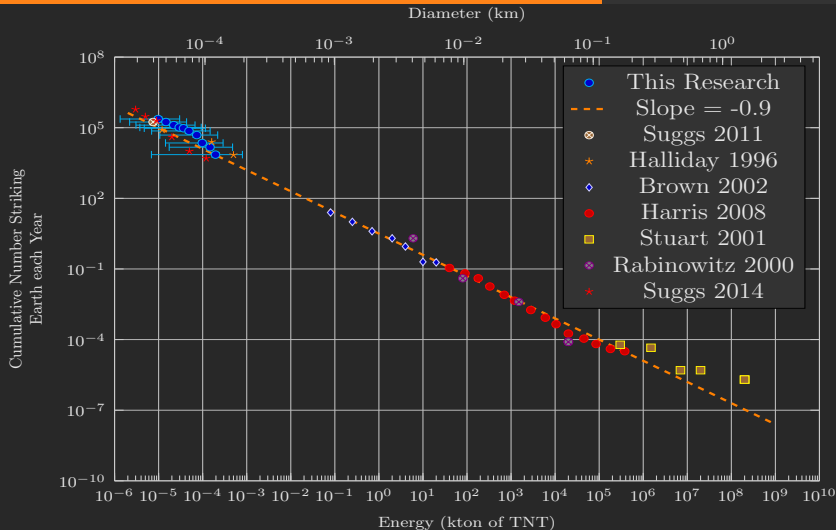
- ISS crossing tonight at 7:30pm to the W
- Bright Iridium flare tonight at 7:18:23pm to the S, 52° above horizon
- Jupiter up in the early evening along with the sliver of a Moon
- Venus up still as well but barely up after sunset
- Mars and Saturn both up higher in the sky and bright

Review Question



On average, given the plot to the side, how many years would be expected between 1×10^5 kton meteorite impacts on Earth's surface?

- A. 0.1 yrs
- B. 10 yrs
- C. 100 yrs
- D. 10 000 yrs

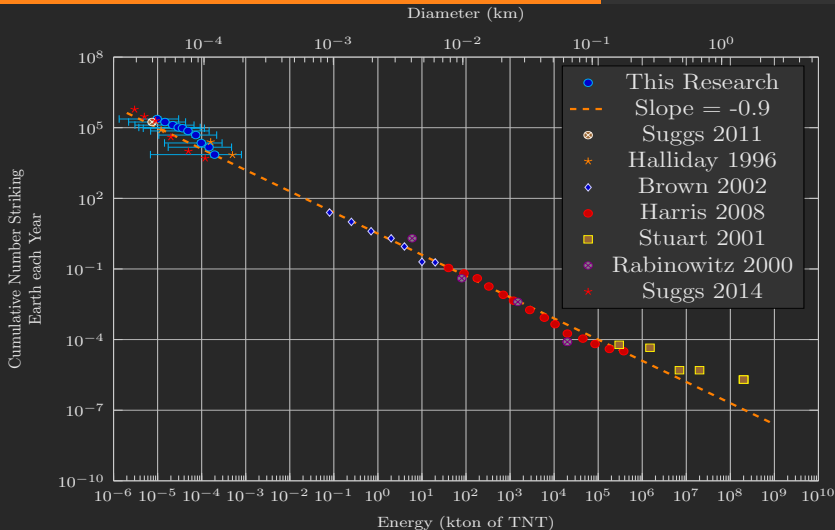


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And now for comets...



- What are comets?
 - Asteroids outer solar system counterparts
 - Formed largely from ices and dust
- Often times seen with tails, but not necessarily
- Tend to have huge, elliptical orbits

Catch a Comet by its Tail(s)



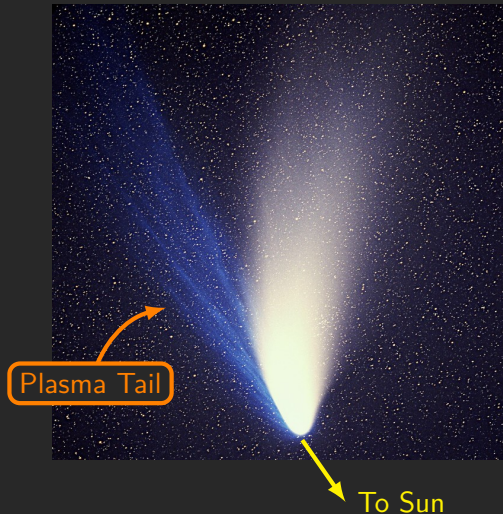
- Comets **only** form tails when they are near the Sun
- When far from the Sun → dirty snowballs
- Tails form when Sun melts/vaporizes part of comet, which then escapes
 - Plasma Tail: Points directly away from Sun
 - Dust Tail: Points away from Sun + some cometary motion



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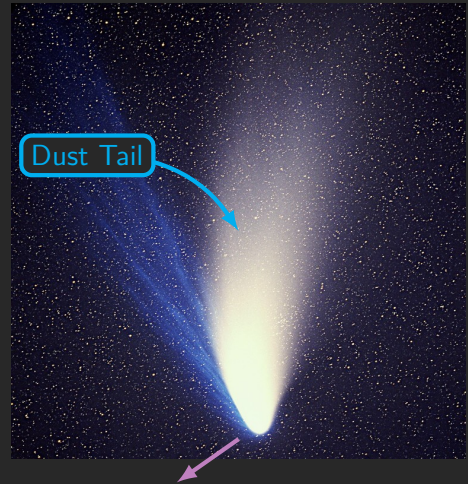
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Dust Tail

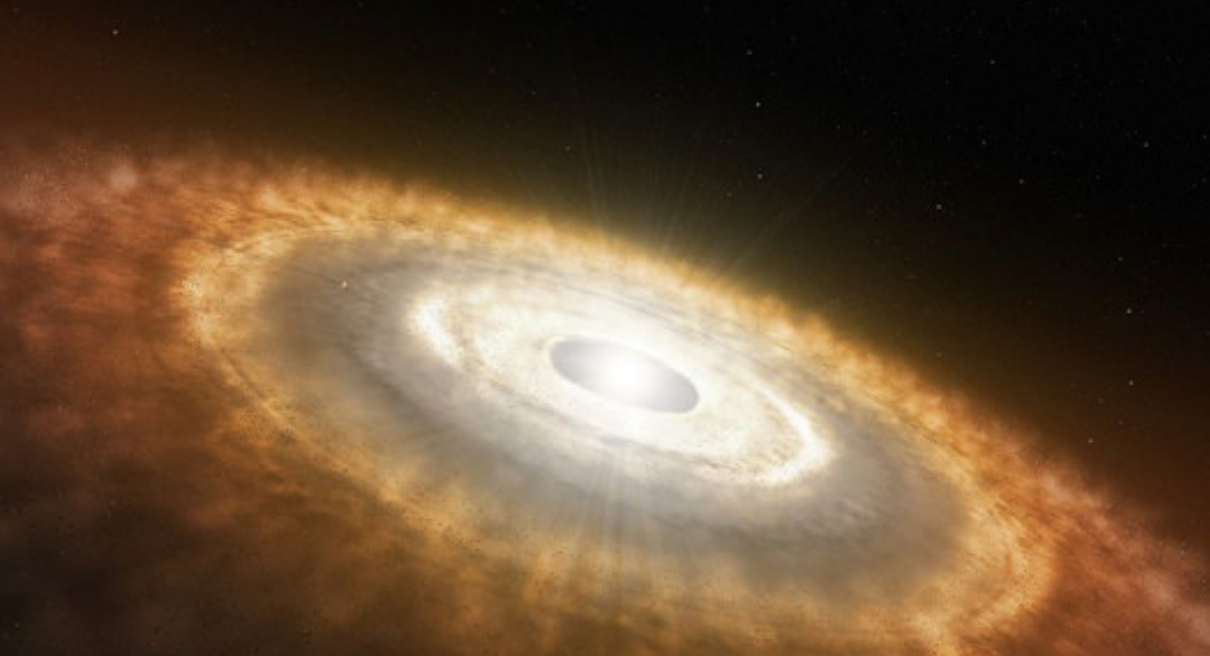
Comet direction



And full length cartoon! https://www.youtube.com/watch?v=HD2zrF3I_II



- We can study the trajectory of visible comets to work out where they came from
- Two major locations:
 - Oort Cloud (Big reservoir of 1×10^{12} comets)
 - Random orientations and directions
 - Flung wide by interactions with planets
 - Kuiper Belt (Donut shaped region beyond Neptune)
 - “Solar System-like” orientations and directions
 - Not many planets in interact with, so largely orbiting behaviour





- Need any decent theory to explain:
 - motions constraints
 - Most planets orbit, and spin in the same direction
 - Solar system largely flat like a disk
 - chemical constraints
 - Planet compositions
 - age constraints
 - Radioactive dating of Earth and Moon rocks
 - Dating of meteorites

A Gassy Start



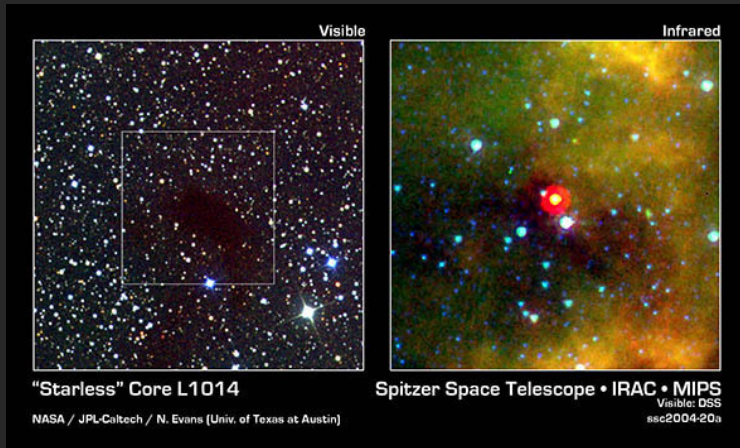
- The galaxy is filled with clouds of gas and dust



Gravity Wins



- Since clouds have mass, they begin to collapse
- Evidence of star formation in these clouds (best seen in IR)



Like Pizza Dough! (... kinda)

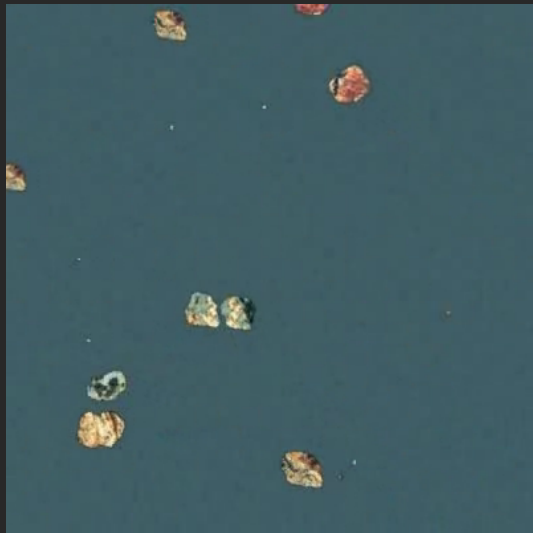


- Gravitational potential energy converted to kinetic
- Increased kinetic energy means things heat up
- Decreased radius means things need to spin up due to angular momentum
- Flattening
 - Gases can cool by colliding, exciting electrons, and then de-exciting and emitting light
 - Angular Momentum is harder to get rid of
 - Means we lose kinetic energy in non-rotating directions

Our (planetesimals) combine... Captain Planet!



- Each planet begins life as a tiny planetesimal
- Basically a tiny chunk of rock/collected smooshed together dust
- Collides with other planetesimals
 - Either smash apart to create more planetesimals
 - Or mush together to combine
- Process known as **accretion**



Accretion is Violent!



- Traces of accretion still continue!

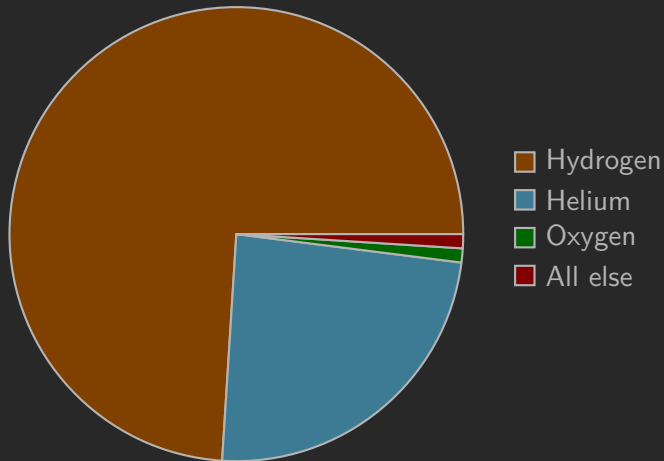


How to bake a Solar System (no oven required!)



- Gather yourself together a large cloud of gas and dust
- Let gravity do its thing:
 - Potential Energy into Kinetic
 - Heats up
 - Spins faster
 - Flattens out
- Center gets hot enough to ignite your Sun
- Leftover bits mash into each other
 - Survival of the fittest
 - =Planets!
- Admire your lovely new Solar System!

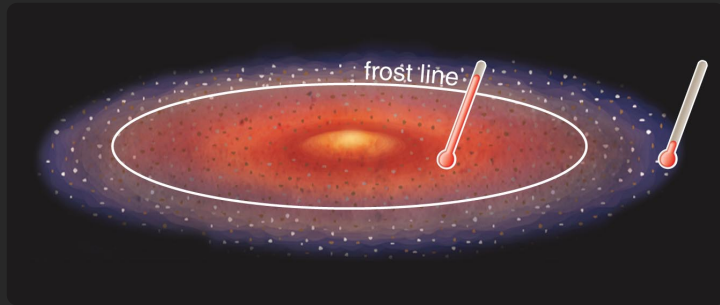
Solar System Composition





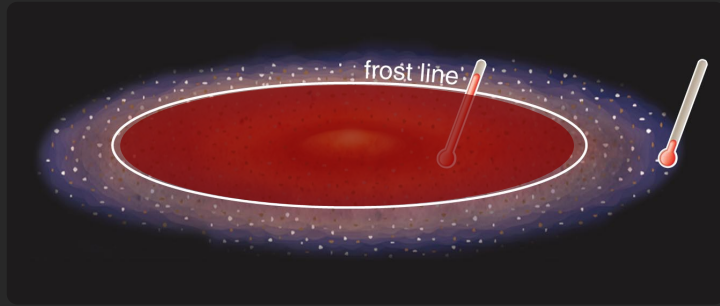
- Just like water condenses below a certain temperature, so do other materials
 - Metals around 1000 K to 6000 K
 - Rocks around 500 K to 1300 K
 - Hydrogen Compounds (like water and methane) around 150 K
 - Hydrogen and Helium never condense in normal space
- What condenses is what forms the “seed” for early planetesimals and accretion ammunition

Take a Ride on the FROST LINE



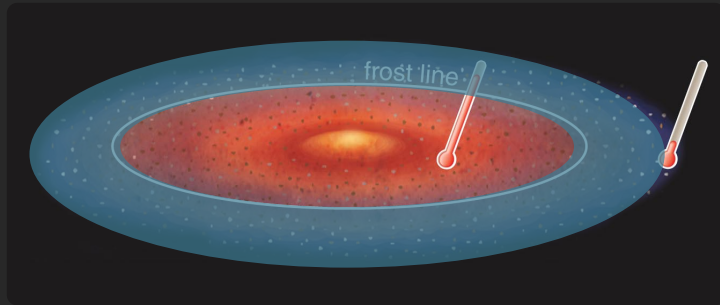
- Inside the frost line, it is too hot for anything besides rocks or metals to condense. Thus planets are generally rocky and small.
- Outside the frost line, even ices can condense. These provide the “seeds” to grow a large enough ice ball to gravitationally attract extra hydrogen and helium gasses.

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- Imagine if you are so slow eating at a restaurant that the waiter is slowly taking away portions of your meal
 - You = the planet
 - Food = rocks, ice, and gas
 - Waiter = the Sun
- Planets do not just get to wait around forever slowly growing
- Once the Sun is ignited, planetary formation is on the clock
 - Radiation and the solar wind slowly push remaining gasses out of the solar system
- The Solar Wind is a outflowing stream of charged particles originating from the Sun