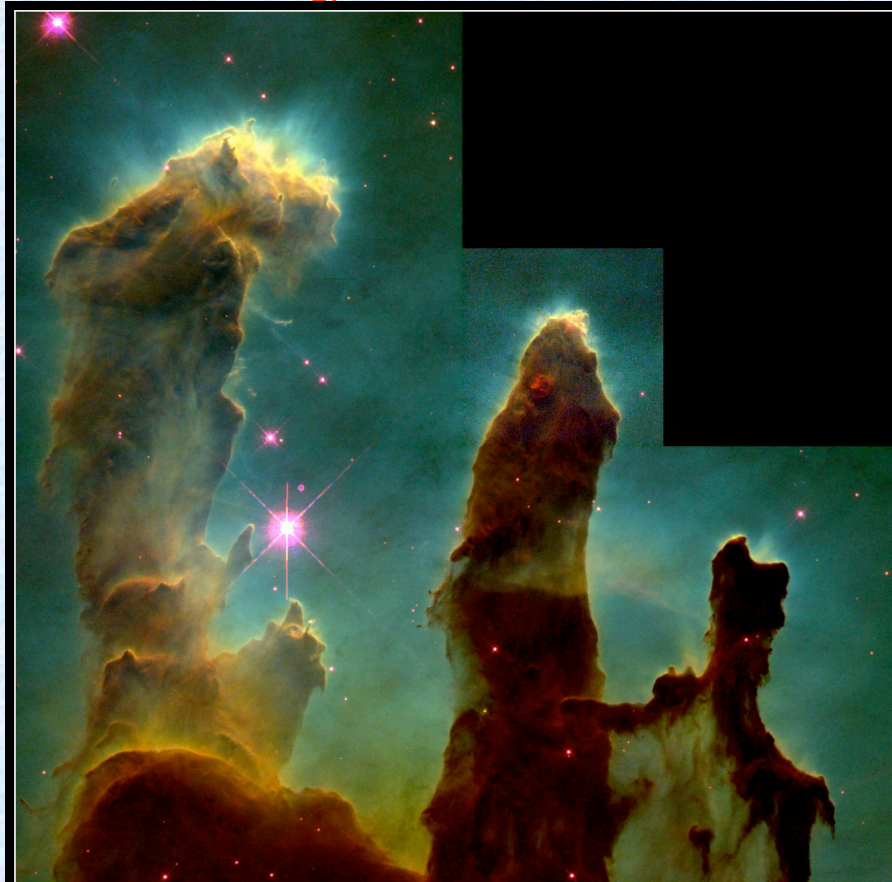


# Astronomy 1 – Winter 2011



**Gaseous Pillars in M16 • Eagle Nebula**  
Hubble Space Telescope • WFPC2

PRC95-44a • ST ScI OPO • November 2, 1995 • J. Hester and P. Scowen (AZ State Univ.), NASA

Lecture 1; January 3 2011

# Astronomy 1

- Lectures:
  - MWF 12-12:50
- Instructor office hours:
  - Prof. Tommaso Treu
    - MW 2:30-3:30; Broida 2015F
- Waitlist:
  - <https://waitlist.ucsb.edu>

# Astronomy 1

- Teaching Assistants and office hours:
  - **Bill Wolf**; T: 11-12:30; W 2-3:30 PSR
  - **Sagar Joglekar**; T: 2:30-5:00; R: 1:30-2:00 PSR
- Discussion Sections:
  - M 5-5:50 PHELP2516 (Wolf)
  - M 4-4:50 HSSB 1173 (Wolf)
  - W 6-6:50 PHELP 2516 (Joglekar)
  - F 1-1:50 PHELP 2516 (Wolf)
  - F 1-1:50 NH 1105 (Joglekar)

# Astronomy 1

- Textbook:
  - Universe 9<sup>th</sup> edition R.A. Freedman, Geller, and Kaufmann
- I will use iclickers, available at the bookstore
- Website: [www.physics.ucsb.edu/~tt/ASTRO1](http://www.physics.ucsb.edu/~tt/ASTRO1)
- Power point files and homework assignments can be found on the website



# Astronomy 1

- **Grading:**
  - 25% Homework and Discussion Section Participation
  - 5% Class participation
  - 15% Midterm-1
  - 15% Midterm-2
  - 40% Final exam (March 16 2011; noon -3PM)
- **Homework:**
  - It is recommended to read the material before lecture
  - Homework is assigned on Wednesday and due on the following Wednesday (talk with TAs). Homework assignments are listed on the course website.

# Astronomy 1 – iClickers

- I will use iClickers starting on the second week (1/10)
- Buy your iClickers and register them online
- iClickers are used to assign points for class participation
  - You just need to reply: it does not matter if you give the right answer!
- You can miss up to 5 lectures without penalty

# Astronomy 1

- **Section attendance is mandatory. Class attendance is recommended. Ask questions! There are no stupid questions!!!**
- **Grades as in Table. If class performs badly I will renormalize the grades**

A+	95%	C+	60%
A	90%	C	55%
A-	85%	C-	50%
B+	80%	D	40%
B	75%	F	<40%
B-	70%		

# Hazing and Harassment

- What you might think of as “joking around” can be a serious problem if it inhibits others from participation
- This includes, but it is not limited to, derogatory comments about women
- This behavior is prohibited by the UCSB Codes for Student Conduct in which it is considered a form of hazing. It can also become a legal case of sexual harassment.



# Hazing and Harassment: what to do about it

- Bullying behavior can be quickly stopped by warning the offenders about the legal consequences. Early warning is best
- If any student, male or female, is the target of or witnesses this activity, they are urged to report the issue.
- We insist that ALL of our students treat each other with respect and courtesy.

# Hazing and Harassment: where to report

- Professor in charge (me)
- Any department faculty
- Faculty undergraduate advisor
- Director of Judicial Affairs, Stephan Franklin (893 4569, [franklin-s@sa.ucsb.edu](mailto:franklin-s@sa.ucsb.edu))
- UCSB office of equal opportunity and sexual harassment/Title IX compliance (893-5410, [kristen.gibson@oeosh.ucsb.edu](mailto:kristen.gibson@oeosh.ucsb.edu))

# Astronomy 1 – Three goals

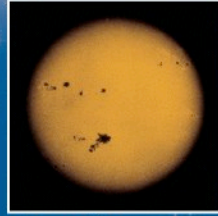
- Improve your understanding of the universe – what are planets, stars and galaxies?
- Understand the scientific method – what is science?  
What is NOT science
- Learn to understand the language of science – words and numbers.

# Goal 1 – The big picture

COSMOLOGY MARCHES ON





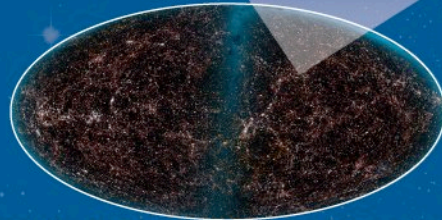
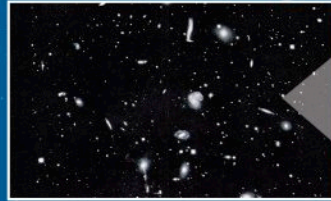


**Sun: diameter =**  
 $1.39 \times 10^6$  km



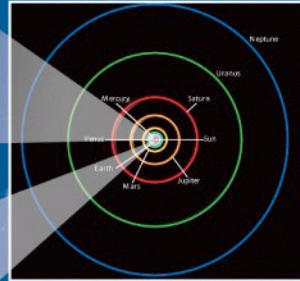
**Earth: diameter =**  
 $6.38 \times 10^3$  km

**Galaxies are grouped into clusters, which can be up to  $10^7$  ly across.**



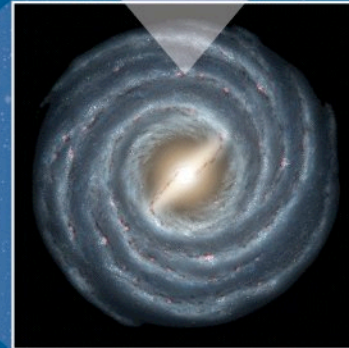
**Each of the  $1.6 \times 10^6$  dots in this map of the entire sky represents a relatively nearby galaxy. This is a tiny fraction of the number of galaxies in the observable universe.**

**The Sun, Earth, and other planets are members of our solar system**

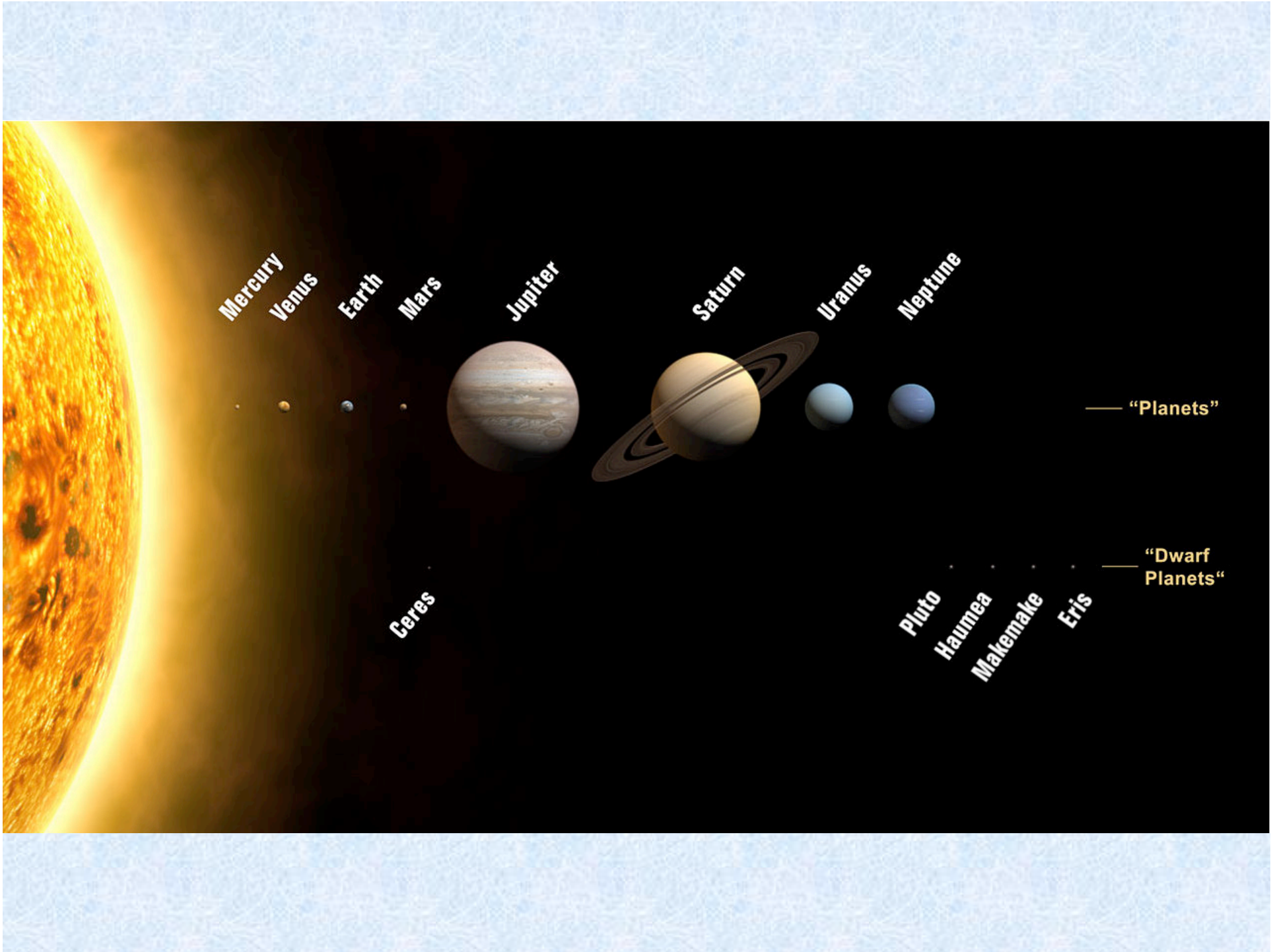


**Diameter of Neptune's orbit: 60 AU**  
**1 AU (astronomical unit) =  $1.50 \times 10^8$  km**  
**= average Earth-Sun distance**

**The Sun is a typical star. Typical distances between our neighboring stars = 1 to 5 ly**  
**1 ly = distance that light travels in one year =  $6.32 \times 10^4$  AU**



**Our Sun is one of more than  $10^{11}$  stars in the Milky Way Galaxy. Distance from the center of the Milky Way to the Sun =  $2.8 \times 10^4$  ly**



Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

Ceres

Pluto

Haumea

Makemake

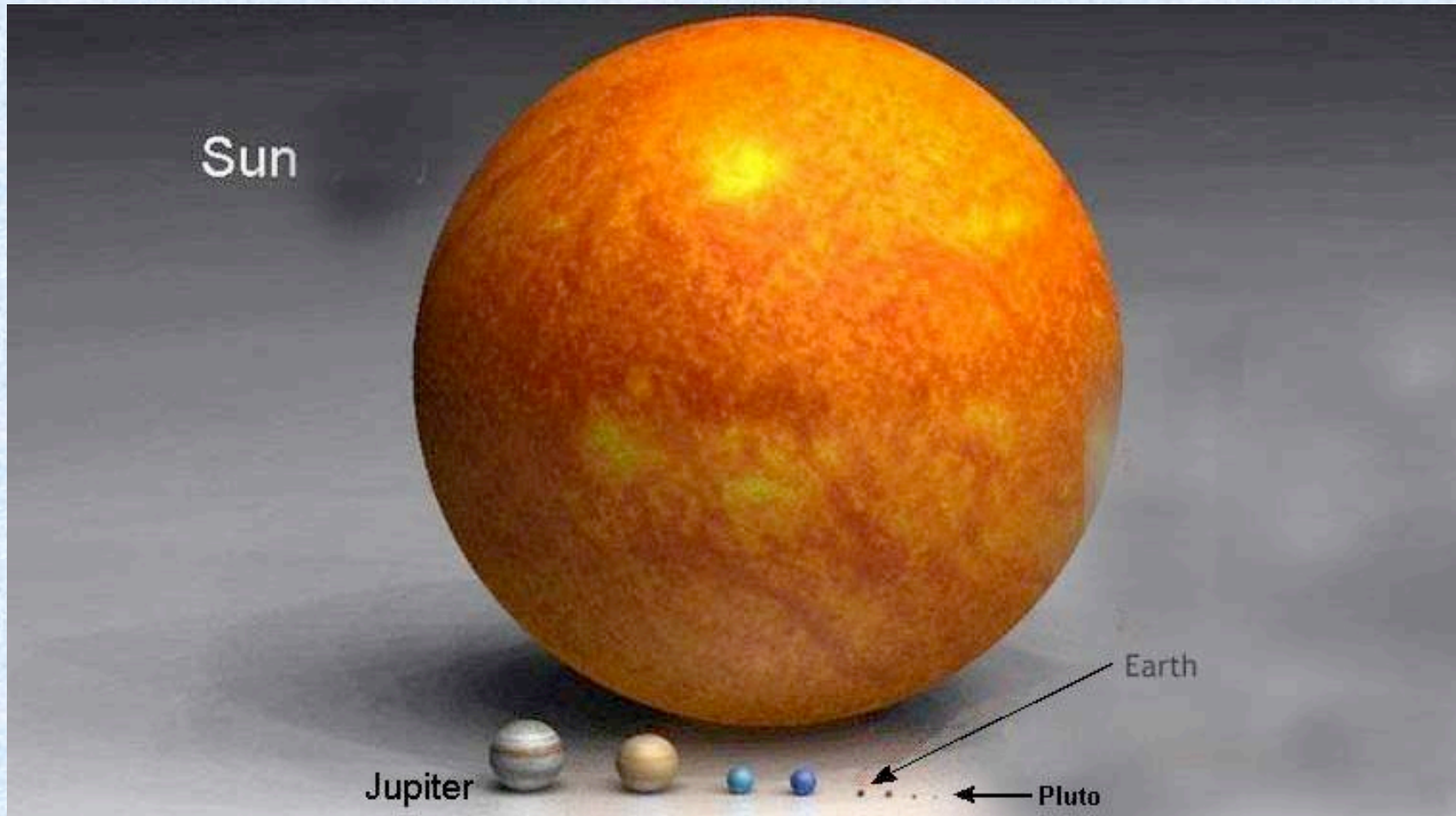
Eris

— "Planets"

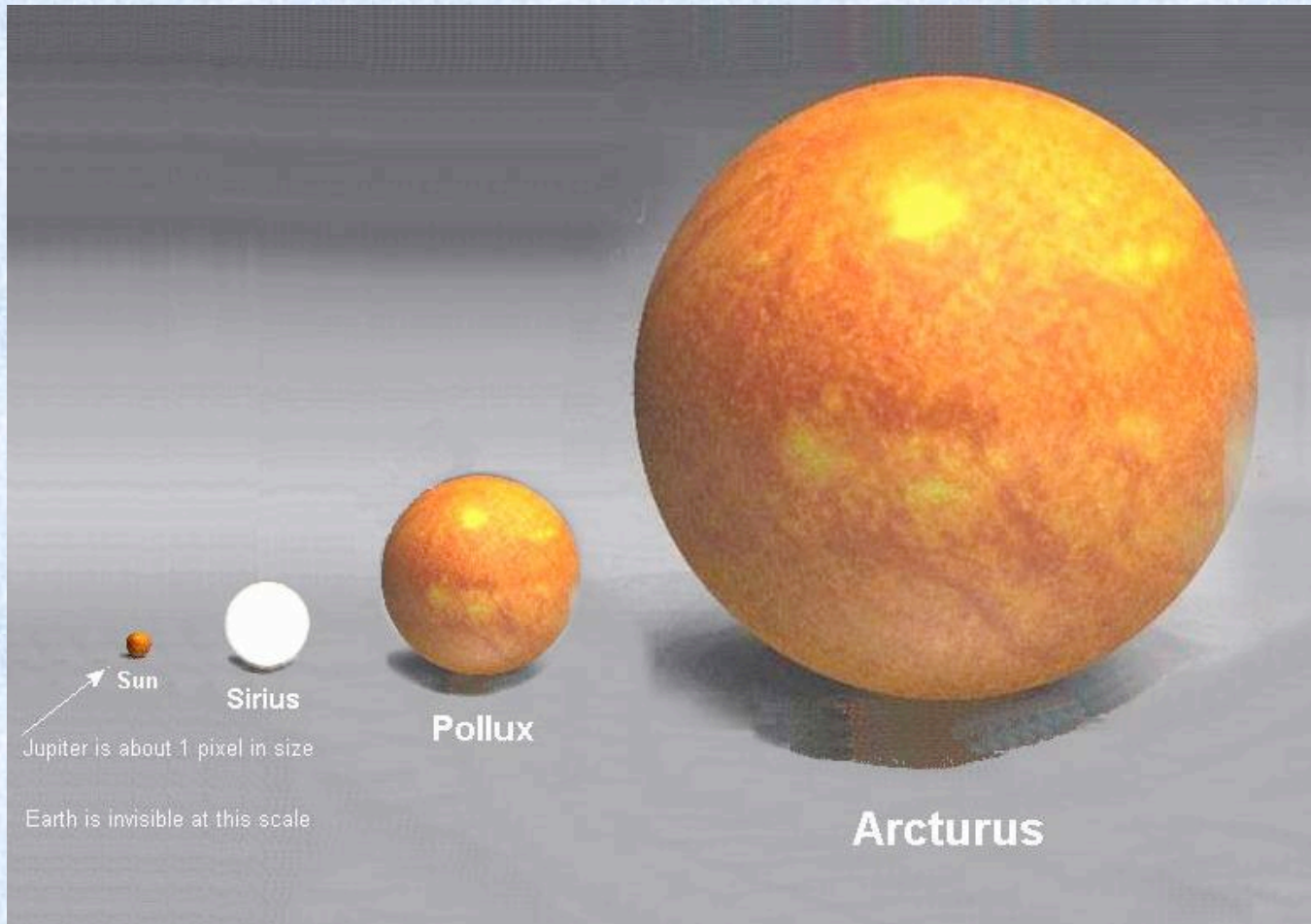
— "Dwarf Planets"



# Our solar system

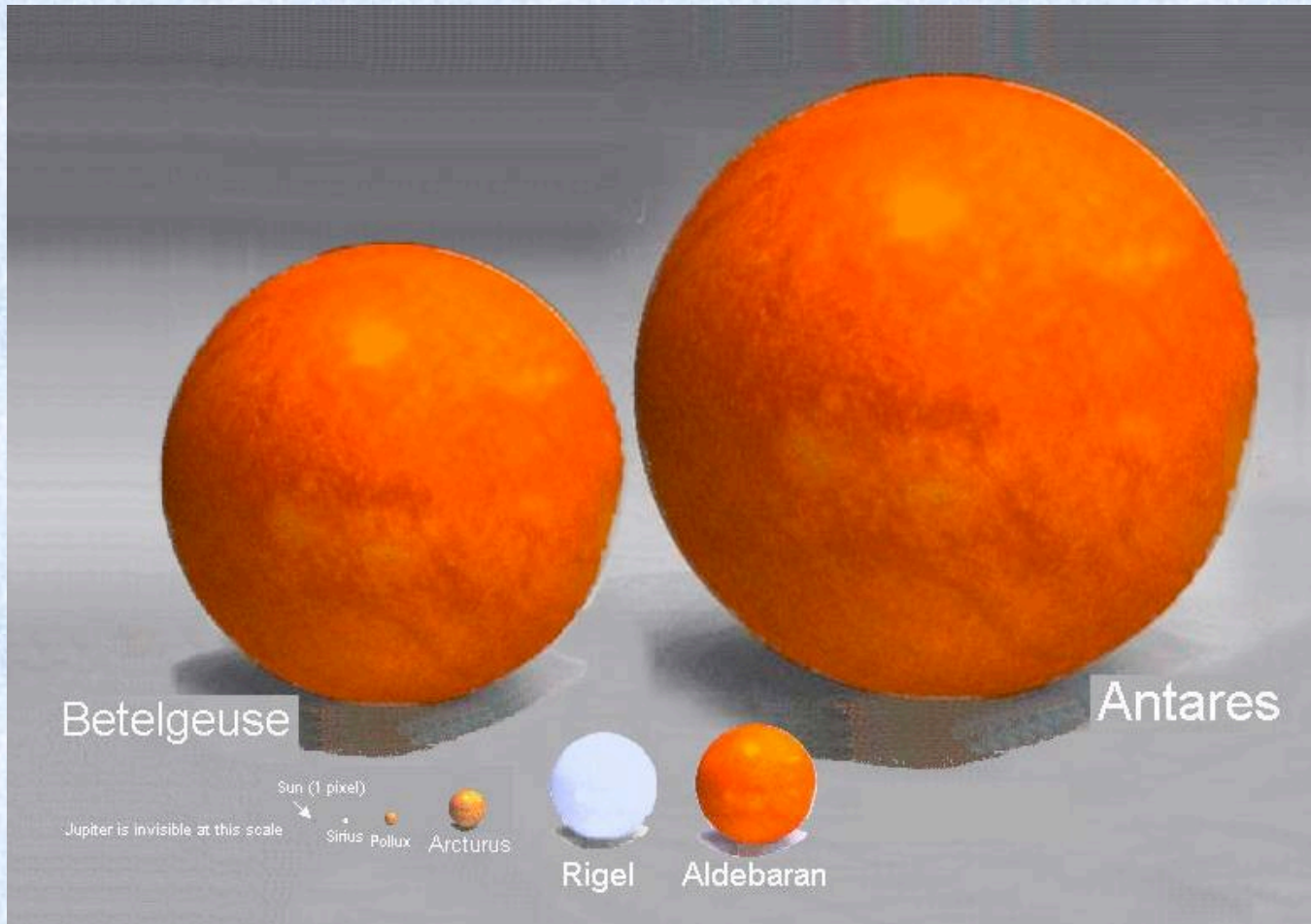


# Stars in our galaxy





# More stars..

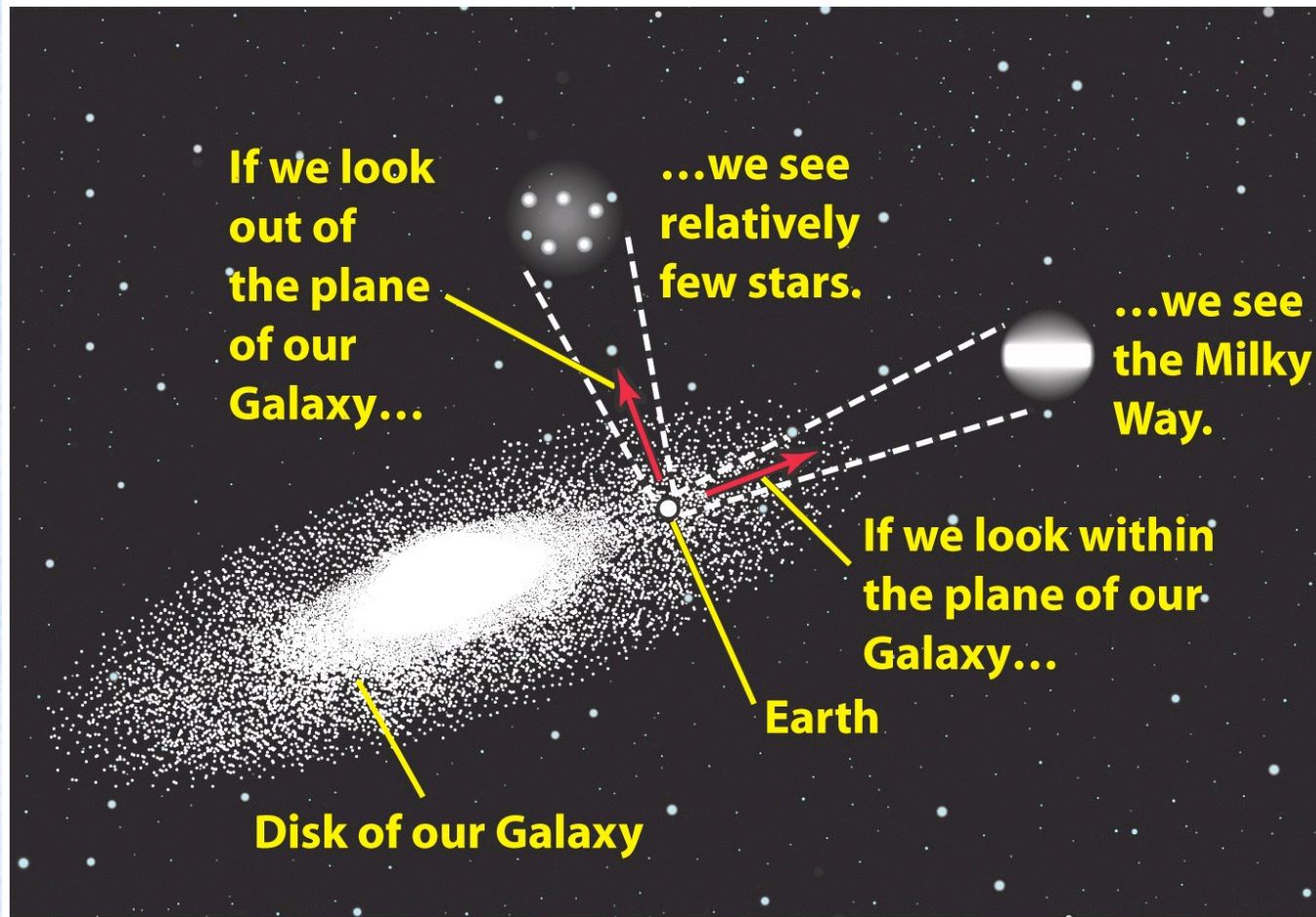


# Our galaxy. What is it?



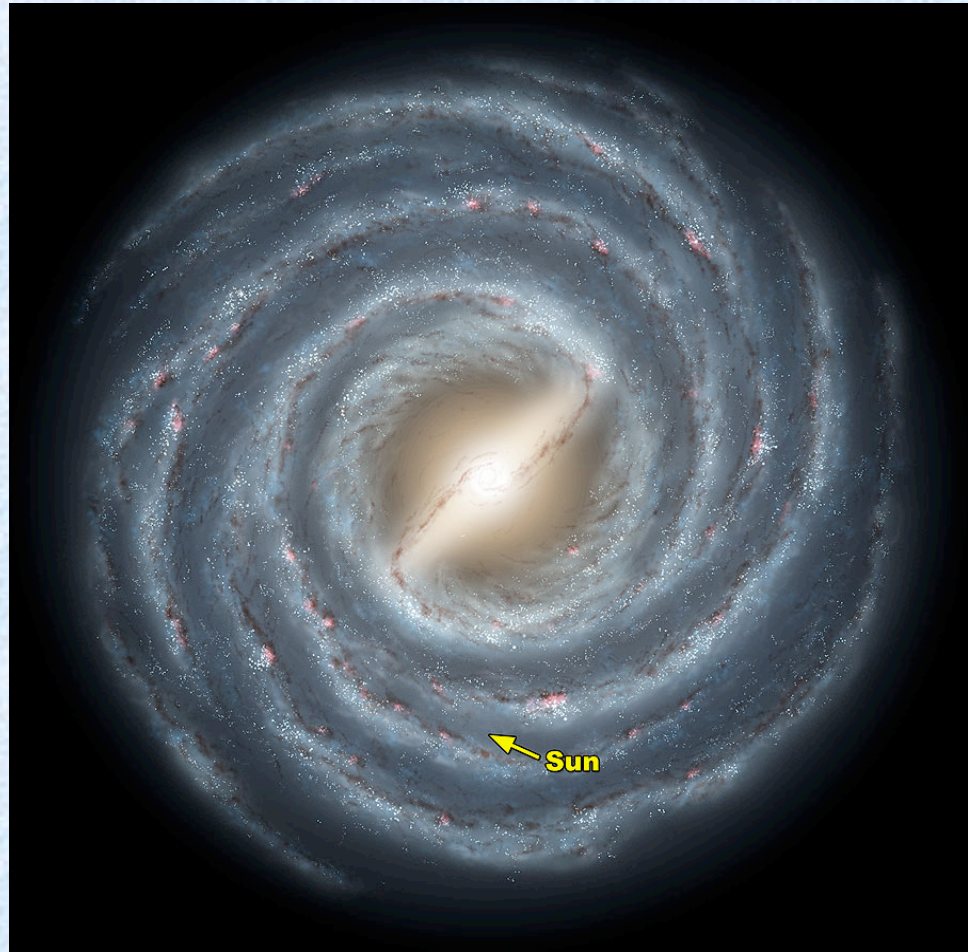


# Our Milky Way



# Where are we in our Galaxy?

- Somewhat in the outskirts...
- 25,000 ly away from the center
- Moving at about 200 km/s around the center of the Milky Way
- TRUMPLER's (1930) discovery of dust





# External Galaxies



What are they? How far are they? How big are they?

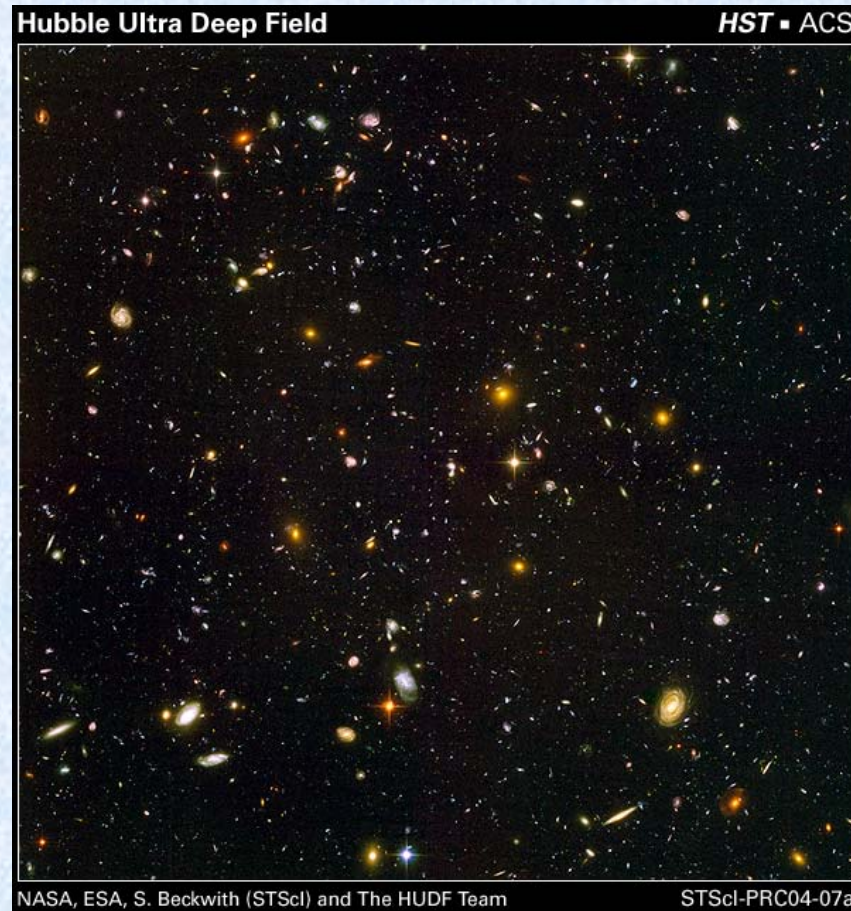
# What are galaxies?

- Until 1923 there was a debate on the distance of “nebulae” (galaxies)
- Are they small objects inside our galaxy or are they “external”?
- Hubble settled this by measuring the distance to Andromeda
  - A whopping 2.5 million light years!



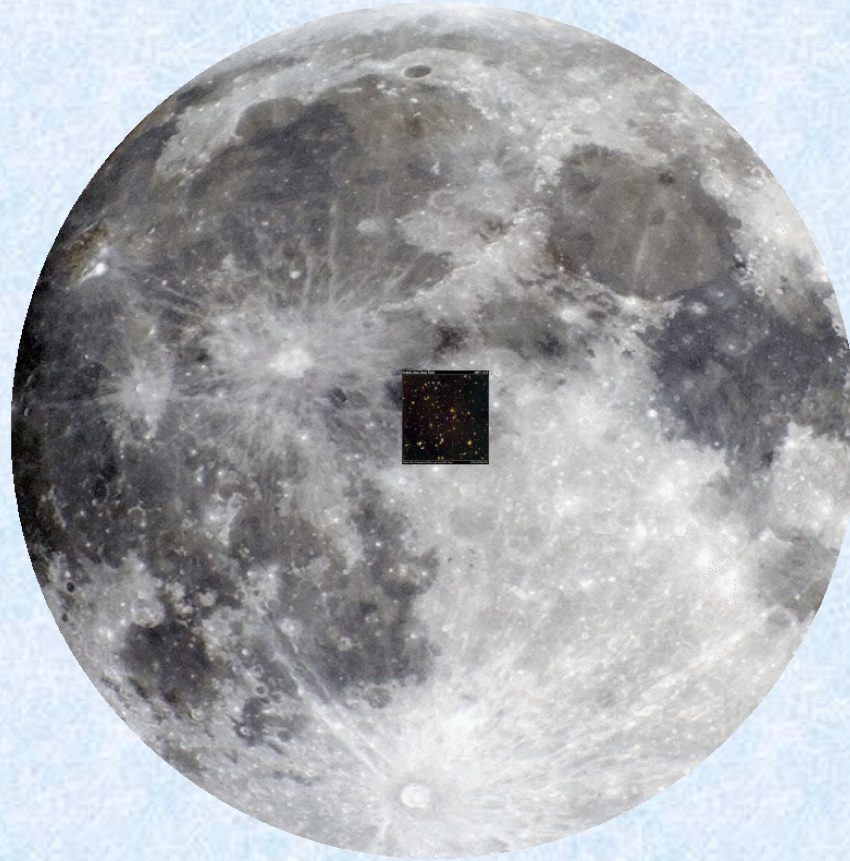


# The Universe is full of galaxies!



10,000 galaxies in a tiny piece of sky! 1/150,000 of the sky

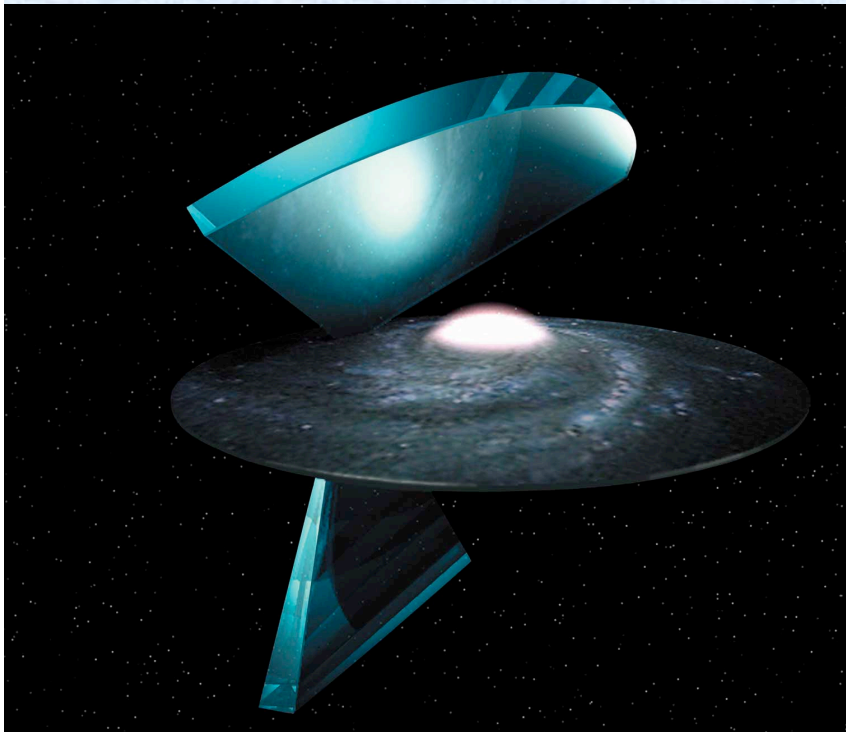
# How many galaxies?



Based on the deep fields we estimate of order a billion visible galaxies



# Large scale structures



Billions of light years



SDSS and 2dF mapped the positions of about 1,000,000 galaxies

## **Goal 2 - What is science?**

Example. Is astrology science?

Let's discuss

# Methodological introduction

- Demarcation: what is science?
- Falsification: how do you test scientific theories?
  - Measurements and errors
- Repeatability:
  - Determinism and probability
  - The unexplained and the supernatural
- Corroboration: what is a “good” scientific theory

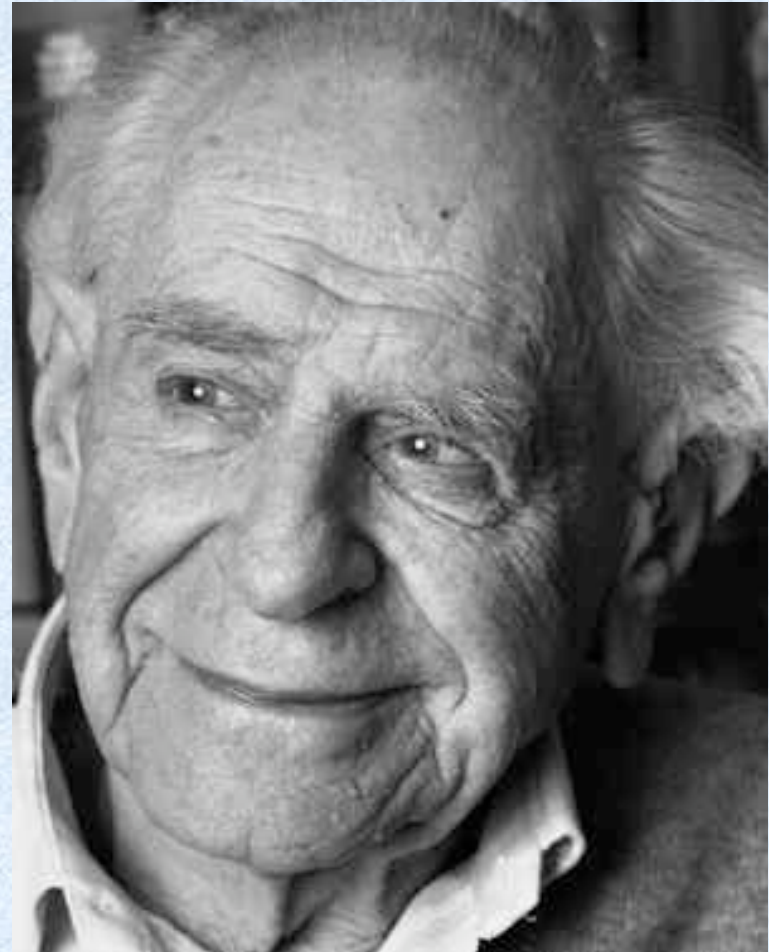
# Demarcation: what is science?

- We need to define what is science. Common methodology:
  - INTERACTION
  - QUALITY CONTROL
- In the same way, we need to agree on the meaning of words in order to have a conversation.
- The solution has to be a CONVENTION
  - dependent on history and culture
- **DEMARCATATION DOES NOT IMPLY RANK. ONE DISCIPLINE IS NOT BETTER THAN ANOTHER**



# Demarcation: Popper's solution

- The currently agreed solution to the demarcation problem is very well described by Karl Popper:
  - Science is falsifiable via experiments
- THE ESSENCE OF SCIENCE IS THAT IT CAN BE PROVEN WRONG
- TODAY ALL PRACTICING SCIENTISTS ADHERE TO THIS CONCEPT

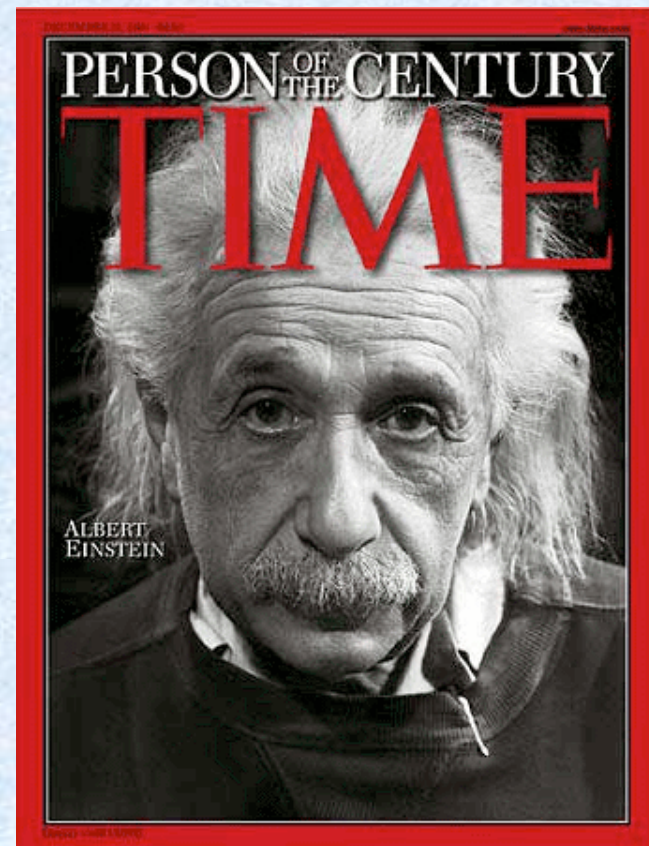
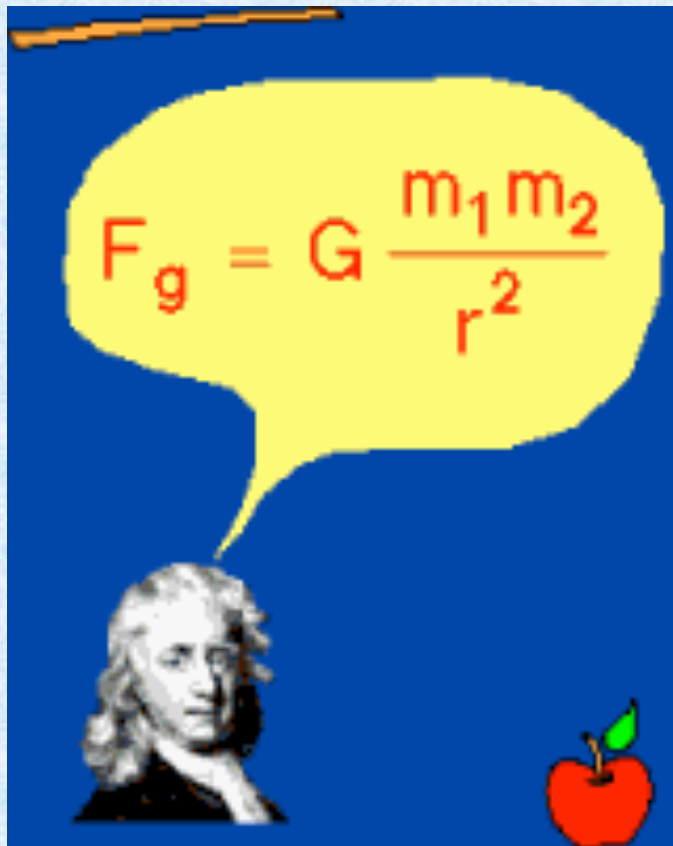


Karl Popper 1902-1994

# Scientific model or theory

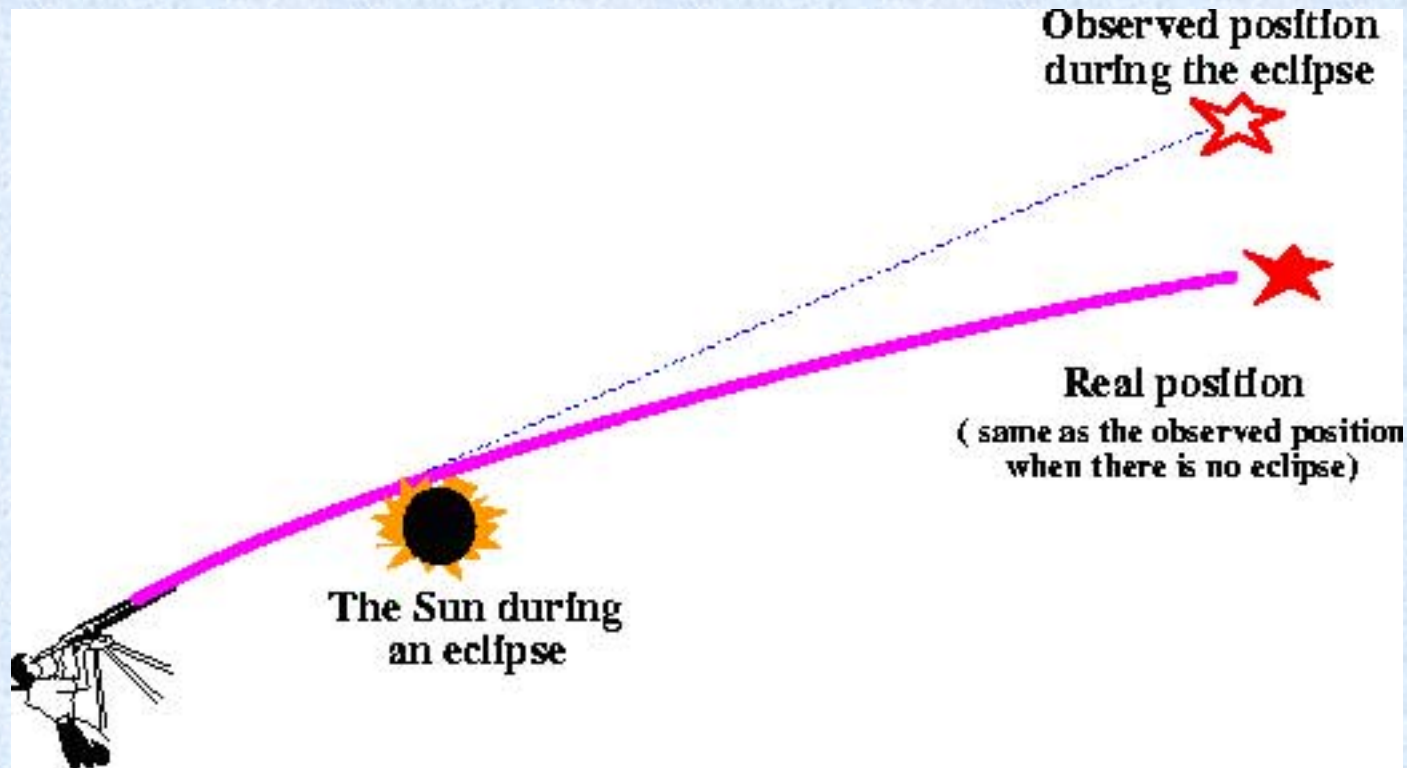
- A scientific theory is a logically self-consistent model or framework for describing the behavior of a related set of natural or social phenomena.
- In general it originates from experimental evidence
- It is **always** corroborated by experimental evidence, in the form of successful empirical tests.
- In this sense a theory is a systematic and formalized expression of all previous observations that is **predictive, logical and testable (falsifiable)**.
- *Scientific theories are always tentative, and subject to corrections or inclusion in a yet wider theory. A model does not aspire to be a “true” picture of reality.*

# Example: gravity, from Newton to Einstein





# Example: gravity, from Newton to Einstein



- 1919 solar eclipse measurement:  $1.61 \pm 0.40''$
- Einstein  $1.75''$ ; Newton  $0.875''$

# Measurements

- Measurements must be REPEATABLE
- Measurements have errors
  - A measurement without an error is meaningless
  - EVERY MEASUREMENT HAS ERRORS
  - HOW TALL ARE YOU?



# Probability and science

- The results of experiments are often cast in terms of probabilities.
- The same is true for scientific theories: Probabilistic predictions are not in conflict with the empirical method because they can be falsified





# Heisenberg's uncertainty principle

- What does it mean?
- NOT that science is not precise
- It means that some quantities cannot be determined *simultaneously* with infinite precision.
- For example the uncertainty on position and momentum ( $\sim$ speed) is larger than
- $\Delta x \Delta p = h/2\pi$



# A “good” scientific theory

- What constitutes a “good” scientific theory?
- If a theory can never be proven right, how is one theory better than another?
- According to Popper:
  - The better theory is the one that passes more stringent tests, both in number and in quality
  - The better theory is the more falsifiable one, if it doesn't fail
- Old theories often become limiting cases of new theories
  - (e.g. Newton vs Einstein)

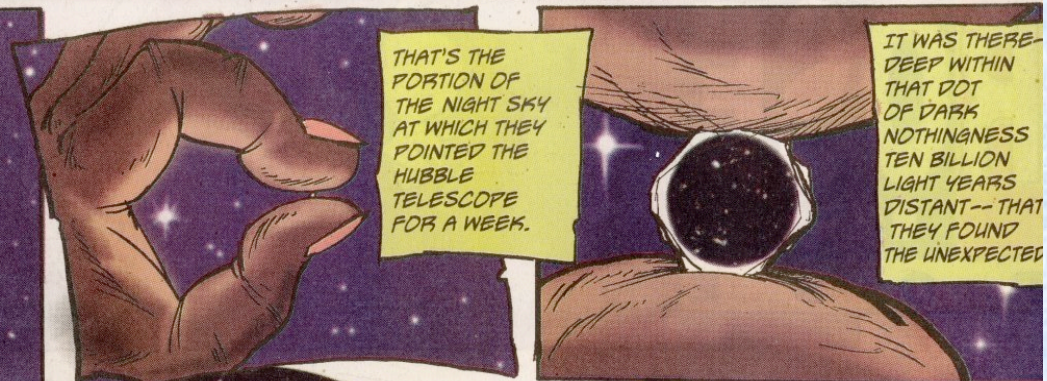
# How about validating the method?

- What constitutes a “good” method?
- Is the scientific method good?
- Does the question even make sense?
- My view is that a method is good as long as it allows you to achieve what you want. What do you want?
- The scientific method answers some questions/obtain some results. What are they?
- If we need to answer other questions we need different tools.





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**GALAXIES!  
THOUSANDS!  
THOUSANDS!**

**...WITH BILLIONS OF STARS!  
... AND TRILLIONS OF NEW WORLDS.**

**AND BEYOND THOSE... MORE!**





# Goal 3 - Scientific language



# Summary

- Goal 1 – The big picture
  - The Universe is huge and awesome and we will make a “Grand Tour”
- Goal 2 – Scientific method
  - Demarcation: what is science?
  - Falsification: how do you test scientific theories?
  - Corroboration: what is a “good” scientific theory?
- Goal 3 – Learning scientific language
  - Science terms have very precise definitions, with sometimes somewhat different meaning than in the current language



**The End**

See you on Wednesday!