Star Birth, Life, and Death

Star Birth, Life, and Death

1 AU away

that's 1.496 x 10^8 km or 8.3 light minutes

Size: 1.392 x 10^6 km in diameter

That's about 110 Earth diameters with a volume of 1.3 million Earths!

Mass: 1.989 x 10^30 kg

That's about 333,000x the mass of Earth

Surface Temperature: 5800 K

Core Temperature: 15,600,000 K (or so)

Age: ~4.6 billion years

Leaving only about 5--7 billion years to go

Composition:
- 74% by mass H (92.1% by atom count)
- 25% by mass He (7.8% by atom count)
- 1% by mass other elements (Li, Na, Fe, etc.)

Density
- Mean: 1410 kg/m^3 (water is 1000 kg/m^3)
- Core: 151,300 kg/m^3

(for you Americans, that's equivalent to 670 lbs in a 2 L bottle)
The Stars

**SUN**

- Rotates on its axis
  - period = 27 d
- Axis tilted 7.25°
  - We see more of N pole in September

**SUN**

How do astronomers think it got started?

- A nebula in the ISM
  - Temp = 100 K
  - Density = 10 particles/cm³ (H₂O = 10²³ molecules/cm³)
  - Diameter of gas cloud destined to be the star = ~10¹⁴ km
- A shock wave from a passing star or distant supernova initiates condensation
  - Core temp increases to 50,000 K due to Kelvin-Helmholtz (compression) heating; Surface temp still only ~500K
  - Density increases to ~10¹² particles/cm³
  - Diameter = 10¹² km (Recall Sun currently 1.4 x 10⁶ km)

**Star Birth**

Orion Nebula (M42)

Emission nebula in the ISM
- **Protostar stage** – Over a period of $\sim 10^7$-$10^8$ years, gravitational collapse of the gases results in Kelvin-Helmholtz (compression) heating
  - Temp rises to 3000 K
  - Density increases to $\sim 10^3$ particles/cm$^3$
  - Diameter decreases to 10$^3$ km (only 10x bigger than current Sun)
- During gravitational collapse and throughout protostar stage, core continues to heat
The Stars

SUN: Structure

Let’s open the Sun up and look inside

Core

Adapted from a NASA Illustration from Orbiting Solar Laboratory, Our Window on the Sun

15,000,000 K

Radiative Zone

Adapted from a NASA Illustration from Orbiting Solar Laboratory, Our Window on the Sun

Core

> Core

> 15,000,000 K
The Photosphere

> The Photosphere
> ~5,800 K

The Chromosphere

> The Chromosphere
> 2,000-3,000 km thick
**SUN: Structure**

- The Corona
- ~1,000,000°C

Cue the Corona in visible (LASCO/SOHO)
Cue the corona in x-ray (EIT/SOHO)
Cue a CME in visible (LASCO/SOHO)

UCAR/NCAR/High Altitude Observatory

LASCO = Large Angle and Spectrometric COronagraph
EIT = Extreme ultraviolet Imaging Telescope

**SUN: Effect of the Solar Wind**

Adapted from J. B. Kaler, *Stars*, Scientific American Library, 1992

**SUN: Effect of the Solar Wind**

The Aurora Borealis

*Magnum Image.*
The Stars

SUN: Sunspots

- Cool (4300 K) regions

SUN: Sunspots

- Cool (4300 K) regions

SUN: Sunspots

- Cool (4300 K) regions
- Regions of strong magnetic field

Global Oscillation Network Group/BBSO
**SUN: Sunspots**

- Cool (4300 K) regions
- Regions of strong magnetic field
- Come in NS pairs

NASA/SkyLab, 1973

---

**SUN: Sunspots**

- Cool (4300 K) regions
- Regions of strong magnetic field
- Come in NS pairs

Vic Winter, ICSTARS

---

**SUN: Sunspots**

- Cool (4300 K) regions
- Regions of strong magnetic field
- Come in NS pairs
- 11 year cycle/22 year cycle