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1. Overview of the Sun

- Type: G-type main-sequence star (Yellow Dwarf)
- Distance from Earth: ~149.6 million km (1 AU)
- Diameter: 1.39 million km (109 times Earth’s)
- Mass: 1.989×10^{30} kg (~333,000 times Earth’s)
- Surface Temperature: ~5,500°C (9,932°F)
- Core Temperature: ~15 million °C (27 million °F)
- Gravity: 274 m/s^2 (28 times Earth’s)
- Age: ~4.6 billion years
- Rotation Period:
    - Equator: ~25 Earth days
    - Poles: ~35 Earth days (Differential rotation)

2. Structure of the Sun

Layer	Description	Temperature
Core	Energy production via nuclear fusion (H to He)	~15 million °C
Radiative Zone	Energy moves outward slowly (radiation)	2 to 7 million °C
Convective Zone	Hot plasma rises, cooler plasma sinks	~2 million °C
Photosphere	Visible surface (produces sunlight)	~5,500°C
Chromosphere	Reddish outer layer, visible during eclipses	6,000 to 20,000°C
Corona	Outer atmosphere, extends millions of km	~1 to 3 million °C

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3. The Sun’s Composition

- Hydrogen (H): 74%
- Helium (He): 24%
- Trace Elements: Oxygen, carbon, neon, and iron.

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4. Energy Production

- Nuclear Fusion:
  - Hydrogen atoms fuse to form helium in the core.
  - Energy released as light and heat.
- Equation:

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4 Hydrogen nuclei → 1 Helium nucleus + Energy
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- Energy Travel Time:
  - From the core to the surface: ~100,000 to 1 million years
  - From the surface to Earth: ~8 minutes (speed of light)

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5. Solar Phenomena

1. Sunspots:

- Cooler, dark patches on the photosphere caused by magnetic activity.
- Cycle: 11 years (Solar maximum/minimum).
- Temperature: ~4,000°C (7,232°F).

2. Solar Flares:

- Sudden energy releases from sunspots.
- Can disrupt Earth’s communications and cause auroras.

3. Coronal Mass Ejections (CME):

- Massive bursts of plasma and magnetic field from the corona.
- Can trigger geomagnetic storms on Earth.

4. Solar Wind:

- Continuous flow of charged particles (plasma) emitted by the corona.
- Shapes Earth’s magnetosphere and causes auroras.

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6. The Sun’s Magnetic Field

- Complex and Dynamic: Changes over an 11-year cycle (solar cycle).
- Polarity Reversal: Occurs every solar maximum (approx. every 11 years).
- Drives sunspots, flares, and CMEs.

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7. The Sun’s Influence on Earth

- Life and Climate:
    - Provides light and heat necessary for life.
    - Drives weather patterns and ocean currents.
- Tides and Seasons:

    - Influences Earth’s axial tilt, creating seasons.
- Geomagnetic Effects:
    - Solar storms can affect satellites, GPS, and power grids.

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8. Lifespan and Evolution of the Sun

- Current Stage: Main-sequence star (~4.6 billion years old).
- Remaining Lifespan: ~5 billion years.
- Future:
    - Red Giant (in 5 billion years): Sun expands, engulfing Mercury and Venus.
    - White Dwarf: After shedding outer layers, the Sun will shrink to a dense white dwarf.

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9. Interesting Facts

- Largest Object: Contains 99.8% of the solar system’s mass.
- Light Speed: Sunlight takes 8 minutes and 20 seconds to reach Earth.
- Volume: Can fit about 1.3 million Earths inside the Sun.
- Magnetic Field: Extends beyond Pluto, shaping the heliosphere.

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10. Solar Eclipses

- Total Solar Eclipse: Moon completely blocks the Sun.
- Partial Eclipse: Moon blocks part of the Sun.
- Annular Eclipse: Moon covers the Sun’s center, leaving a ring.

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11. Key Measurements

Property	Value
Diameter	1.39 million km
Distance from Earth	149.6 million km (1 AU)
Mass	1.989×10^{30} kg
Surface Temperature	5,500°C
Core Temperature	15 million °C
Rotation Period	25-35 days
Age	4.6 billion years

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12. The Sun in Mythology and Culture

- Named After: Latin “Sol” (root of solar).
- Mythology:
  - Greek: Helios (Sun god).
  - Roman: Sol Invictus.
  - Egyptian: Ra, god of the Sun.
- Cultural Significance: Central in festivals, rituals, and timekeeping across civilizations.

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13. Differences Between the Sun and Earth

Feature	The Sun	Earth
Type	Star	Planet
Diameter	109 times Earth’s size	12,742 km
Mass	333,000 times Earth’s	5.97×10^{24} kg
Surface Temp.	5,500°C	15°C
Composition	Hydrogen, Helium	Rock, Water
Rotation	25-35 days	24 hours

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14. Can We Explore the Sun?

- Direct Exploration: Impossible due to extreme heat and radiation.
- Spacecraft Missions:
    - Parker Solar Probe (2018): Closest human-made object to the Sun (~7 million km).
    - Solar Orbiter (2020): Studies the Sun’s poles and solar wind.