

Sex in Space: Astronomy 330

TR 1000-1050

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Office Hours:

W: 11:00 a.m. – noon

or by appointment

This class (Lecture 2):

Pluto & Size Scales

Next Class:

Cosmology and the
origins of elements

HW1 due on Sunday!
(grace period the following Sunday)

Music: *Astronomy*– Metallica

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Outline



- The Drake equation
- The Pluto thing (it's old but still many students want to talk about it)
- Let's take some time to get our bearings around the Universe.
- We live in the Milky Way.

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Astro 330: Sex in Space?



One of the neat aspects of this course is that we can address the concept of ET life with an open mind and scientific rigor.

Don't be scared of science. It is really just common sense and logic. Although not all scientist have those in any larger amounts than non-scientists.

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Be Careful of Science



- Sometimes people make big claims in the name of science.
 - Ancient world thought that the Earth was the center of the Universe (nope, we just don't feel like we're moving).
 - Percival Lowell (~1913) thought he saw canals on Mars (nope, just an optical illusion).
 - Eddington (~1940) tried to make the fine structure constant ($\alpha=1/137.036$) a rational number (nope, Eddington just being irrational).
- We need to learn from these mistakes.

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But Learn to Speculate



- The French Academy of Sciences once pronounced that meteorites were nonsense
 - EVIDENCE and REASON can produce just as many thrills as dogmatic faith-based belief
 - They were eventually just shown a meteorite!
- The professors of Astronomy in the early 1600s, were teaching a geocentric solar system.
 - The Catholic church only forgave Galileo about his heliocentric solar system ideas in 1992!

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Life on Earth



- A miracle?
- An accident?
- More-or-less inevitable given the laws of nature and chemistry with suitable conditions?
- **Principle of Mediocrity**: There's nothing terribly special about the astronomical, geological, physical and chemical circumstances on Earth; most likely nothing special about biology either

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Major Premise of Course



The Universe is *homogenous* and *isotropic*.

- The laws of nature are the same everywhere.
- So we can apply the lessons learned from life on Earth to extrapolate about life in space.
- Life probably should have repeated elsewhere, given the same circumstances.
- **The Universe is freaky big!**

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Question



In this class we will assume that the Universe is *homogenous* and *isotropic* because

- a) It gives the best chance for finding other life.
- b) It allows us to apply our understanding of science to other stars, planets, and life.
- c) It assumes that the rules for life on our planet will be very different from other planets.
- d) It assumes that the laws of nature are different everywhere.
- e) It will probably be assumed by aliens too.

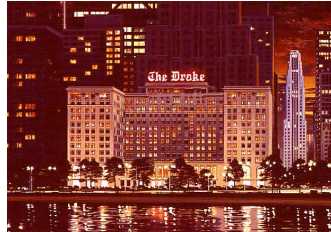
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Course Goals



- This class is designed to be fun.
- This course will revolve around the "Drake Equation".
- The Drake Equation looks like an attempt to calculate how many intelligent extraterrestrial civilizations exist with whom we *might* be able to communicate in our Galaxy.
- However, the equation actually helps us understand our ignorance about the subject and illuminates the various topics and issues worth thinking about when we ask the question, "*Are we alone?*", with an open mind.



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Drake Equation

Frank Drake



N =

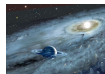
of
advanced
civilizations
we can
contact in
our Galaxy
today

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Drake Equation

Frank Drake



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

of
advanced
civilizations
we can
contact in
our Galaxy

Rate of
star
formation

Fraction
of stars
with
planets

of
Earthlike
planets
per
system

Fraction
on which
life arises

Fraction
that evolve
intelligence

Fraction
that
commu-
nicate

Lifetime of
advanced
civilizations

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Question



What does the Drake equation really tell us?

- It calculates the number of advanced civilizations in the Universe.
- It means nothing, a fake equation. It is only meant to guide our thinking about the relevant questions.
- It gives us an exact number of alien lifeforms (intelligent or not) in the Galaxy.
- It calculates the number of advanced civilizations in our Galaxy.
- It allows us to estimate the age of the Universe.

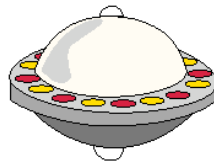
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Have we been visited by ETs?



*“Extraordinary Claims Require
Extraordinary Evidence”*



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An Example: Meteor 1972



<http://www.uwgb.edu/dutchs/>

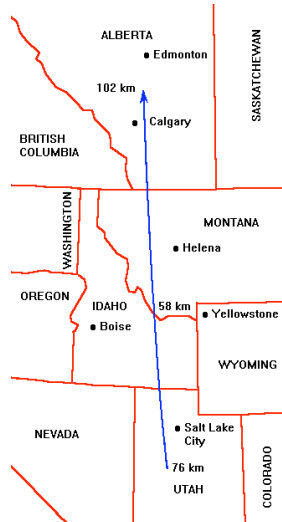
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Yikes, a Near Miss



- A bus sized object entered atmosphere over Utah and exited over Canada
- Velocity of 15 km/sec
- Missed Earth by 58 km



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But...



- Event was completely unexpected
- Crossed relatively sparsely-inhabited region
- Only visible for a *total* of 101 seconds
- Visible for no more than 30 seconds at any one spot



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But...



- Nonetheless, we have dozens of clear photographs of this event
- Still, we have no comparable images of UFOs.
- And today digital cameras and camera phones should make unusual events even more seen.



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Perhaps we shouldn't look for Aliens?



- But we've been broadcasting our presence on Earth for the last 65 years now!
- At the present time, the Earth is brighter in radio than the Sun.
- Is anyone out there watching TV right now?
- Also there have been a few intentional messages...



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SETI: Listening for ET



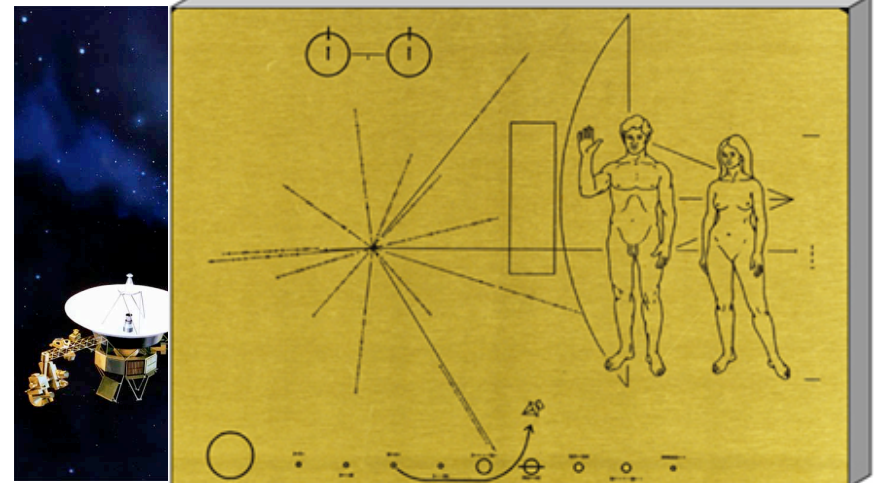
- Communications via radio signal
 - 18–21 cm wavelength range good for interstellar communication
- SETI search is ongoing
 - SETI
 - <http://www.seti.org>
- If they exist, should we contact them?



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Voyager—the message is out.



<http://voyager.jpl.nasa.gov/spacecraft/scenearth.html>

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What is a planet?



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The Planet Eris?



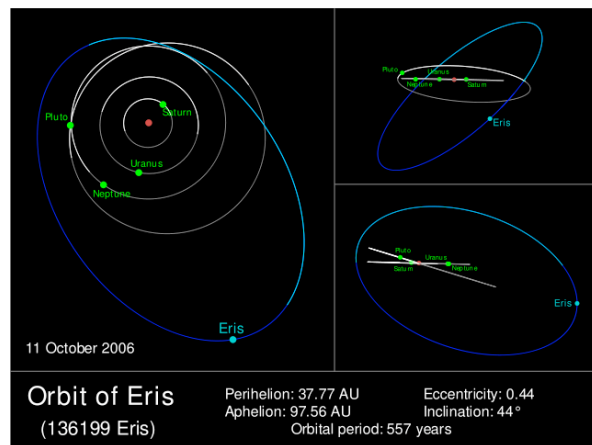
- ~20% larger than Pluto
- ~30% more massive than Pluto
- Has a moon (Dysnomia)
- Weird orbit



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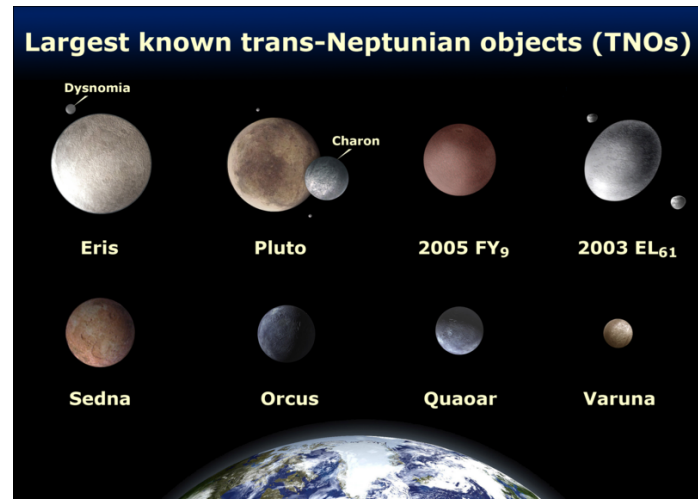
The Planet Eris?



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Planet or Plan-not?



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The Initial Proposal

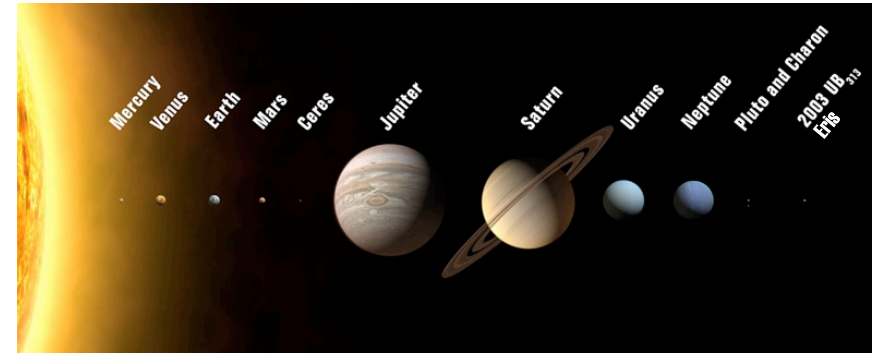


A planet is a celestial body that
(a) has sufficient mass for its self-gravity assumes a
nearly round shape, and
(b) is in orbit around a star, and is neither a star
nor a satellite of a planet

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12 Planets?



**My Very Eccentric Mother Curiously Just Showed Us
Nine Planets Conducting Encores**

My Very Excellent Mother Just Served Us Nine Pizzas

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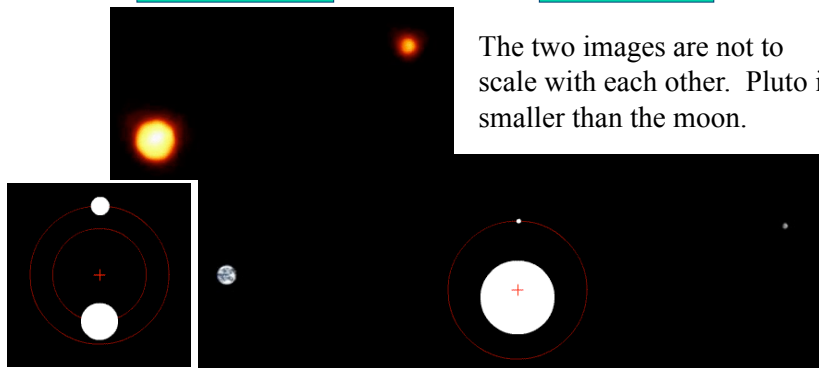
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Why Charon and not our Moon?



Pluto-Charon

Earth-Moon



The two images are not to scale with each other. Pluto is smaller than the moon.

**When a moon orbits a planet, or a planet orbits a star,
both bodies are actually orbiting around their *center of mass***

Two Dozen Planets???



The Alternate Proposal

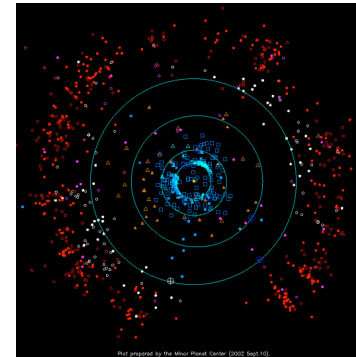


A planet is a celestial body that
(a) has sufficient mass for its self-gravity assumes a
nearly round shape, and
(b) is in orbit around a star, and is neither a star
nor a satellite of a planet, and
(c) has cleared the neighborhood around its orbit

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This definition would exclude Pluto (and others)
 because it's one of many...



Red & white dots show other Pluto-like objects
 discovered around & beyond Neptune's orbit

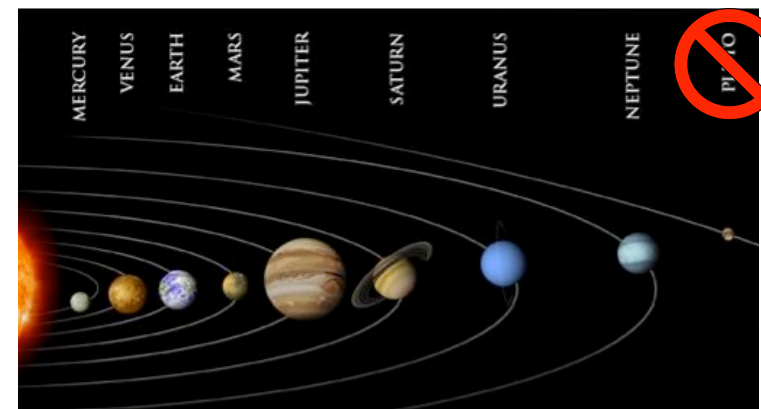
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The Results...



~~8~~
~~Nine~~ Planets



My Very Excellent Mother Just Served Us Noodles!

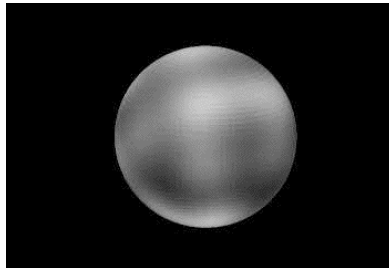
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So what do we call Pluto now?



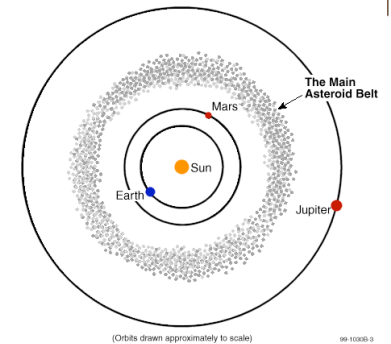
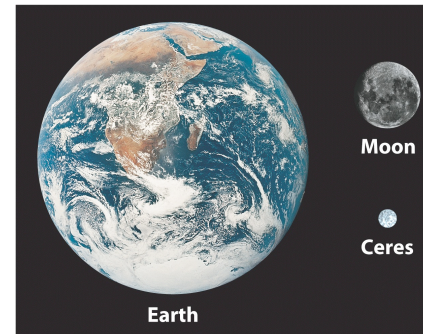
Planet-ish objects that meet the earlier definition, but fail to make the grade because of the new criterion would be called **dwarf planets**

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Ceres, Another Former Planet



- Ceres was considered a planet for 50 years after its discovery in 1801
- Demoted after similar bodies were found
- Now, called an **asteroid**

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Drake Equation

Frank Drake



$N =$

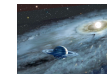
of advanced civilizations we can contact in our Galaxy today

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Drake Equation

Frank Drake



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

of advanced civilizations we can contact in our Galaxy today

Rate of star formation

stars/yr

Fraction of stars with planets

systems/star

of Earthlike planets per system

planets/system

Fraction on which life arises

life/planet

Fraction that evolve intelligence

intel./life

Fraction that communicate

comm./intel.

Lifetime of advanced civilizations

yrs/comm.

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What's this All about Then?



- Planets are now defined
- Stars – Nuclear burning machines, usually turning hydrogen into helium
 - Colors (temperatures: cold/red to hot/blue),
 - Sizes (Jupiter-sized to 1000x the Sun)
 - Masses (80x Jupiter to 100x the Sun)
 - Ages (Just born to nearly the age of the Universe)

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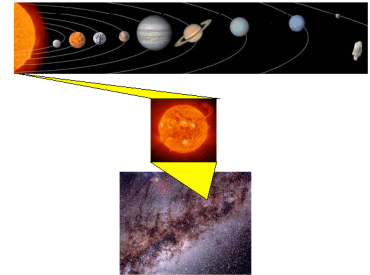
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One of



We are:

- 1 planet out of 8×10^{11} in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- What's next? This took until the 1920s to suss.



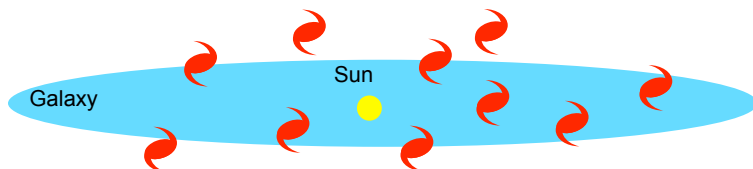
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Those weird Spiral Nebulae?



- Dim, diffuse, “interstellar” nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.
 - “A galaxy is a spiral “island universe” and the other spiral nebulae are the same and far away”
 - “Milky Way is all there is in the Universe, and the spiral nebulae are nearby.”



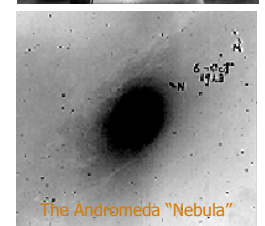
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Edwin Hubble: Solved It



- In 1923, Hubble resolved M31, the Andromeda “Nebula”, into stars
- If these stars were like the stars in our Galaxy, then M31 must be far away!
- Estimated the distance to M31 to be 1 million light-years (modern estimate is 2.5 million light years)
- Andromeda is an “island universe” like our own Galaxy.



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What's this All about Then?



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 - Colors (temperatures: cold/red to hot/blue),
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 - Masses (80x Jupiter to 100x the Sun)
 - Ages (Just born to nearly the age of the Universe)
- Galaxies
 - Collection of stars, gas, and dust (huge!)

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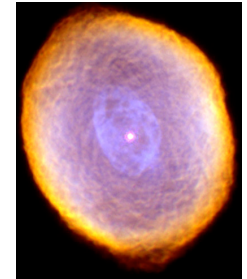
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Where do we Live? And What is our Fate?



- Our Sun is an average star, halfway through its lifespan.
- Will evolve to a Red Giant in about 5 billion years.
- Thousand years after that, it will eject its outer layers forming a planetary nebulae and a central white dwarf.

But our Solar System is located in our Galaxy– The Milky Way.



<http://spaceflightnow.com/news/n0009/07hubble/>

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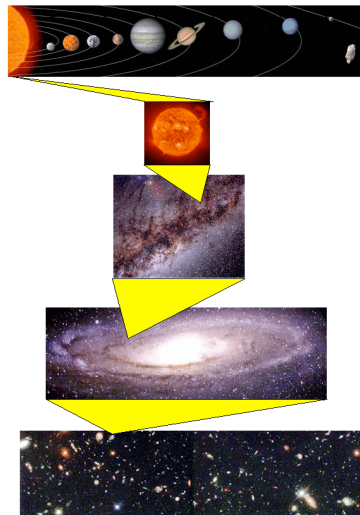
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One of



We are:

- 1 planet out of 8 in our solar system.
- 1 stellar system of 100 billion stars in our Milky Way
- 1 galaxy of the 100 billion galaxies in the observable Universe.



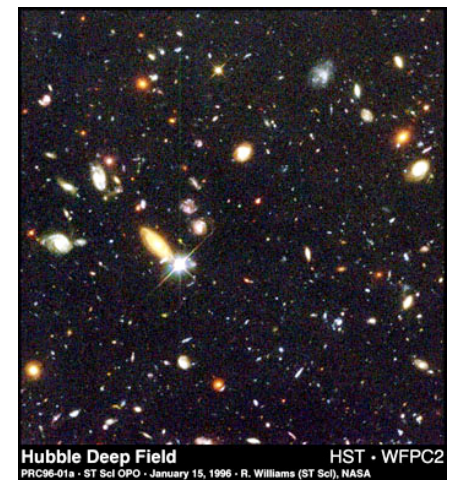
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Galaxies – Fundamental “Ecosystems” of the Universe



- Galaxies “fill” universe.
- Typical separation **3 million light years!**
- Most distance galaxies are billions of light years away
- Range in size from large (Milky Way-like) to small “Dwarf”
 - 1 billion to 100’s of billions of stars



Hubble Deep Field HST • WFPC2
PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

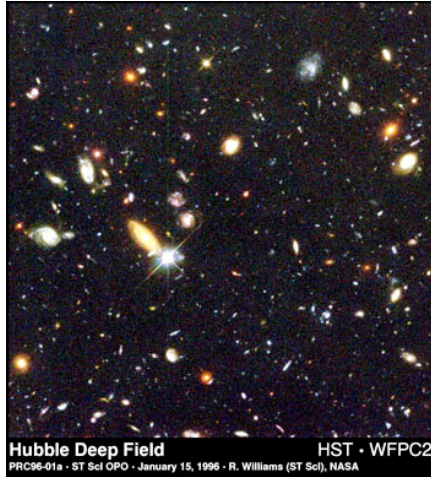
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Galaxies – Fundamental “Ecosystems” of the Universe



- Galaxies are the cosmic engines that turn gas into stars and recycle the gas the stars eject, back into stars
- In between, no star formation occurs – “nothing happens” in intergalactic space.

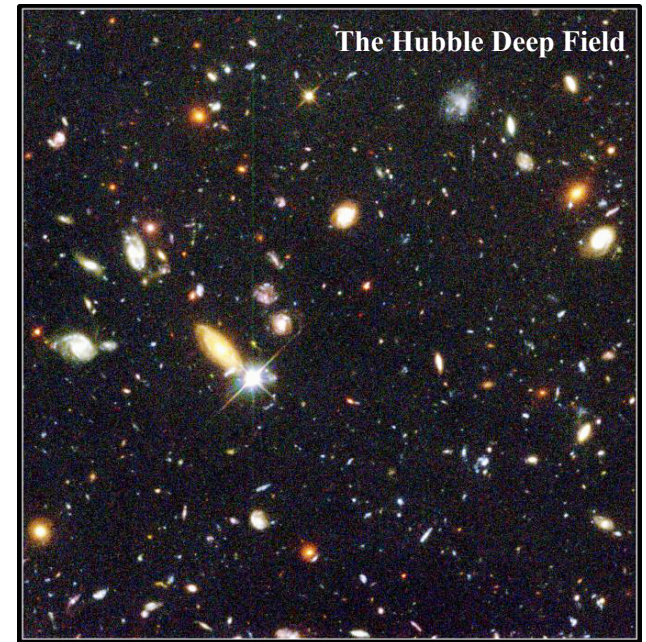


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Distant galaxies:

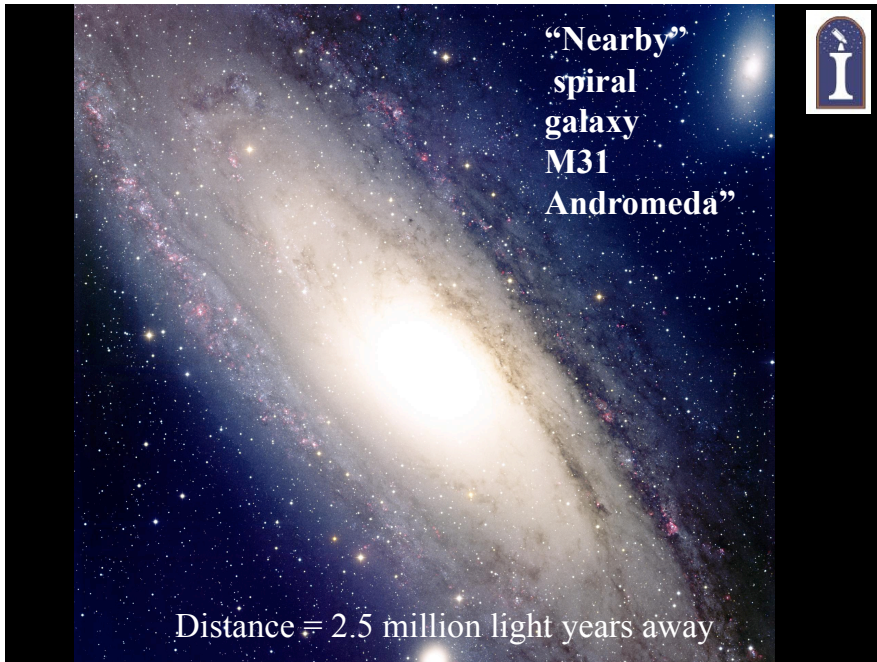
- The deepest optical image of a patch of sky
- Like looking back in time ...
- Galaxies as they were, 1 to 10 billion years ago.



“Nearby”
spiral
galaxy
M31
Andromeda”

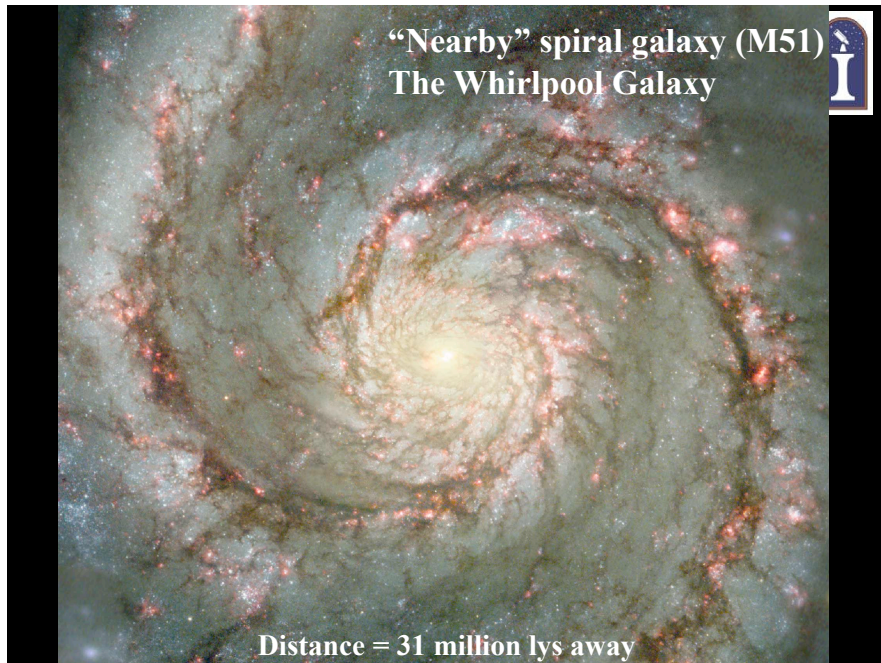


Distance = 2.5 million light years away



Sombrero Galaxy: 30 million lyrs away





Galaxies are the Fundamental “Ecosystems” of the Universe



Three Main Types of Galaxies:

- Spirals (77%)
- Ellipticals (20%)
- Irregulars (3%)



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