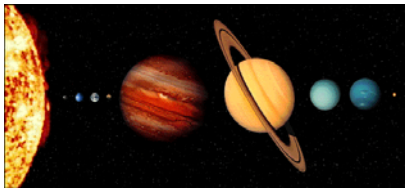
ISP205-2 Visions of the Universe

- The big questions
- Course details
- Example of how scientific discoveries are made
- Brief tour of the universe
- Reading for next class



The Big Questions

1. Laws of physics. Copernican revolution & the birth of science. How did science begin?

2. Solar system & planets. How did the solar system form?

3. The stars. What powers the sun? What is the future sun? Where does oxygen come from? “We are stardust.”

4. The universe: What is the universe made of? How old is the universe? The Big Bang.

Nicolai Copernicus (1473-1543)

Orion Nebula

Visions of the Universe
ISP 205, Section 2

- Instructor: Ed Loh, Loh@msu.edu, 884-5612, 3260 BPS
- TA: Nicholas Earl, EarlNich@msu.edu
- Office hours (BPS atrium), ½ hour after class, or by appointment
- Course web site: angel.msu.edu
  - Lecture slides by the end of the day
- ISP 205 Lab is not required
- Grading: 14% in-class exercises & homework, 51% three tests, 35% final exam.

Clickers

- Purpose for in-class exercises
  - Assess whether an idea is clear
    - For the student: Did I understand the idea?
    - For the instructor: Do I need to say more about the idea?
- In-class exercises require i-clickers
  - New textbooks have a coupon for a clicker.
  - If you have one already, you don't need to buy a new one.
- You must bring your clicker to class starting next Tues.
  - 10% of clicker questions are dropped.
  - You may turn in clicker questions on paper for at most 2 classes.

Other stuff

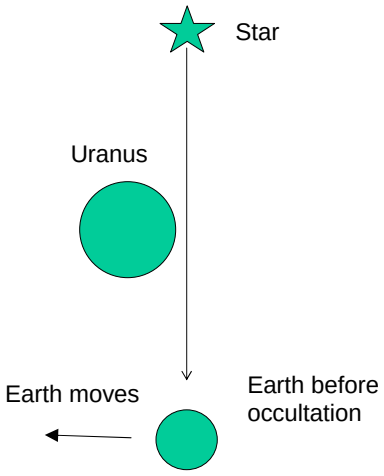
- Homework
  - Purpose is to help you think about ideas.
  - Hwk 1 will be ready on Thurs. In angel.msu.edu, select Lessons>Homework 1>
    - Due 6am Thurs, 22 Jan.
  - You have a week to complete it.
  - If you have questions, ask during office hours.
- E-mail
  - Write something about ISP205 in the subject line. I have to sort through a lot of spam; I don't want to mistake your e-mail for spam.

The method of ISP205

- Goals
  - Ideas & ways of thinking for astronomy, a physical science.
  - How are discoveries made?
- NOT goals
  - Memorize facts
  - Constellations
- After each class, test your understanding
  - What are the one or two big ideas? You must understand these.
  - What are less important ideas? How are they related to the big ideas?
  - What are details?

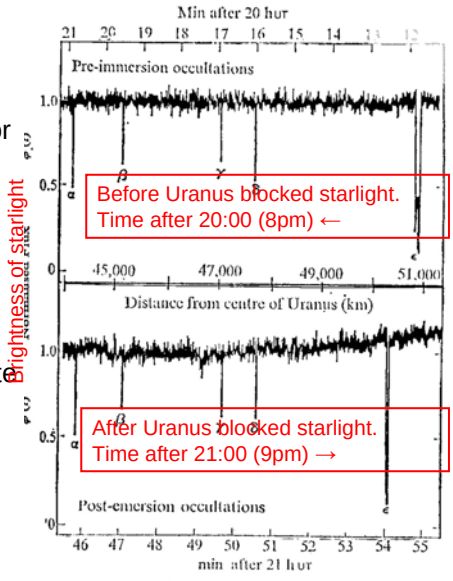
Example of a scientific discovery: Occultation of a star by Uranus

- Big idea: Scientists discovery
  - You should be able to describe scientific discovery and point to the main features using this example.
- Uranus blocks light of a bright star
- Occultation of 10 March 1977
  - Very rare. Many teams observed occultation to study the atmosphere of Uranus
  - Discovered something unexpected
- Questions
  - What is the evidence? Collect clues.
  - What are models that explain the evidence?
  - Does any clue refute any part of the model?
  - What was discovered?



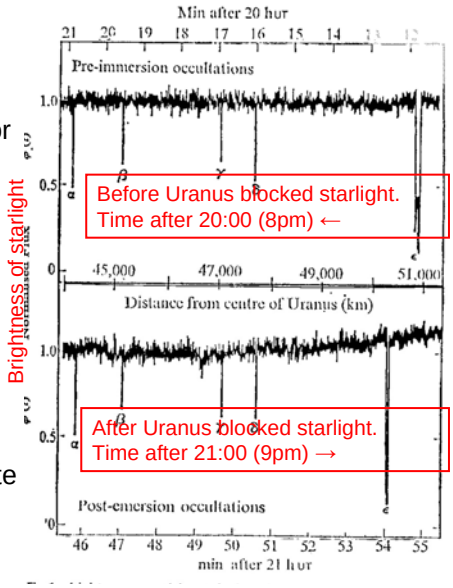
Uranus occults light of a star

- Scientific practice
  - There is an explanation for the observations
  - Collect clues
  - What is a model that explains some clues? Brainstorm
  - Test model against all clues. Does any clue refute any part of the model?



Uranus occults light of a star

- Scientific practice
  - There is an explanation for the observations
  - Collect clues
    - Which is the darkest pre-immersion occultation? α, β, γ, ε
  - What is a model that explains some clues? Brainstorm
  - Test model against all clues. Does any clue refute any part of the model?

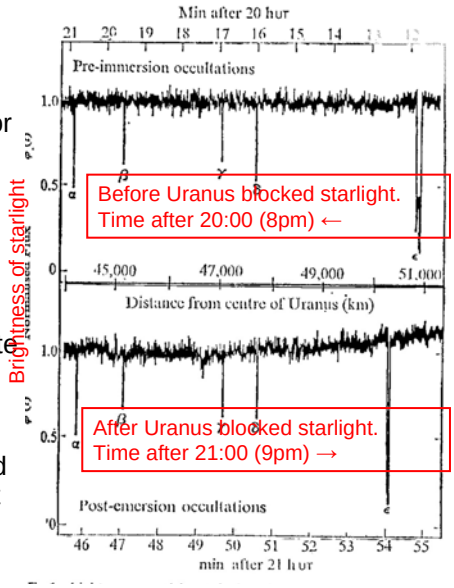


Possible models

- Some clouds came through and blocked the light.
- Moons of Uranus blocked the light.

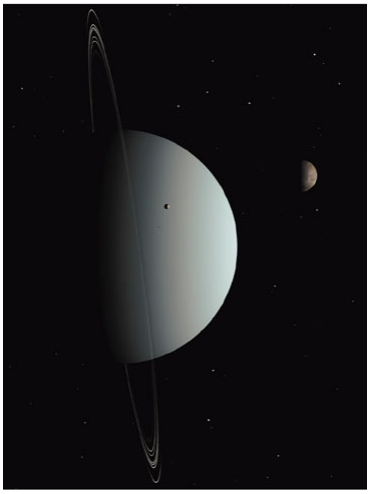
Uranus occults light of a star

- Scientific practice
  - There is an explanation for the observations
  - Collect clues
  - What is a model that explains some clues? Brainstorm
  - Test model against all clues. Does any clue refute any part of the model?
    - A team proposed the idea that previously unseen moons caused the occultations. What evidence refutes this idea?



Uranus has rings

- Uranus has rings
- Not visible with reflected light because they are sparse
- A scientific idea can be proven wrong, but it cannot be proven to be right.
  - Scientific ideas cannot be proven right, because new observations may disprove it.
    - One team with less extensive data thought they had discovered moons.

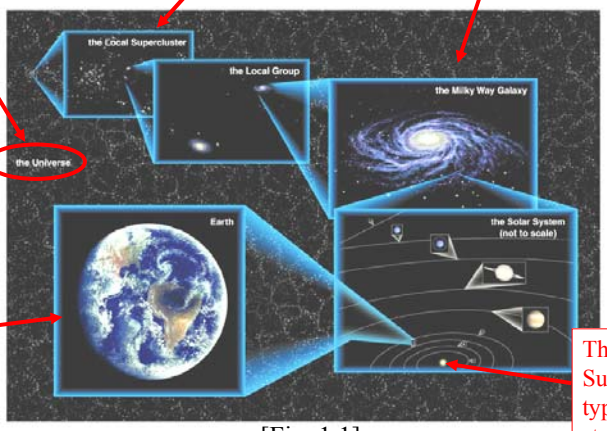


Quick tour of the universe

The Universe: Everything we can see or know about. Billions of galaxies, clusters of galaxies & superclusters are seen. Others cannot be seen because light from them has not gotten to us.

System of 100,000 galaxies like our Galaxy

System of 100,000,000,000 stars like our sun



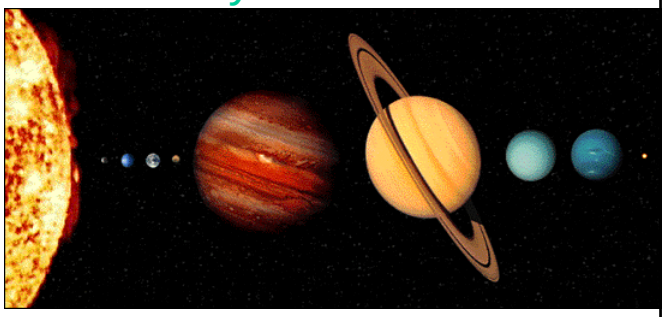
A lump of material left over from forming our Sun

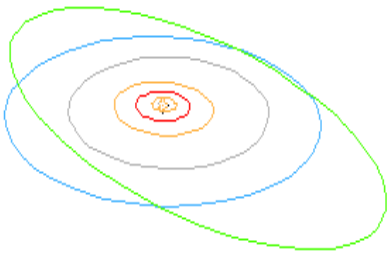
The Sun: a typical star.

[Fig. 1.1]

The Solar System

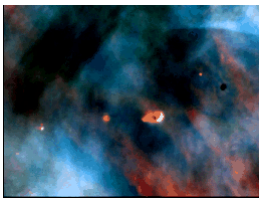
- Sun
- 9 planets (8 planets?)
- 65+ moons
- comets
- asteroids
- dust
- gas
- cosmic rays





The Orion Nebula
a present-day site of star formation

1500 ly away from us.
Recently-formed stars heat dense,
opaque gas cloud.
A cavity has blown-out, so we can see in.



Hubble Space Telescope
image of "proto-star"
with surrounding disk.

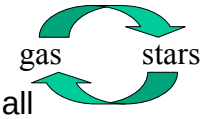
The oldest stars

The globular cluster M10

- about 100,000 stars
- formed about 10 billion years ago

Andromeda Galaxy

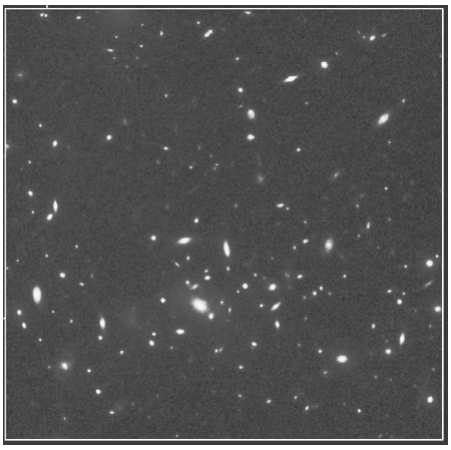
- Originally all gas
- Now ~10^{11} stars similar to our sun.
- Stars are born, evolve, then die.
- Material processed through stars.
  - Galactic ecology



- This is source of all chemical elements

except Hydrogen (H)
Helium (He)
Lithium (Li)
} made in "big bang"

Clusters of galaxies



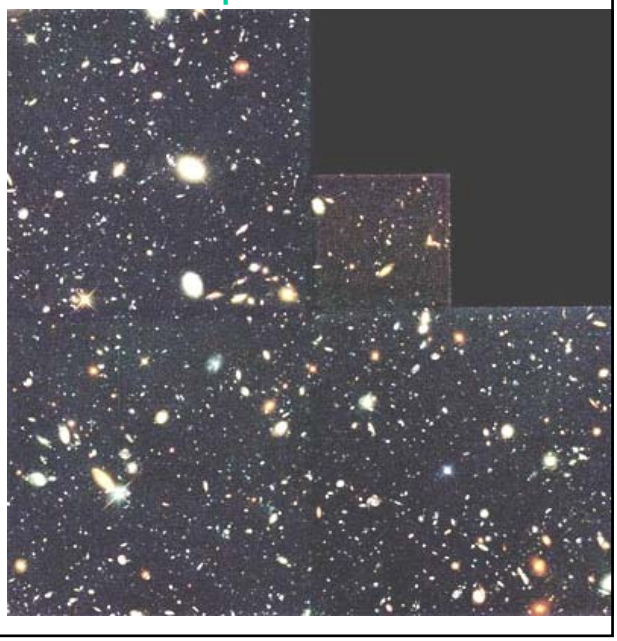
Hubble Space Telescope image

The distant galaxy cluster MS1054-0321

- Contents: thousands of galaxies and trillions of stars
- Mass: the equivalent of several thousand of our Milky Ways
- Distance:8 billion light-years from Earth.

The Hubble Deep Field

- Tiny area of sky.
  - 1/12 angular size of full moon.
- Among the faintest objects ever measured.
- 10 days' exposure with Hubble Space Telescope.
- Only 20 stars.
- Remaining 5000 objects are galaxies.



1. Arrange in order of increasing distance.
   a. Orion nebula, Jupiter, center of Milky Way, Andromeda galaxy
   b. Jupiter, Orion nebula, center of Milky Way, Andromeda galaxy
   c. Center of Milky Way, Orion nebula, Jupiter, Andromeda galaxy
   d. Jupiter, Center of Milky Way, Orion nebula, Andromeda galaxy

The Birth of Science (for Thurs)

- Study of the motion of the planets by Copernicus, Brahe & Kepler led to Newton's laws of the motion of all bodies
  - All of physics and astronomy follow Newton's path
  - All other sciences follow the same practice: detailed observations of a restricted case→ interpretation→general understanding that applies to many cases or that leads to more questions to study

Copernican Revolution: questions on reading assignment

1. Retrograde or normal motion of a planet concerns
   a. whether it rises in the east or west
   b. its motion with respect to the stars behind it.
2. Ptolemy (200AD) believed
   a. The earth moved around the sun once a year
   b. The sun moved around the earth once a year
   c. The earth moved around the sun once a day
   d. The sun moved around the earth once a day
3. We now know… (Use same answers as in #2.)