

Today's Class: Properties of the Sun

Homework:

1. Space Weather: Section 14.3 in *Cosmic Perspective*.
2. Homework #4 due next Wednesday.



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Space in the News: Kayhan Space New Startup

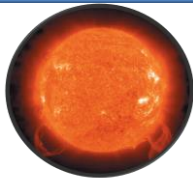
Presented by Nicholas Kuhn

- Kayhan Space (based in Boulder) just closed pre-seed investment round
- To Develop Kayhan Satellite Collision Assessment and Avoidance System
- Currently satellite operators get notifications of close approaches but it's up to their discretion on how to act on each one
- Goal is to make a fully autonomous process to avoid noise, time and money lost

Could this lead to unsafe conditions in space and do you think there are negative effects to overcrowding in space? What are the best ways to mitigate these effects?

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Today's Class: The Sun



- The Sun is a mass of incandescent gas
- A gigantic nuclear furnace
- Where hydrogen is built into helium
- At temperatures of millions of degrees

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Class Exercise (based on reading for today)

Which of the following parts of the Sun has the lowest temperature?

- A. core
- B. photosphere
- C. chromosphere
- D. corona

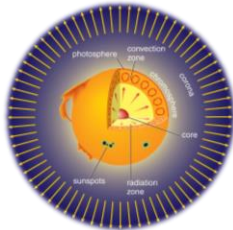
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Class Exercise

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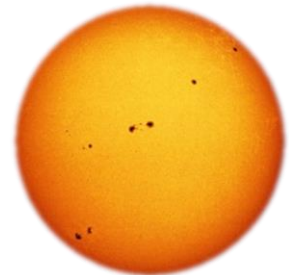


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Sun Facts

- Mass = 300,000 times Earth
- Radius = 100 times Earth
- 70% hydrogen by mass, 28% helium
- Traces of other elements
- Energy released is 1 second is 3,000,000 times yearly energy consumption of entire USA. Power is equivalent to 4×10^{24} light bulbs of 100 Watts each.



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Structure of the Sun- from the core outwards

- Core temp **15 million K**, hot & dense from the gravitational weight of all that mass.
- Hydrogen fuses into helium, releasing energy (gamma rays). This is called the **nuclear fusion**.

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Moving Energy out from the Core

- Radiation moves through the interior of the Sun = **Radiation Zone**.
- Absorption and re-radiation in cooler layers converts gamma-rays to less energetic photons.

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Moving Energy out from the Core

- Outer third: gas becomes turbulent.
- Convection zone**: hotter regions rise, cool, sink.
- Energy continues to work its way out: 1 million years to get out!

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Convection

- Convection: up and down movement of heating and cooling gas.
- Granulation**: appearance of convection patterns.
- Darker areas are cooler, sinking on outside of pattern.

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Convection on the Sun

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Atmosphere of the Sun

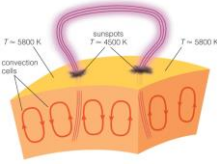
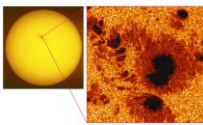
- “Visible surface” of the Sun: **photosphere**.
- T = only 5800 K.
- Photons free to fly- seen at Earth 8 min later.
- Thermal spectrum, T= 5800 K plus absorption from cooler gasses just on top.

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Magnetic Fields in the Sun


- Magnetic fields entrain gas in huge bubbling loops
- Areas at "liftoff" cause "sunspots"

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Sunspots



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Class Exercise

Discuss with your neighbor why Sunspots appear darker than their surroundings on the Sun?

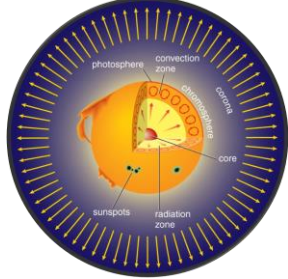


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Outer Atmosphere

- Outer regions are hotter!
- **Chromosphere:**
T= 10,000 K,
- Heated by energy twisting and spilling around magnetic field lines?

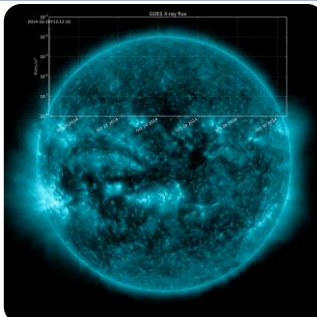


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Energy Flow to Outer Atmosphere

- **Corona =>T = 1 million degrees K =>X-rays!**
- Energy deposited by big flares and ejected gas?




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Solar Eclipse by the Moon

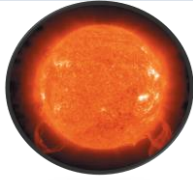
Chromosphere and Corona become clearer in visible light without glare from the rest of the Sun



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What did we learn today?



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