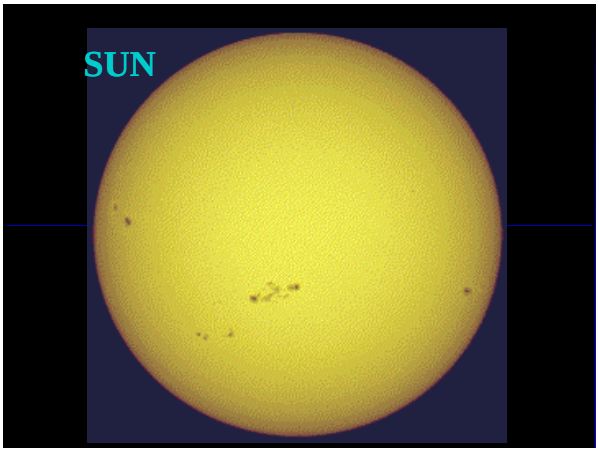
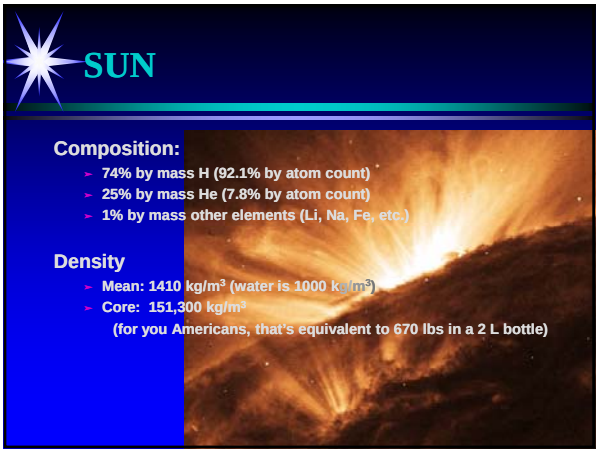
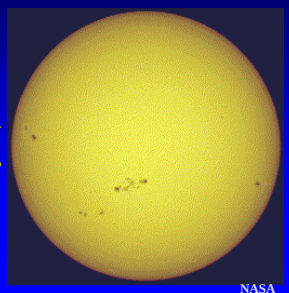

Star Birth, Life, and Death


SUN


SUN
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/m3 (water is 1000 kg/m3)
Core: 151,300 kg/m3
(for you Americans, that's equivalent to 670 lbs in a 2 L bottle)

SUN

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



NASA

SUN

How do astronomers think it got started?

- A nebula in the ISM
  - Temp = 100 K
  - Density = 10 particles/cm^3 (H_2O = 10^{23} molecules/cm^3)
  - Diameter of gas cloud destined to be the star = ~10^{14} 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 ~10^{12} particles/cm^3
  - Diameter = 10^{12} km (Recall Sun currently 1.4 x 10^6 km)

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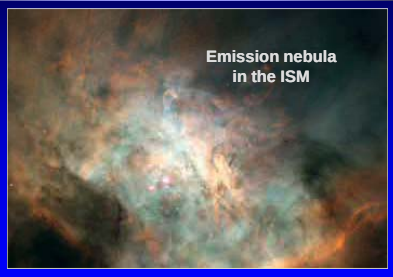
Star Birth

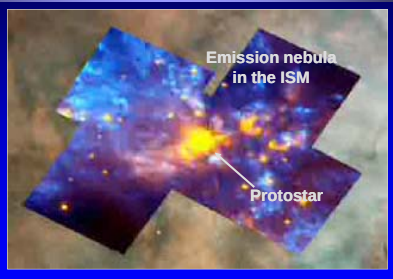
Orion Nebula (M42)



WFPC2 Orion Mosaic STScI-PRC97-13, 1997

Star Birth

Orion Nebula (M42)



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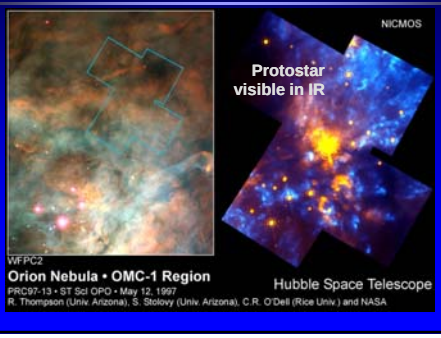
Star Birth

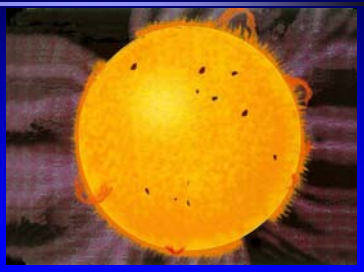


Star Birth

- ***Protostar stage*** – Over a period of ~10^7-10^8y gravitational collapse of the gases results in Kelvin-Helmholtz (compression) heating
  - Temp rises to 3000 K
  - Density increases to ~10^{22} particles/cm^3
  - Diameter decreases to 10^7 km (only 10x bigger than current Sun)
- During gravitational collapse and throughout protostar stage, core continues to heat

SUN: Structure

Let's open the Sun up and look inside



SUN: Structure

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

SUN: Structure

- Core
  - 15,000,000 K

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SUN: Structure

- Core
  - 15,000,000 K
- Radiative Zone
  - Opaque
  - Photon random walk

SUN: Structure

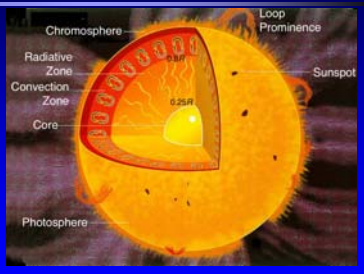
- Core
  - 15,000,000 K
- Radiative Zone
  - Opaque
  - Photon random walk
- Convection Zone

SUN: Structure

- Core
  - 15,000,000 K
- Radiative Zone
  - Opaque
  - Photon random walk
- Convection Zone
- Photosphere

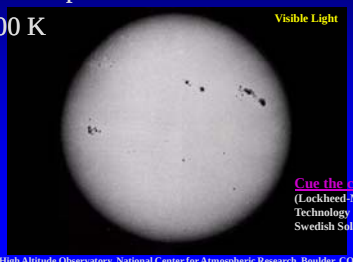
SUN: Structure

REVIEW



SUN: Structure

- The Photosphere
- ~5,800 K



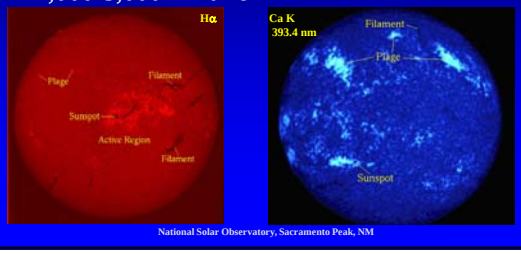
Cue the convection cells!
(Lockheed-Martin Advanced Technology Center/ Swedish Solar Observatory)

High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO

SUN: Structure

- The Chromosphere
- 2,000-3,000 km thick

Cue the spicules in Hα (BBSO)



National Solar Observatory, Sacramento Peak, NM

SUN: Structure

- The Corona
- ~1,000,000°C

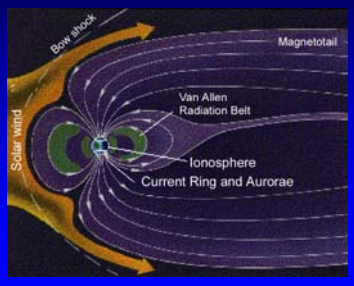
Cue the Corona in visible (LASCO/SOHO)
Cue the corona in x-ray (EIT/SOHO)
Cue a CME in visible (LASCO/SOHO)

UCAR/NCAR/High Altitude Observatory

Yohkoh Satellite

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

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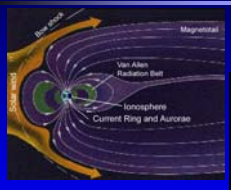

The Aurora Borealis

SUN: Sunspots

- Cool (4300 K) regions

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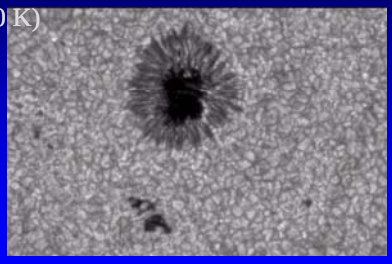
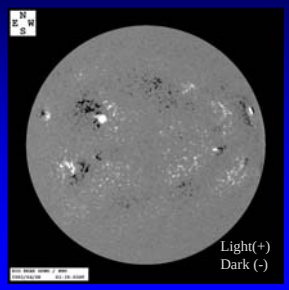


SUN: Sunspots

- 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

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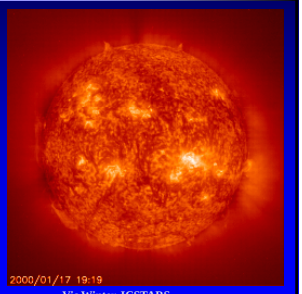

Vic Winter, ICSTARS

SUN: Sunspots

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