

Lecture 8:  
The Cosmological Revolution:  
The Depths of Space and Time

Astronomy 141 – Winter 2012

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This lecture explores the revolution in cosmology that has revealed the vastness of space and cosmic time.

The Earth is one of 8 planets in the Solar System

The Sun is a small middle-aged star that is part of the Milky Way Galaxy

The Milky Way is one of hundreds of billions of galaxies in the Universe.

The Universe was formed in a hot, dense state about 13.5 Gyr old and has been expanding ever since.

The physical laws found on Earth apply throughout the Universe.

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The Copernican Revolution was only the beginning...

Telescopic observations over the 400 years since Galileo have revealed a vast and ancient Universe.

By the end of the 19<sup>th</sup> century, we had expanded the size of the Solar System out to Neptune and measured the distances to the nearest stars.

By the first half of the 20<sup>th</sup> century, we had discovered the nature of the stars and galaxies, and discovered that the Universe is expanding.

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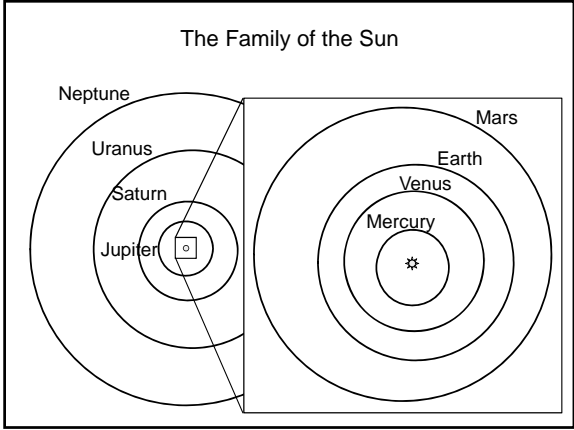
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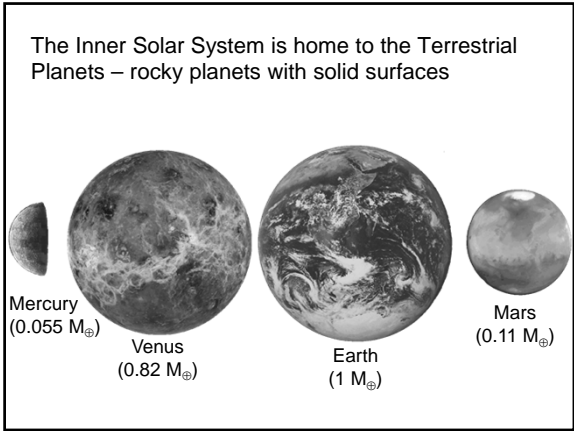
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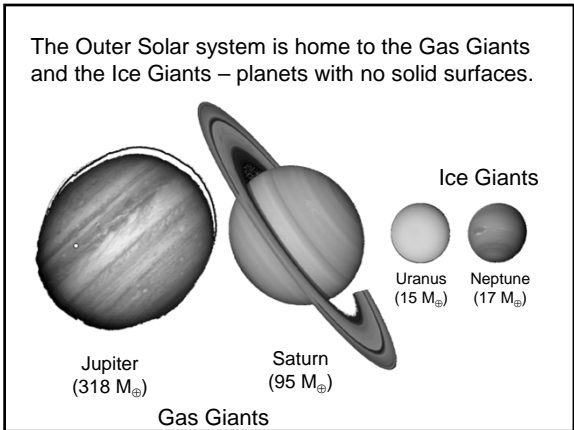
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1 light year (ly)

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○  $\alpha$  Centauri  
4.26 ly away

● Proxima Centauri  
4.22 ly away

The nearest star is the red dwarf  
Proxima Centauri, 4.22 ly away.

The nearest Sun-like star is  
 $\alpha$  Centaury, 4.26 ly away

Sun ○

1 ly =  $9.46 \times 10^{12}$  km = 63,235 AU

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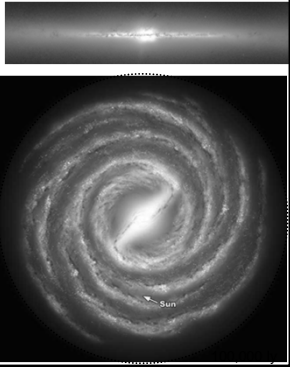
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The Milky Way is a flattened, rotating disk of about  
200 billion stars.

100,000 light years  
in diameter

~3000 light years thick

The Sun orbits the center  
of the Milky Way at a  
distance of ~26,000 ly.




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The Andromeda Galaxy is the nearest large galaxy  
to the Milky Way.

~2.5 Million ly away

About the same size  
as the Milky Way

We slowly orbit each  
other in the Local  
Group of Galaxies




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The Milky Way is a Spiral Galaxy, only one of hundreds of billions of galaxies in the Universe.



Vast assemblies of stars and gas held together by gravity.

Spiral Galaxies are sites of active star formation.



Elliptical Galaxies are old and dead, not having formed new stars for Billions of years.

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Galaxies are organized into groups, clusters, and superclusters of galaxies.

Clusters can contain many thousands of galaxies and can be 1 – 10 Mly across

Superclusters are clusters of clusters.



They are the largest structures in the universe, 100s of Millions of Light years in size.

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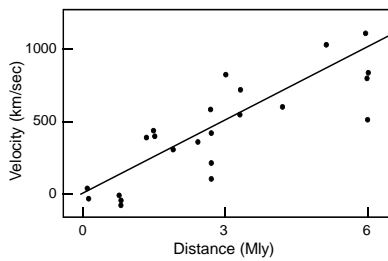
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In 1929, Edwin Hubble discovered that the more distant a galaxy is, the faster it appears to be moving away from us.



Follows a simple linear trend: a galaxy twice as far away appear to be moving away from us twice as fast!

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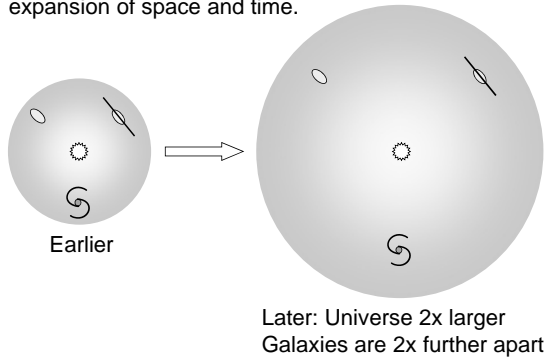
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What Hubble had discovered was the systematic expansion of space and time.



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If we go back in time far enough, eventually the Universe would be very hot, dense, and opaque.

This initial state must have existed at some *finite* time in the past.

We call this very hot, very dense initial state

***“The Big Bang”***

Our best current measurements give that the Big Bang occurred about 13.5 Billion years ago.

This sets the age of the Universe.

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The lessons of the Cosmological Revolution are at once humbling and hopeful.

The Earth and Sun do not occupy a special place in the Universe.

The Universe is vast in size and very old, but we are young.

The elements of life: C, H, N, & O, are abundant throughout the Universe.

Because the same physical laws found on Earth apply throughout the Universe, the physical processes that make life possible here should also operate elsewhere...

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