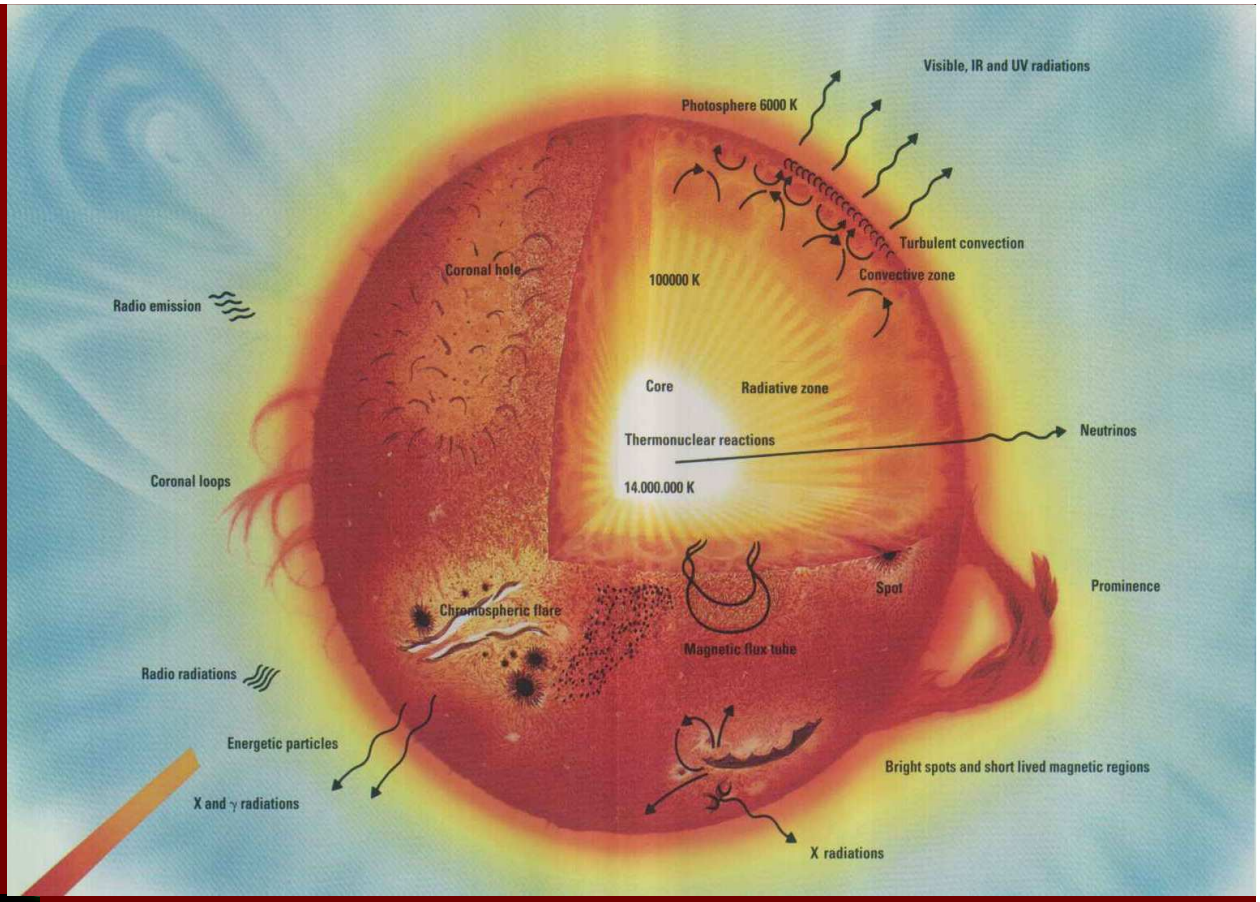
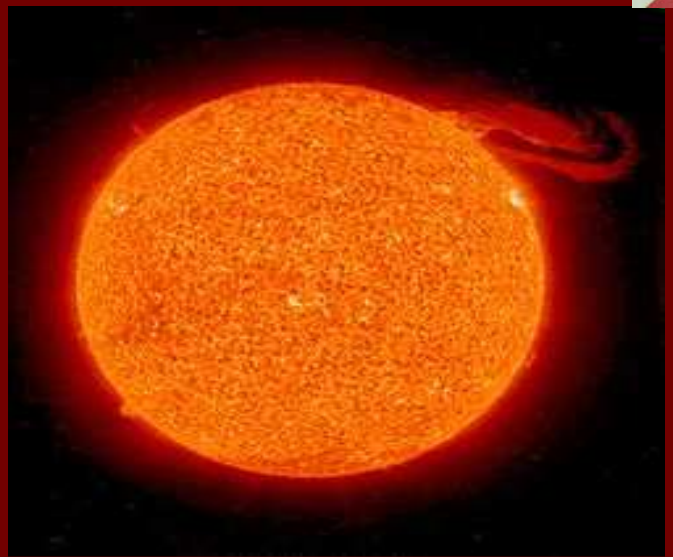

Visible, IR and UV radiations
Photosphere 6000 K
Turbulent convection
Coronal hole
100000 K
Convective zone
Radio emission
Core
Radiative zone
Thermonuclear reactions
Neutrinos
Coronal loops
14.000.000 K
Spot
Prominence
Chromospheric flare
Magnetic flux tube
Radio radiations
Energetic particles
Bright spots and short lived magnetic regions
X and γ radiations
X radiations



Chapter 28

The Sun

28.1 Structure of the Sun

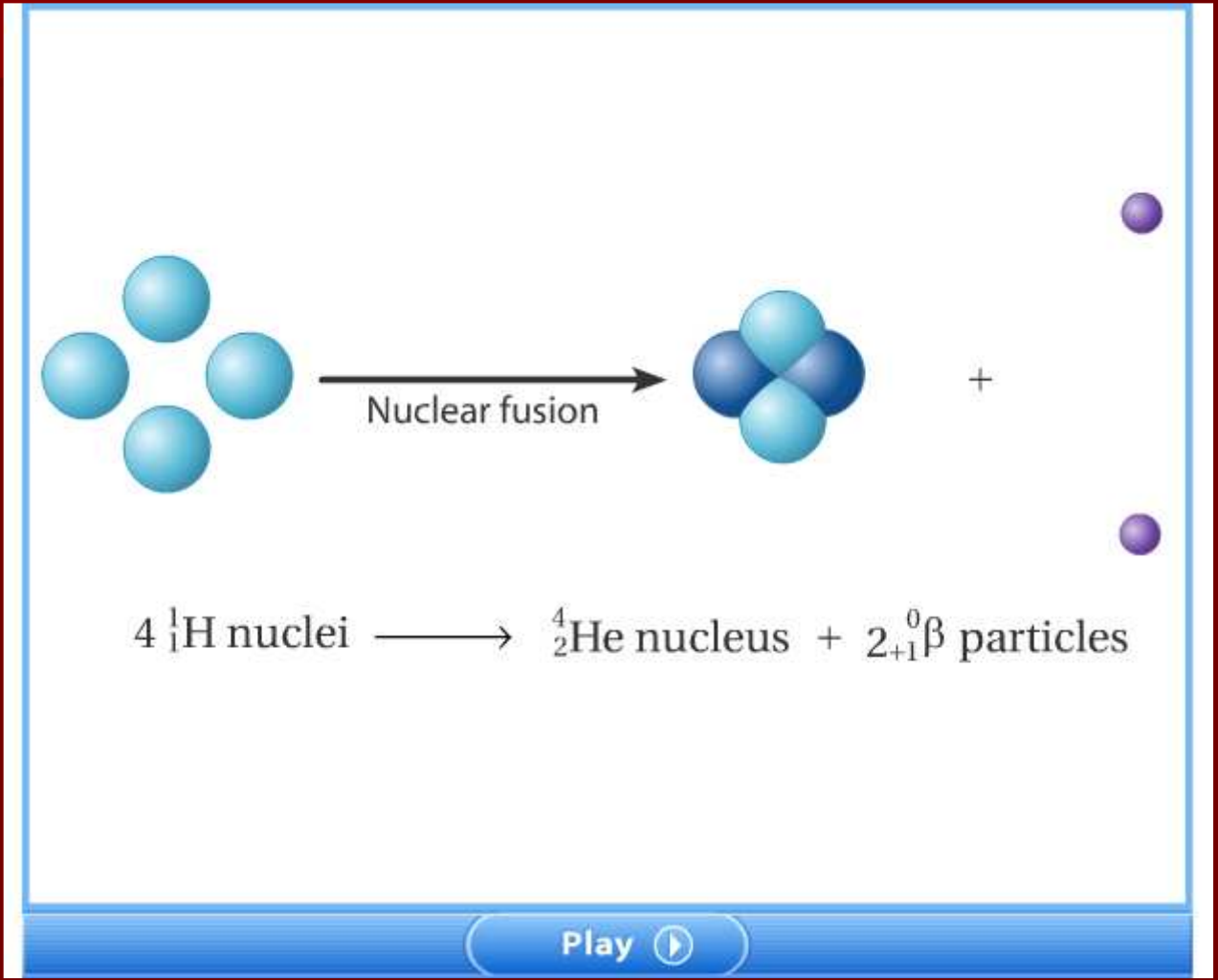
The Sun

- Made of 70% hydrogen
- 28% helium
- 2% everything else (metals, carbon, etc.)
- 3 basic layers:
  - The core
  - Inner zones
  - Atmosphere

The Core

- At the center of the sun is the core.
- The core makes up 25% of the sun's total diameter of 1,390,000 km.
- The temperature of the core is about 15,000,000 ^{o}C.
- The core is made up entirely of ionized gas, and is 10 times as dense as iron.

Hydrogen Fusion



Mass Into Energy

- One of the final products of the fusion of hydrogen in the sun is always a helium nucleus.
- The helium nucleus has about 0.7% less mass than the hydrogen nuclei that combined to form it do. The lost mass is converted into energy during the series of fusion reactions that forms helium.
- The energy released during the three steps of nuclear fusion causes the sun to shine and gives the sun its high temperature.

Radiative Zone

radiative zone the zone of the sun's interior that is between the core and the convective zone and in which energy moves by radiation

- The radiative zone of the sun surrounds the core.
- The temperature of the radiative zone ranges from about 2,000,000°C to 7,000,000 °C .
- In the radiative zone, energy moves outward in the form of electromagnetic waves, or radiation.

Convective Zone

Convective zone the region of the sun's interior that is between the radiative zone and the photosphere and in which energy is carried upward by convection

- The convective zone surrounds the radiative zone. The temperature of the convective zone is about 2,000,000°C.
- Energy produced in the core moves through this zone by *convection*.
- *Convection* is the transfer of energy by moving liquids or gases.

The Sun's Atmosphere

- The sun's atmosphere surrounds the convective zone of the sun's core.
- The sun's atmosphere has three layers: the **photosphere**, the **chromosphere**, and the **corona**.

Photosphere

photosphere the visible surface of the sun

- *Photosphere* means "sphere of light." The photosphere of the sun is the innermost layer of the sun's atmosphere.
- The photosphere is made of gases that have risen from the convective zone. The temperature in the photosphere is about 6,000°C.
- Much of the energy given off from the photosphere is in the form of visible light.

Chromosphere

chromosphere the thin layer of the sun that is just above the photosphere and that glows a reddish color during eclipses

- The chromosphere lies just above the photosphere. The chromosphere's temperature ranges from 4,000°C to 50,000 °C.

Corona

corona the outermost layer of the sun's atmosphere

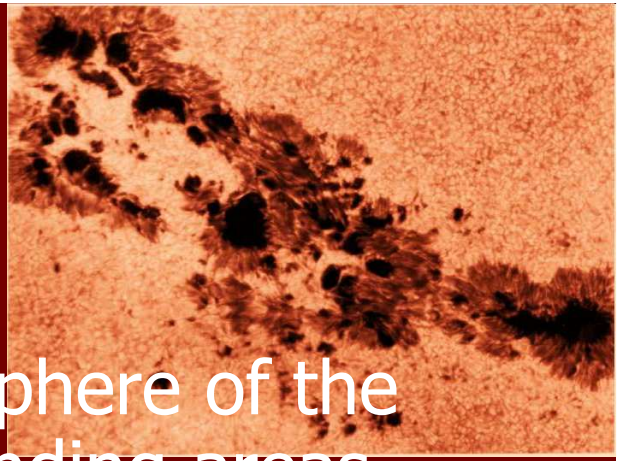
- The corona is a huge region of gas that has a temperature above 1,000,000°C.
- As the corona expands, electrons and electrically charged particles called *ions* stream out into space.
- These particles make up *solar wind*, which flows outward from the sun to the rest of the solar system.

28.2 Solar Activity

Motion of the Sun

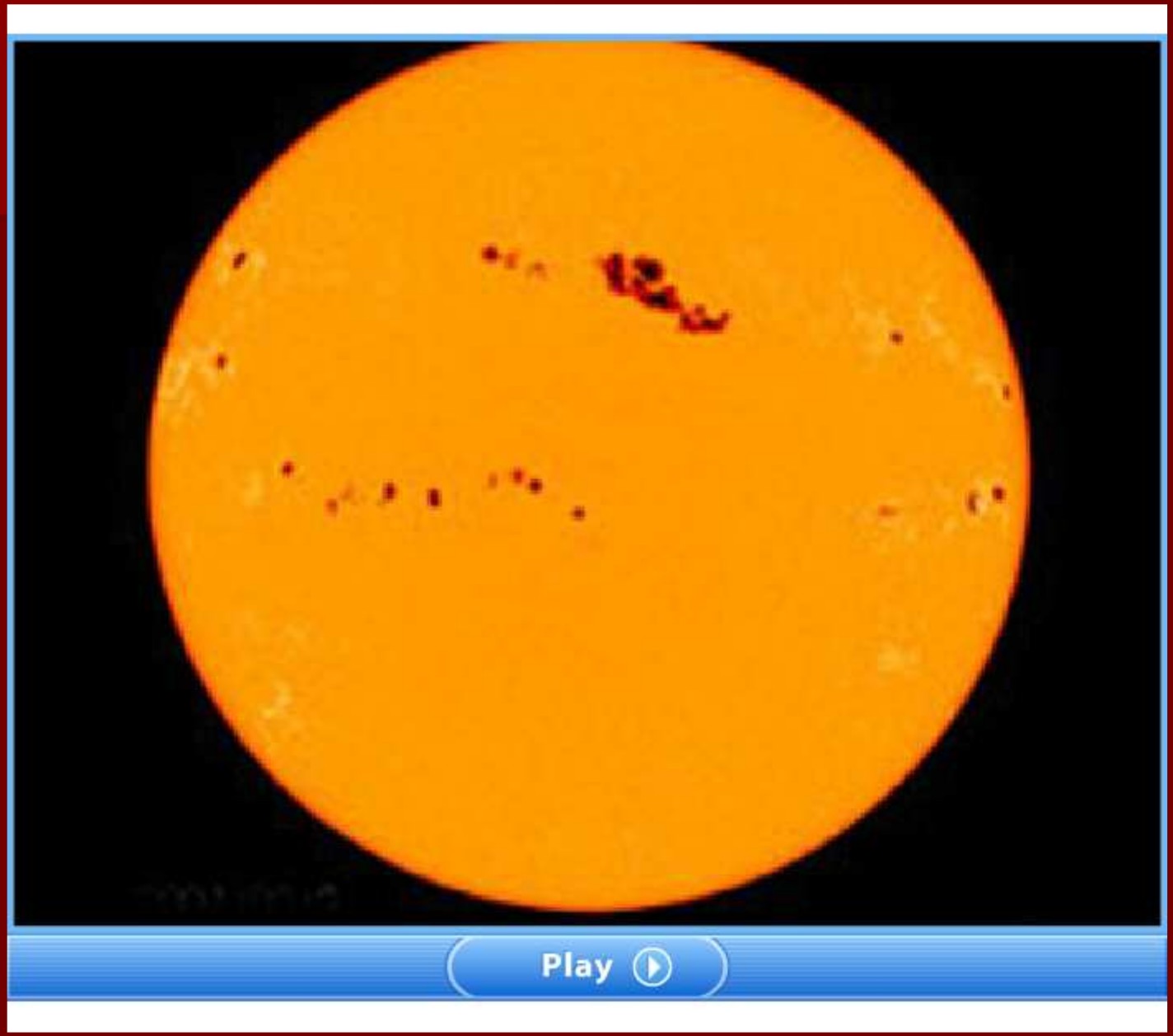
- Gases of the Sun are in constant motion
- Because the Sun is not a solid sphere, the gases rotate at different speeds.
- Places close to the Sun's equator take about 25.3 Earth-days to rotate once.
- Points near the poles take 33 days.
- Astronomers use an average of 27 days for the Sun's rotation.

Sunspots



sunspot a dark area of the photosphere of the sun that is cooler than the surrounding areas and that has a strong magnetic field.

- Magnetic fields produced by the movement of the sun slow down convection.
- Slower convection = less energy reaches the surface of the photosphere.
- Less energy = "cooler" areas of the surface.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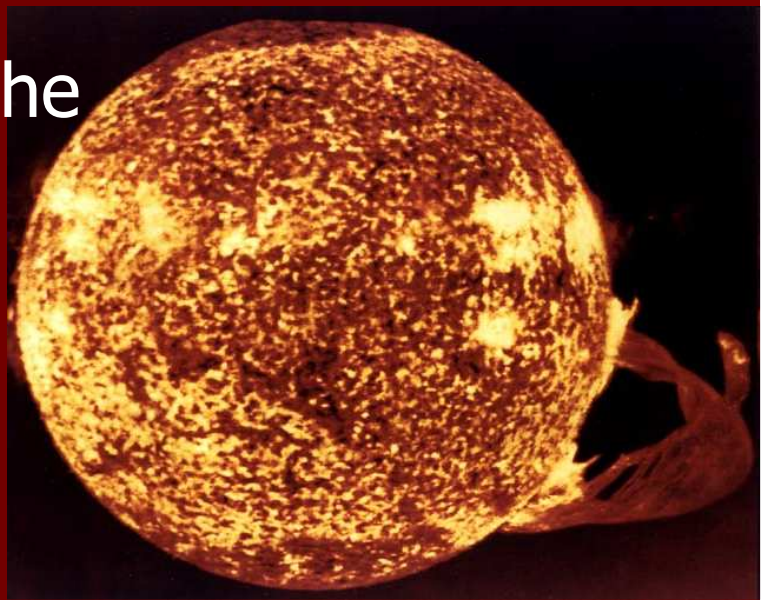
Prominence

prominence a loop of relatively cool, incandescent gas that extends above the photosphere.

- Prominences are huge arches of glowing gases that follow the curved lines of the magnetic force from one sunspot to another.



Solar Flares

solar flare an explosive release of energy that comes from the sun and that is associated with magnetic disturbances on the sun's surface

- Solar flares are the most violent of all solar disturbances.

Auroras

aurora colored light produced by charged particles from the solar wind reacting with the magnetosphere; usually seen in the sky near Earth's magnetic poles.

- Auroras are the result of the interaction between the solar wind and Earth's magnetosphere.
- Auroras are usually seen close to Earth's magnetic poles because electrically charged particles are guided toward earth's magnetic poles by Earth's magnetosphere.

28.3 Formation of the Solar System

28.3 Formation of the solar system

- Most scientists in the 1600's & 1700's thought the sun formed first and threw off materials that later formed the planets.
- 1796, a French mathematician Marquis Pierre Simon de Laplace stated that the sun and planets formed out of the same spinning nebula.
- Laplace also stated that our entire solar system formed at approximately the same time.
- This hypothesis developed into what we call the nebular theory.

Formation of the Sun

- The Big Bang scattered matter and energy throughout the universe.
- Some of this material gathered into clouds of gas and dust, forming the solar nebula.
- A star – our sun – began to form in the center.
- 99% of all matter in the solar nebula became part of the sun.

Formation of the planets

- While the sun was forming in the center, planets were forming in the outer regions of the solar nebula.
- Small bodies are called planetesimals.
- Planetesimals joined together through collisions and the force of gravity to form larger bodies called protoplanets.

Formation of the planets

- Protoplanets condensed and became the planets and moons.
- Planets and moons are smaller and denser than protoplanets.
- The 4 protoplanets closest to the sun became Mercury, Venus, Earth and Mars.
- These planets contained large amounts of heavier elements, such as iron.

Formation of the planets

- The next 4 protoplanets became Jupiter, Saturn, Uranus and Neptune.
- The outer planets formed in the cold outer regions of the solar nebula.
- The icy material of the outer protoplanets consisted of helium and hydrogen.
- Also frozen gases; water, methane, and ammonia.

Formation of the planets

- Because they were so far from the heat of the sun, the outer protoplanets developed into huge planets.
- Thick layers of ice surrounded small cores of heavy elements.
- Inner planets are called *terrestrial planets*.
- Outer planets are called *gas giants* or Jovian planets.

The Solid Earth

- Temperature on young earth was enough to melt iron.(2800°F,1500°C)
- Melted iron sank to the center of the planet.
- As earth cooled, layers separated by density. Heavier elements sank, lighter elements rose.
- 3 distinct layers
  - Core: mostly iron and nickel.
  - Mantle: middle layer, very thick.
  - Crust: surface layer of less-dense solids.

The Atmosphere

- As the Earth protoplanet grew large enough, its gravity captured some of the hydrogen and helium from the solar nebula. (1st atmosphere)
- Where do you find these 2 elements today? In the upper atmosphere.
- Solar wind and explosions probably blasted away most of Earth's first atmosphere.

The Atmosphere

- 2nd atmosphere resulted from volcanic eruptions.
- Volcanoes released large amounts of carbon dioxide and water vapor (and other gases).
- Cyanobacteria and early plants converted carbon dioxide into oxygen during photosynthesis.
- Oxygen levels slowly increased to current levels.

The Oceans

- As the atmosphere was forming, the Earth cooled enough for liquid water to form.
- Previously, the heat of the planet kept water as a gas.
- Between 3 billion and 3.5 billion years ago, water vapor began to condense.

The Oceans

- Water fell to Earth as rain and formed oceans in the lower surface areas.
- Scientists also think much of Earth's water came from comets bombarding the planet for 30,000 years.
- Ocean water absorbed carbon dioxide from the air.
- By 1.5 billion years ago, the atmosphere was similar to today.