

The Solar System!

Jo-Anne Brown

Outline

- Questions!
- Earth, Moon, Sun
- A little, teeny, tiny bit of history...
- Terrestrial planets
- Gas Giants
- Poor Pluto
- Magnetic fields

Tell me what you know!

When you look up, what do you see?



Earth **Critical Data** Mass: $5.97 \times 10^{24} \text{kg} = 1 \text{M}_{e}$ Radius: $6378 \text{ km} = 1R_{e}$ Moons: 1 Moon Mass: 0.0123 M_e Distance to Moon: 60 R e Distance to Sun: 23,456 R_e= 1AURotation Period: 1 Day Orbital Period: 365.25 Days = 1 YrAtmosphere: 78% Nitrogen 21% Oxygen 1% Water vapor 0.4% Carbon Dioxide Surface Temp: 184K - 331K (-89C to +57.7C)Interesting fact: Only planet with life(?)

Does the Moon Rotate?

SUN

Critical Data

Mass: 332 946 $M_e = 1$ Solar Mass Radius: $109 R_e = 1$ Solar Radius Distance to the GC: 26000 ly Rotation Period: 25 days (at equator) Orbital Period: 2.25 x10⁸ yr Atmosphere: 73.46% Hydrogen 24.85% Helium 0.77% Oxygen 0.29% Carbon 0.16% Iron Surface Temp: 5778 K

2008/12/17 00:19

NASA SOHO imae - DECEMBER 17, 2008

Interesting fact: In ~7 billion years the Sun will become a red giant and swallow the Earth!

Imagine trying to fit these together...

- You see a moon...
- You see the Sun (actually a close star!)
- You see stars
- You see moving stars... (actually planets!)

Planetary Motion Historical Overview



Aristotle (384-322BC):

- Geocentric model
- Noticed retrograde motion



Galileo (1564-1642): • Heliocentric model

- Telescope obs.
- condemned of heresy



Ptolemy (~85-165AD):

- Geocentric model
 - epicycles & deferent paths

Copernicus (1473-1543):

- Heliocentric model
- circular orbits
- epicycle motion



Kepler (1571-1630)

- Heliocentric model
- Tycho Brahe obs.
- Kepler's Laws

Newton (1642-1727)

- Heliocentric model
- Newton's Laws
- Law of Gravitation

The Four Terrestrial Planets



NASA Image: http://solarsystem.nasa.gov/multimedia/gallery/terr_sizes.jpg

Mercury

Critical Data



Mass: 0.055 M_e Radius: 0.3829 Re Moons: NONE Distance to Sun: 0.387 AU Rotation Period: 58.6 days Orbital Period: 87.9 days Atmosphere: 42% Molecular Oxygen 29% Sodium 22% Hydrogen 6% Helium 0.5% Potassium Surface Temp.: 80K - 700K **Interesting fact:** *Most eccentric orbit of* all the planets!

NASA image from MESSENGER



Critical Data

Mass: 0.815 Me Radius: 0.949 Re Moons: NONE Distance to Sun: 0.723 AU Rotation Period: 243 Days Orbital Period: 0.614 Yr Atmosphere: 96.5% Carbon dioxide 3.5% Nitrogen 0.015% Sulfur dioxide 0.007% Argon 0.002% Water vapor Surface Temp.: 735K (461 C) **Interesting facts**: spins in the OPPOSITE direction to most planets (spins "Clockwise"), and has most circular orbit.

Image processing by R. Nunes <u>http://www.astrosurf.com/nunes</u>



Critical Data



NASA Image from Hubble Space Telescope June 26, 2001.

Mass: 0.107 M_e Radius: 0.533 Re Moons: 2 Distance to Sun: 1.523 AU Rotation Period: 1.026 Days **Orbital Period: 1.88 Years** Atmosphere: 95.72% Carbon Dioxide 2.7% Nitrogen 1.6% Argon 0.2% Oxygen 0.07% Carbon Monoxide Surface Temp.: 186K-268K (-87C to -5C) **Interesting fact:** *Of all the planets, Mar's* seasons are most similar to Earth's.

The Asteroid Belt



• Formed from the primordial Solar Nebula Located between Mars and Jupiter • Jupiter's gravity prevented planet formation. • Ceres is the largest object at 950 km diameter. It is also the only hydrostatic equilibrium object in the belt. • 3 other objects have diameters greater than 400km



The Four Gas Giants

Jupiter

Critical Data

Mass: 317.8 Me Radius: 11.2 R_e Moons: 63 Moons! (4 Galilean moons) Distance to Sun: 5.204 AU Rotation Period: 9.925 hours! Orbital Period: 11.86 Yr Atmosphere: 89.8 % Hydrogen 10.2 % Helium 0.3% Methane 0.026% Ammonia 0.003% HD Surface Temp.: ~165K **Interesting Fact:** *Is 75 times too small* to be a star -BUT it radiates more energy than it receives from the Sun!

NASA image from Voyager

Saturn

Critical Data Mass: 95.152 M_e Radius: 9.449 R_e Moons: 60! Distance to Sun: 9.582 AU Rotation Period:10 hours, 32-47 min. Orbital Period: 29.657 Yr Atmosphere: 96% Hydrogen 3% Helium 0.4% Methane 0.01% Ammonia 0.01% HD Surface Temp.: ~134K Interesting Fact: 34 moons are less than 10 km diameter; only 7 are in hydrostatic equilibrium (Titan is 150% the Moon)

NASA image from Cassini

Uranus

Critical Data

Mass: 14.536 Me Radius: 4 R_e Moons: 27 Distance to Sun: 19.2 AU Rotation Period: 17 hr, 14 min Orbital Period: 84.3 Yr Atmosphere: 83% Hydrogen (H) 15% Helium 2.3% Methane 0.009% Hydrogen Surface Temp.: 53K Interesting Facts: Uranus lies on its side! It has an axial tilt of 97.7 degrees. It also spins clockwise like Venus.



NASA image from Hubble Space Telescope

Neptune

NASA image from Voyager

Critical Data Mass: 17.147 M_e Radius: 3.883 R_e Moons: 13 Distance to Sun: 30.1 AU Rotation Period: 16h 6min Orbital Period: 164.79 Yr Atmosphere: 80% Hydrogen (H₂) 19% Helium 1% Methane Surface Temp.: 72K (-201C) **Interesting Fact:** Both Neptune's and Uranus's magnetic field seem to be generated in a shell of the planet - unlike the terrestrial and gas giants where the fields are generated in the cores.

ρίυτο

Pluto was a planet. But now it doesn't pass. Pluto was a planet. They say it's lacking mass. Pluto was a planet. Pluto was admired. Pluto was a planet. Till one day it got fired.

From: Comets, Stars, the Moon, and Mars by Douglas Florian

Pluto

Critical Data



Mass: 0.0021 M_e Radius: 0.19 Re Moons: 3 Distance to Sun: 39.48 AU Rotation Period: 6.4 days Orbital Period: 248.09 Yr Atmosphere: Nitrogen, Methane Surface Temp.: 44 K Interesting Facts: Spins Clockwise. **Recently demoted to "Dwarf Planet".**

Image from: http://snarkbutt.blogspot.com/2007/09/pluto-dwarf-planet.html

Pluto

Critical Data

Mass: 0.0021 M_e Radius: 0.19 R_e Noons: 3 Distance to Sun: 39.48 AU Rotation Period: 6.4 days Orbital Period: 248.09 Yr Atmosphere: Nitrogen, Methane Surface Temp.: 44 K Interesting Facts: Spins Clockwise. Recently demoted to "Dwarf Planet".

Image from: http://snarkbutt.blogspot.com/2007/09/pluto-dwarf-planet.html

Definition of a Planet

- 1. Orbits around the Sun
- 2. Has enough gravity to pull itself into a spherical shape (hydrostatic equilibrium).
- 3. Must be the largest thing on its orbit.

Pluto is only 0.07 times the mass of other objects on its orbit... thus in 2006 it was laterally promoted to Dwarf planet in the Kuiper Belt.

Largest known trans-Neptunian objects (TNOs)



Scale Sizes: Diameter of the Solar System



11.2 billion km = 80 Au = 10 light-hours

Scale Sizes: Diameter of the Galaxy:



$1.543 \times 10^{18} \text{ km} = 10.3 \text{ billion Au} = 163,091 \text{ ly}$

How does the Solar System fit in the Galaxy?



Magnetic Fields of the Cosmos

OK... So the Earth has a magnetic field...



Earth photo credit: NASA Goddard Space Flight Center

...which protects us from the Solar wind...



Image from SOHO Image Gallery

...and helps produce the aurora...





Photo credits: Jan Curtis and NASA Goddard Space Flight Center

Auroral Ovals are Around the Poles



Around the magnetic North is a large current ring called the *Auroral electrojet*.









Other planets have Aurora too!

The Sun also has a magnetic field...





2008/12/17 00:19

(*images from SOHO*)

...which protects the Solar system from the interstellar wind...



...but the Galaxy has a magnetic field too?

Absolutely!

So what does the magnetic field in a the Galaxy do?



a stellar nursery

• Star formation and evolution

• Galaxy formation and evolution

galaxy NGC4414

Image credits: Hubble Heritage Team

How do we measure a magnetic field?

Measurements in the Solar System

30 On 1977-2007 SPACE EXPLORATI

NASA's Voyager 1+2 Launched: 1977 Mission objective: Included measuring **B** for the Sun, Jupiter, Saturn, Uranus, Neptune, and the ISM.

In December of 2004, these instruments left the Solar system...

Voyager Locations as of 2008



In December of 2004, these instruments left the Solar system... ...but they have not reached the ISM!

Since we can't use space probes for measurements....

...use Nature's probes!

Two "Probes": Pulsars and Other Galaxies





Hubble Deep Field: Lots of Galaxies!

Galactic Magnetic Field Basics



- Two components: large, small
- Concentrated in the disk
- follows the spiral arms (?)
- local field is cw
- Sagittarius field is ccw
- Determining the existence and location of additional reversals will help us understand the origin and evolution of the field.

Summary (Things to walk away with...)

- ★ Solar System Basics:
 - the Sun is our nearest star
 - ♦ 8 planets; 4 terrestrial, 4 gas giants
 - Pluto is a dwarf planet
 - the Solar system is "tilted" in the Galaxy
- ★ Magnetic fields are an important part of the cosmos!