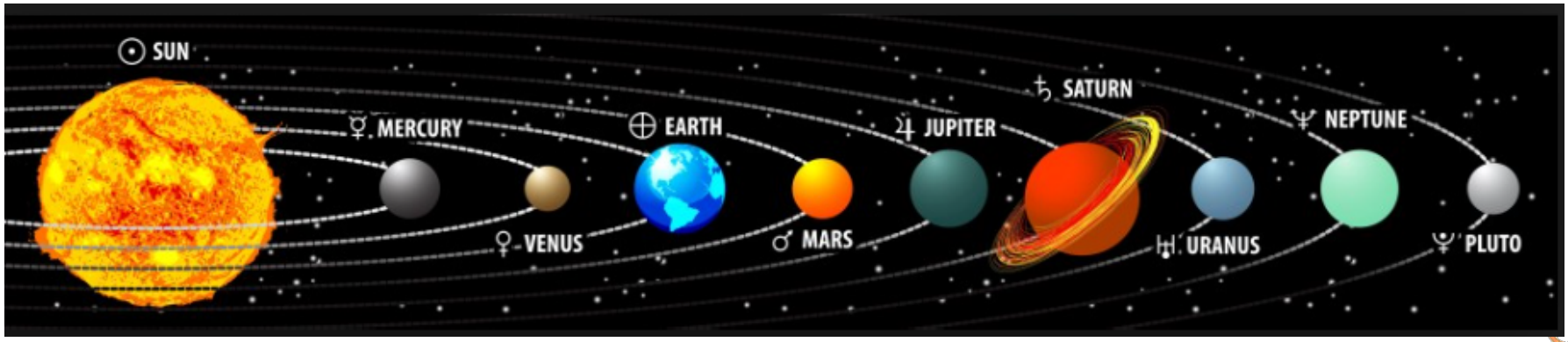
Physics 320
Astronomy and Astrophysics I

Wenda Cao

NJIT Physics Department

Outline

- Physics 320 – Course Information
- Lecture 1 – Introduction to the Solar System
  - 1.1 Why do we study astronomy and solar system?
  - 1.2 What constitutes the Solar System?
  - 1.3 Scaling the Solar System
  - 1.4 The Thousand-Yard Model
  - 1.5 Summary



Course Information: Instructor

- Instructor: Prof. Wenda Cao
- Office: 101 Tiernan Hall
- Office hour: 2:30 - 4:00 PM Monday and Thursday. Other time by appointment
- Telephone: 973-596-5301; Email: *cao@njit.edu*
- Website: *http://web.njit.edu/~cao/320.htm*where you will find weekly reading assignments, lecture notes, reviews, homework assignments and solutions etc.

Course Information: Materials

- 1:00 pm-2:25 pm, Monday and Thursday at FMH 110
- Lecture notes available at *http://web.njit.edu/~cao/320.htm*
- Primary Textbook: "*An Introduction to Modern Astrophysics*", 2nd *Edition, by Carroll and Ostlie*
- Reading Material: reading assignments are listed below. For this course, we will be covering Chapters 1, 2, 6, 11, 12, 19, 20, 21, 22 and 23 (the part of the Sun and the Solar System). Complete the readings **before** the corresponding lectures.

Course Information: Homework

- Problem sets are given every Monday or Thursday before the classes.
- Homework due the following Monday or Thursday at the classes.
- The homework assignments will be collected on each Monday or Thursday in the classes.

Course Information: Grating

- In-class Exams (15% each, 30% total)
  - **Midterm Exam 1:** Monday, October 1st, 1:00 – 2:25 pm
  - **Midterm Exam 2:** Thursday, November 3rd, 1:00 – 2:25 pm
- Final Exam (30%)
- Homework (20%)
- Project and Attendance (20%)
  - **Project Presentation:** Monday, November 5th, in class
- Final Letter Grade

A	85+
B+	80-84
B	70-79
C+	65-69
C	55-64
D	50-54
F	< 50

Classroom Response System: i-Clicker

- iClicker is required as part of the course
  - Similar to requiring a textbook for the course
  - Can be purchased at the NJIT bookstore
  - Can't share with your classmate
- iClicker use will be integrated into the course
  - To be used during most or all lectures/discussions
  - iClicker questions will be worked into subject matter
  - Some related issues ("My iClicker doesn't work", or "I forgot my iClicker.") More later.

Astronomy Courses

- The NJIT Physics Department now has an undergraduate ***minor and a concentration in Astronomy***, and has enhanced the astronomy offerings for both technical and non-technical students.
  - Phys. 202, 202A – Introduction to Astronomy and Cosmology
  - Phys. 203, 203A – The Earth in Space
  - **Phys. 320 – Astronomy and Astrophysics I**
  - Phys. 321 – Astronomy and Astrophysics II
  - Phys. 322 – Observational Astronomy
  - Phys. 420 – Special Relativity
  - Phys. 421 – General Relativity
  - Phys. 444 – Fluid and Plasma Dyn

Astronomy and Astrophysics I

- **Phys 320** A quantitative introduction to the astronomy of the Sun, Earth, and the solar system, with an emphasis on the physical principles involved. Includes celestial mechanics, planetary atmospheres, and the physics of comets, asteroids, and meteorites.
- **Description** Students will study the motion, structure, atmosphere, energy, and magnetism of the Sun, planets, and satellites. The major themes include: the role of gravity in shaping the solar system, the energy balance of the planets, magnetism, and physics of light and colors. Importantly, students will learn to *reason* out of observational facts using basic physics knowledge.
- **Methodology** we will learn about them from the point of view of physics. The language of physics is mathematics. We will be using the somewhat more advanced language of algebra, trigonometry, calculus, and even a bit of simple differential equations.

PHYS 320

Lecture 1

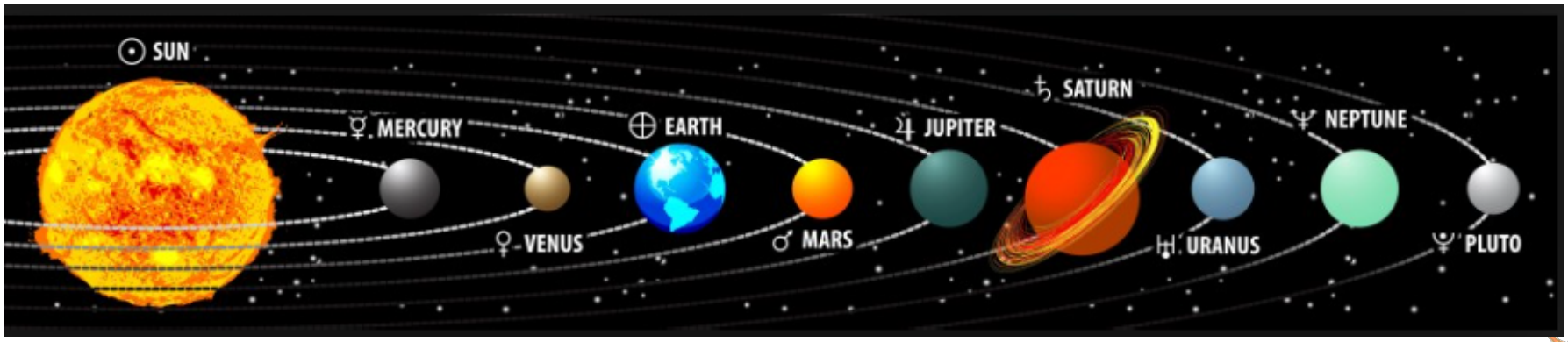
The Sun and the Solar System

Introduction and Overview

Jiong Qiu
MSU, Physics Department

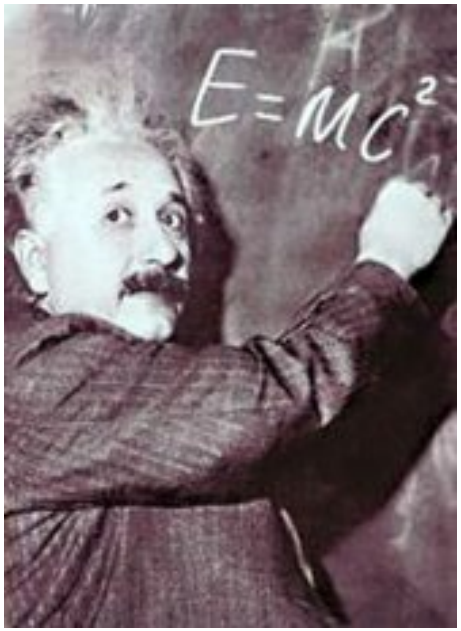
Outline

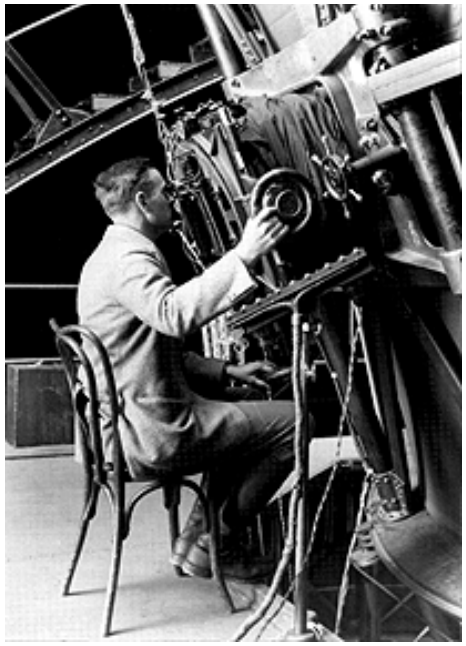
- Physics 320 – Course Information
- Lecture 1 – Introduction to the Solar System
  - 1.1 Why do we study astronomy and solar system?
  - 1.2 What is the Solar System?
  - 1.3 Scaling the Solar System
  - 1.4 The Thousand-Yard Model
  - 1.5 Summary



1.1 Astronomy is a physical science

To understand the universe, astronomers employ **scientific methods** to test **hypothesis**, build **models** and **theories**, and uncover the **laws of physics**.





What physics will we learn from the Sun, planets, and satellites?

Advances in astrophysics benefit from, as well as contribute to, new understandings of fundamental physical rules and technology development.

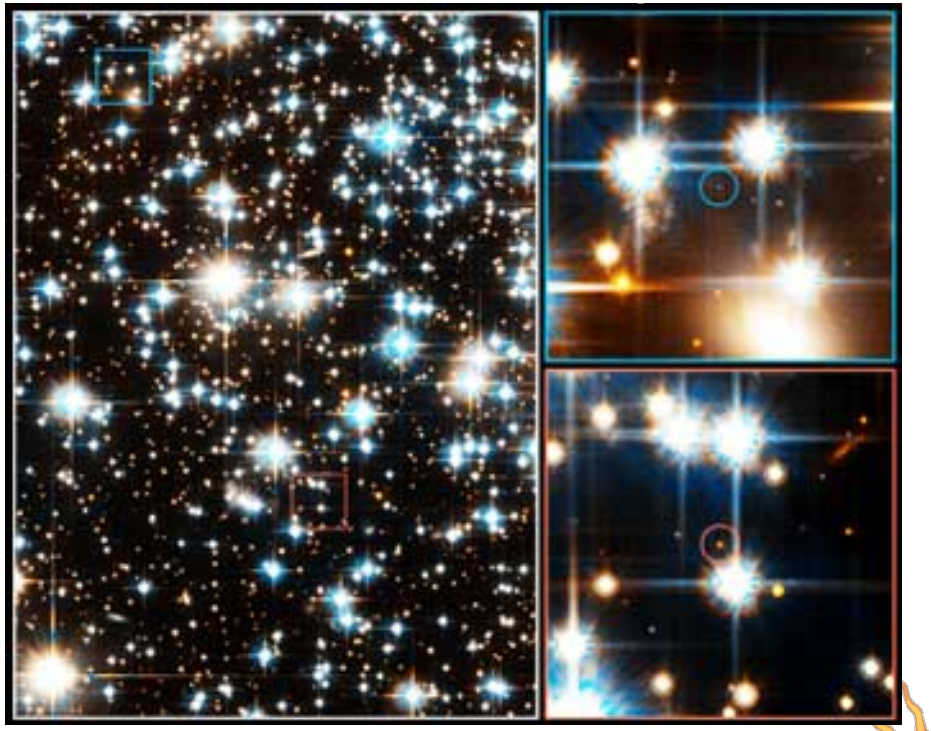
(a) celestial objects being laboratories to test physical rules.

Ex.1: astronomical proofs of general relativity.

(b) development in observing technologies

Ex.2: Hubble Space Telescope

(c) high speed computers used to *simulate* astrophysical processes on extreme time-spatial scales and with extreme physical conditions



HST has uncovered the dimmest stars in globular star clusters.

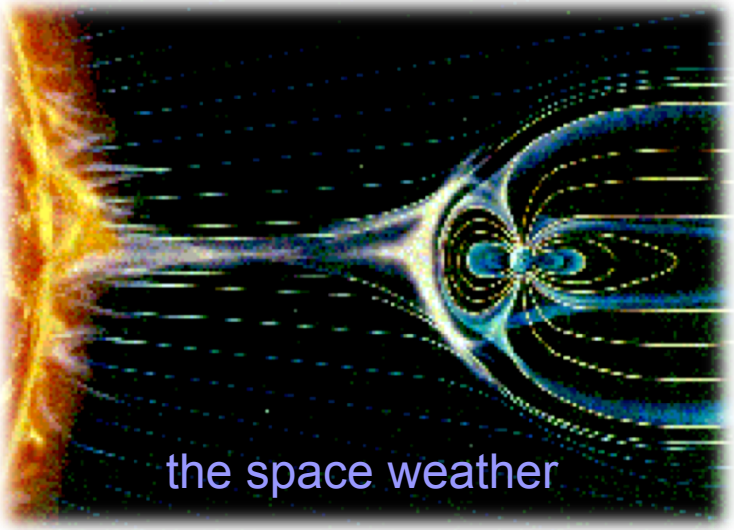
Why the Solar System?

- By exploring the planets, astronomers uncover clues about the formation of the solar system.

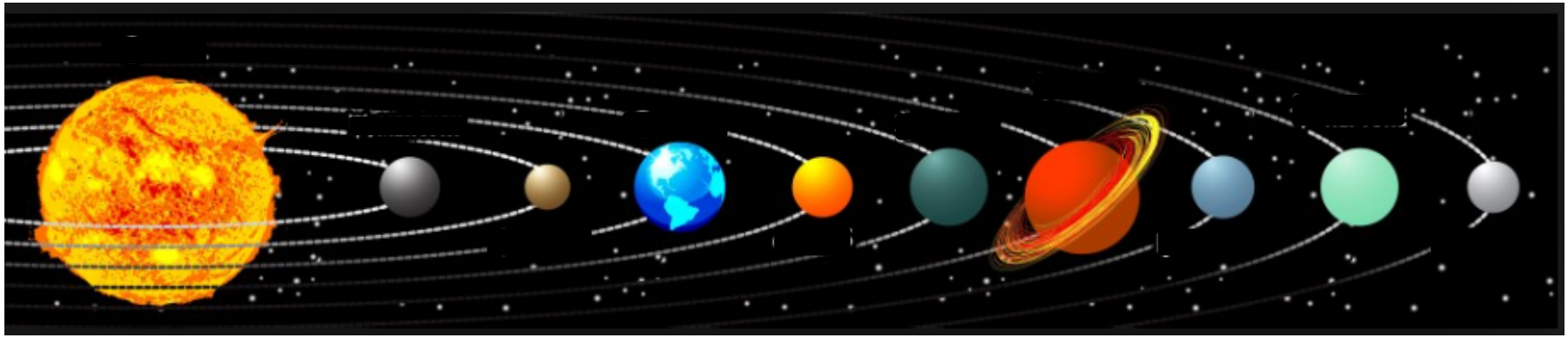
Our spacecrafts have visited all planets.

Mars Rover: our Robot geologist on Mars.

Why study the Sun?

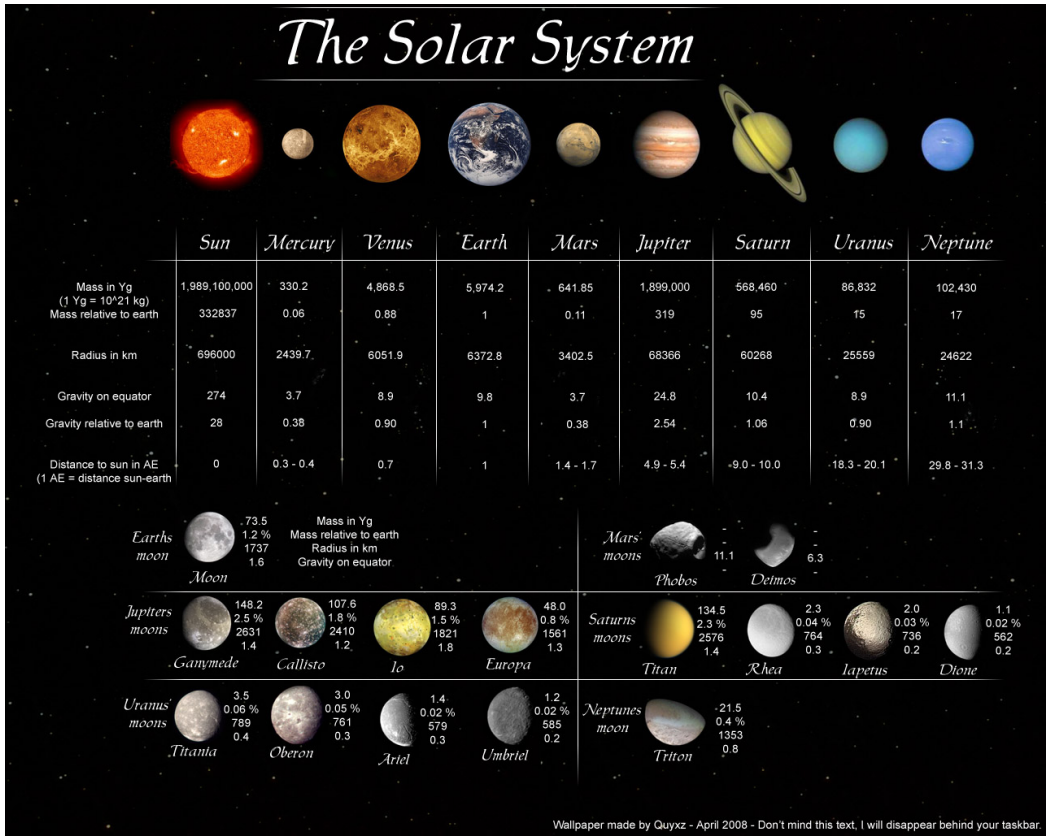


1.2 Solar System



Mercury, **V**enus, **E**arth, **M**ars, **J**upiter, **S**aturn, **U**ranus, **N**eptune, (**P**luto).
(**MVEMJSUN** – ***M**y **V**ery **E**asy **M**ethod **J**ust **S**eems **N**o **U**se*)

- The star we call the Sun and all the celestial bodies that orbit the Sun
  - including Earth
  - the other seven planets
  - all their various moons
  - smaller bodies such as asteroids, comets, meteoroids and dust



- We will learn the motion, structure, atmosphere, magnetic field of the Sun, planets, and satellites, and how to observe them.
- We will learn how to explain them - gravity, energy, and nature of light.
- We will learn why our planet, the Earth, hosts life.

PART I: INTRODUCTION TO ASTRONOMY

1. Introduction to the Solar System
2. Astronomical Distance
3. Nature of Light I
4. Nature of Light II
5. Optics and Telescopes
6. Celestial Mechanics

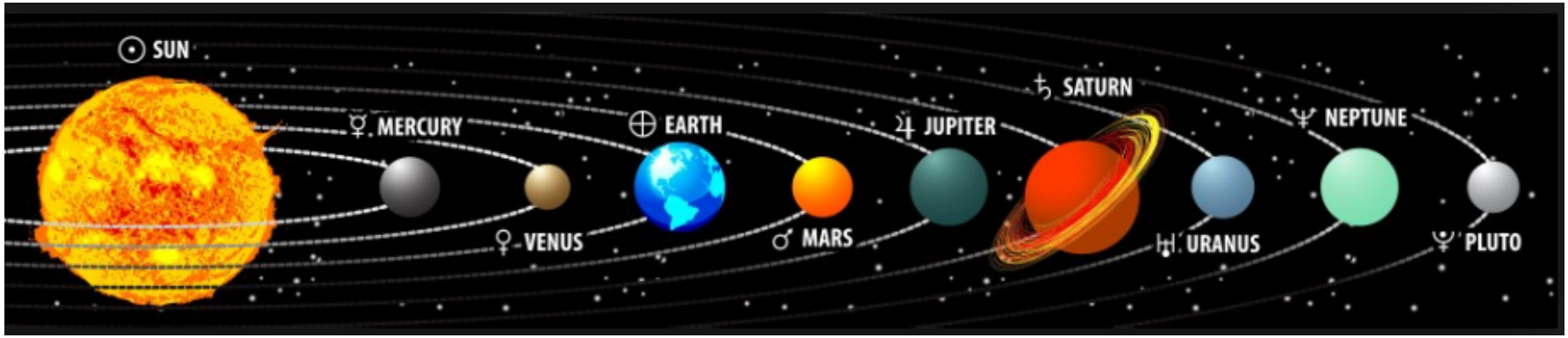
PART II: PLANETS AND MOONS

1. Our Solar System: Overview
2. Physical Processes in the Solar System
3. The Living Earth
4. The Moon and Eclipses
5. Terrestrial Planets - Mercury and Venus
6. Terrestrial Planets - Mars
7. Jovian Planets – Jupiter and Saturn
8. Pluto and Kuiper Belt
9. Asteroids, Comets and Meteors

PART III: OUR STAR: THE SUN

1. Standard Solar/Stellar Model
2. Solar Interior and Helioseismology
3. Solar Cycle
4. Solar Atmosphere
5. Solar Magnetism
6. The Active Sun
7. Space Weather

1.3 Scaling the Solar System



- Astronomical and Physical Constants – Appendix A: Inside Front Cover
- Unit Conversions – Appendix B: Inside Back Cover
- Solar System Data – Appendix C: A-1
- Solar Radius R⊙ = 695,500 km

Object	Orbital Radius D (x 10^6 km)	Equatorial Radius R (km)	D/R_o	R/R_o
Sun	---	696,000	---	1.0
Mercury	57.9	2,439	83.2	0.0035
Venus	108.2	6,052	155.5	0.0087
Earth --Moon	149.6	6,387 1,738	215	0.0092 0.0025
Mars	228.0	3,393	327.6	0.0049
Jupiter	779.3	71,398	1118	0.1026
Saturn	1427	60,000	2050	0.0862
Uranus	2871	25,559	4125	0.0367
Neptune	4497	24,800	6461	0.0356
Pluto	5913	1,140	8496	0.0016

Units of Distance in Astronomy

- Solar Radius ($R_\odot$)
  - 695,508 km = 6.95508×10^8 m
- Astronomical Unit (AU)
  - One AU is the average distance between Earth and the Sun
  - 1.496×10^8 km or 92.96 million miles
  - the distance of light traveled in 500s
- Light Year (ly)
  - One ly is the distance light can travel in one year at a speed of about 3×10^5 km/s or 186,000 miles/s
  - 1 ly = 9.46×10^{12} km or 63,240 AU
- Parsec (pc)
  - the distance at which 1 AU subtends an angle of 1 arc-second
  - 1 pc = 3.09×10^{13} km = 3.26 ly

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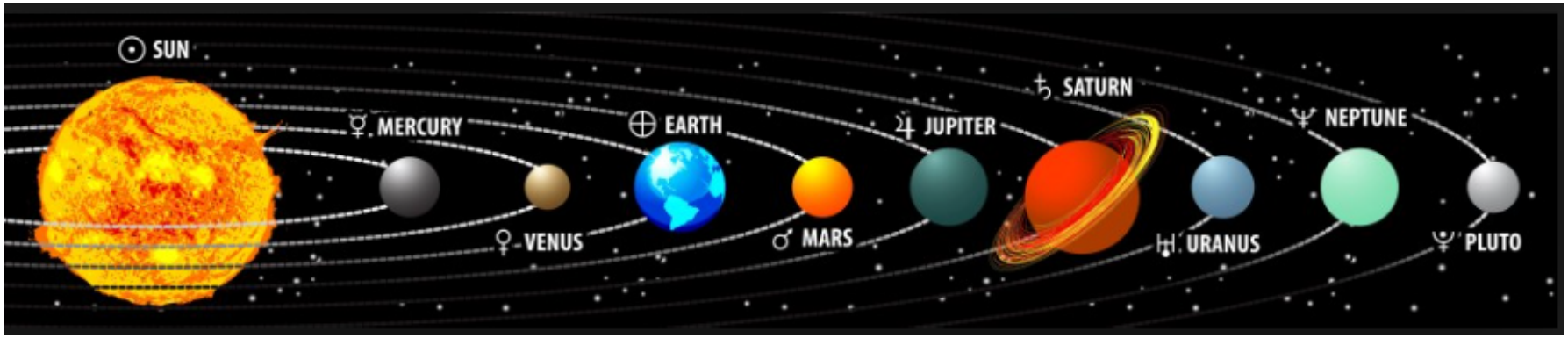
Q: What are the distances of planets to the Sun in units of AU ?

Scaling Solar System



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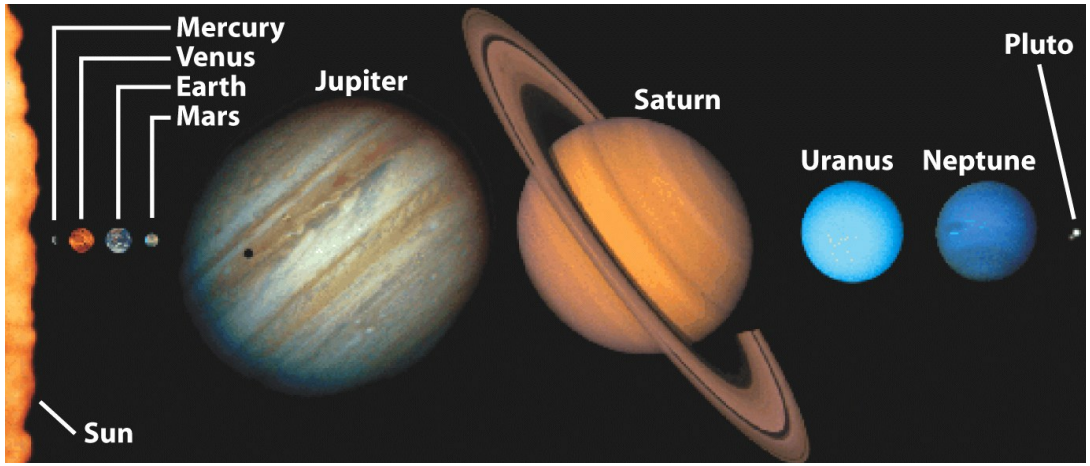
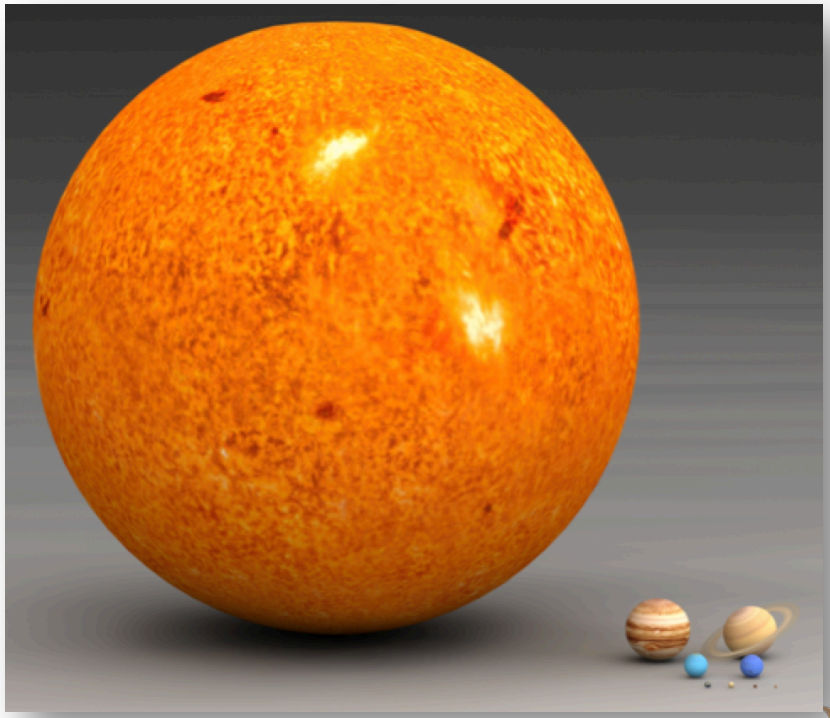


1.4 The Thousand-Yard Model

- Choose 1 inch = 100,000 miles
- Our Sun will be about 8.6 inches in diameter

Object	Distance *D* (yards)	Diameter *R* (inches)	Model Object
Sun	---	8.6	Melon
Mercury	10	0.03	Mustard seed
Venus	19	0.08	Peppercorn
Earth --Moon	26	0.08 0.02	Peppercorn
Mars	39	0.04	Mustard seed
Jupiter	134	0.88	Walnut
Saturn	246	0.74	Acorn
Uranus	495	0.32	Peanut
Neptune	775	0.31	Peanut
Pluto	1020	0.01	Mustard seed



Tabulation

- Choose 1 inch = 100,000 miles
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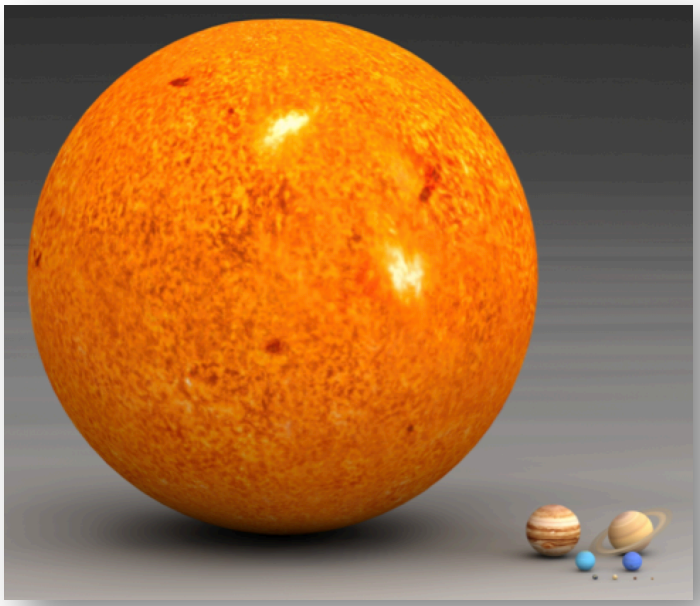
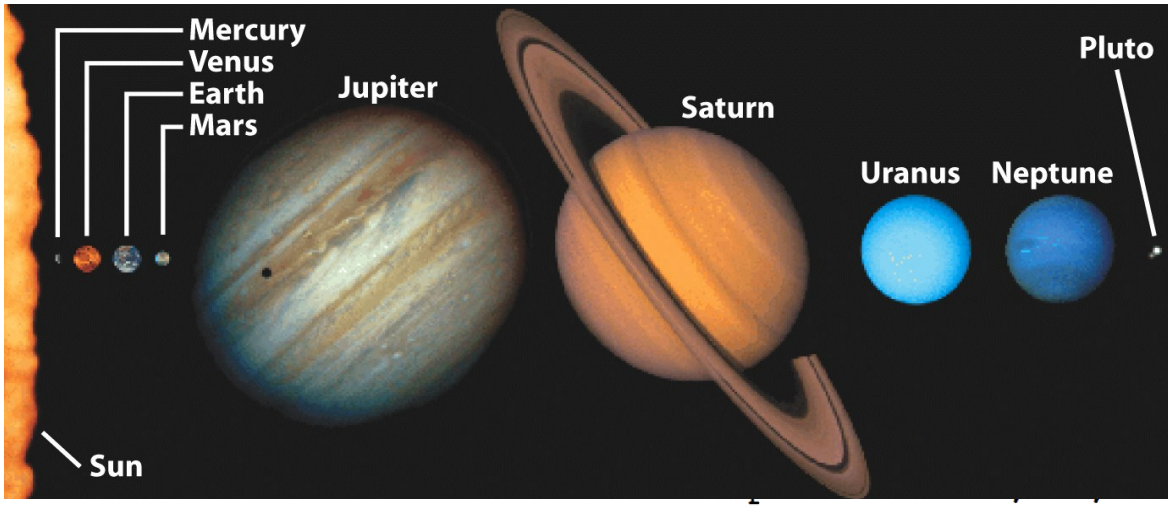


Our scale is 1: 6,336,000,000. This means that:

1 inch	represents	100,000	miles
1 foot	"	1,200,000	"
1 yard	"	3,600.000	"
1 mile	"	6,336,000,000	"
928 miles	"	5,880,000,000,000	

		in model
Moon to Earth	1.28 light-seconds	2.4 inches
Sun to Earth	8.3 light-minutes	26 yards
Sun to Jupiter	43.27 light-minutes	132 yards
Sun to Pluto	5 1/2 light-hours	1019 yards
Sun to Proxima Centauri	4.22 light-years	4000 miles

The Thousand-Yard Model



		in the model yards	inches	
			8.0	(ball)
diameter of Jupiter	90,000	10		
			0.03	(pinhead)
distance from orbit of Jupiter to Saturn	403,000,000	9		
			0.08	(peppercorn)
diameter of Saturn	75,000	7		
			0.08	(peppercorn)
distance from orbit of Saturn to Uranus	896,000,000	14		
			0.04	(pinhead)
diameter of Uranus	32,000	95		
			0.90	(chestnut)
distance from orbit of Uranus to Neptune	1,011,000,000	112		
			0.75	(filbert)
diameter of Neptune	30,000	249		
			0.30	(peanut)
distance from orbit of Neptune to Pluto	872,000,000	281		
			0.30	(peanut)
diameter of Pluto	1,400	242		
			0.01	(pinhead)
total of distances	3,666,000,000	1,019		
distance from Earth to Moon	240,000		2.40	
diameter of Moon	2,000		0.02	(pinhead)

Summary

- To understand the universe, astronomers use the laws of physics to construct testable theories and models to explain observations and predict new phenomena.
- Astronomers study planets to learn the formation of the solar system.
- Astronomers study the Sun to learn the structure and evolution of stars and sun-earth connection (climate and space weather).
- Solar system constitutes the Sun and all the celestial bodies that orbit the Sun.
- The thousand-yard model gives a clear picture of sizes and relative distances of all the celestial bodies orbiting the Sun by scaling the solar system.