Astro 358/Spring 2006

(48915)

Galaxies and the Universe

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Figures from Lecture 24+ 25: Tu Apr 18 + Th Apr 20

Looking back in time over the last 13 Gyr
How did galaxies form and evolve?

Studying the Formation and Evolution of Galaxies

* Today the Universe is 13.7 Gyr old and many massive mature galaxies (e.g., ellipticals, spirals) with well-defined components (e.g., disks, bars, bulges) are already in place.

* One of the main goals of astronomy is to answer questions such as :

- When and how did proto-galaxies – the precursors of galaxies-- first form?

- How did these proto-galaxies evolve and assemble over the last 13 Gyr into the mature galaxies that we see today?

- When and how did most of the stars that we see today in galaxies form ?

- When did barred spiral galaxies like our own Milky Way come into existence?

- What was the role played by dark matter?

To answer these questions, need to

à **observe galaxies at different cosmic epochs or lookback times**

Lookback time T_{back} at epoch when Universe had age t

= Age of Universe today (13.7 Gyr) - t

Key Ingredients of Galaxy Surveys :HST Images and Redshifts

Galaxy surveys use Hubble to get high resolution images of galaxies

à to separate galaxies from each other

à to resolve components (bulge,disks, bars, spirals, tidal tails) of each galaxy

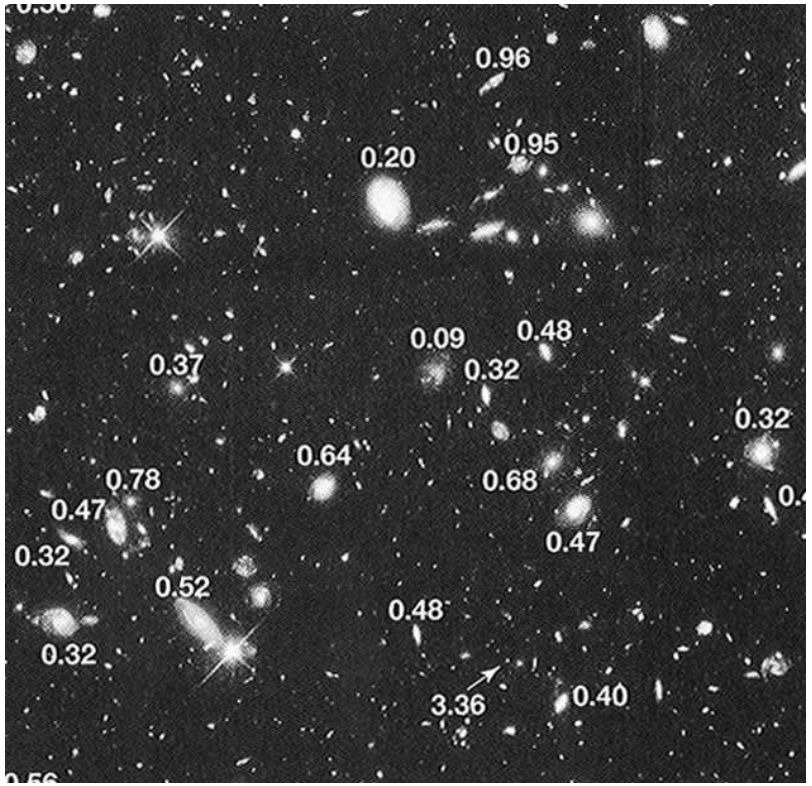
The thousands of galaxies surveyed have different lookback times T_{back} because light reaching us now was emitted

-- by distant galaxies a long time ago, when Univ was much younger

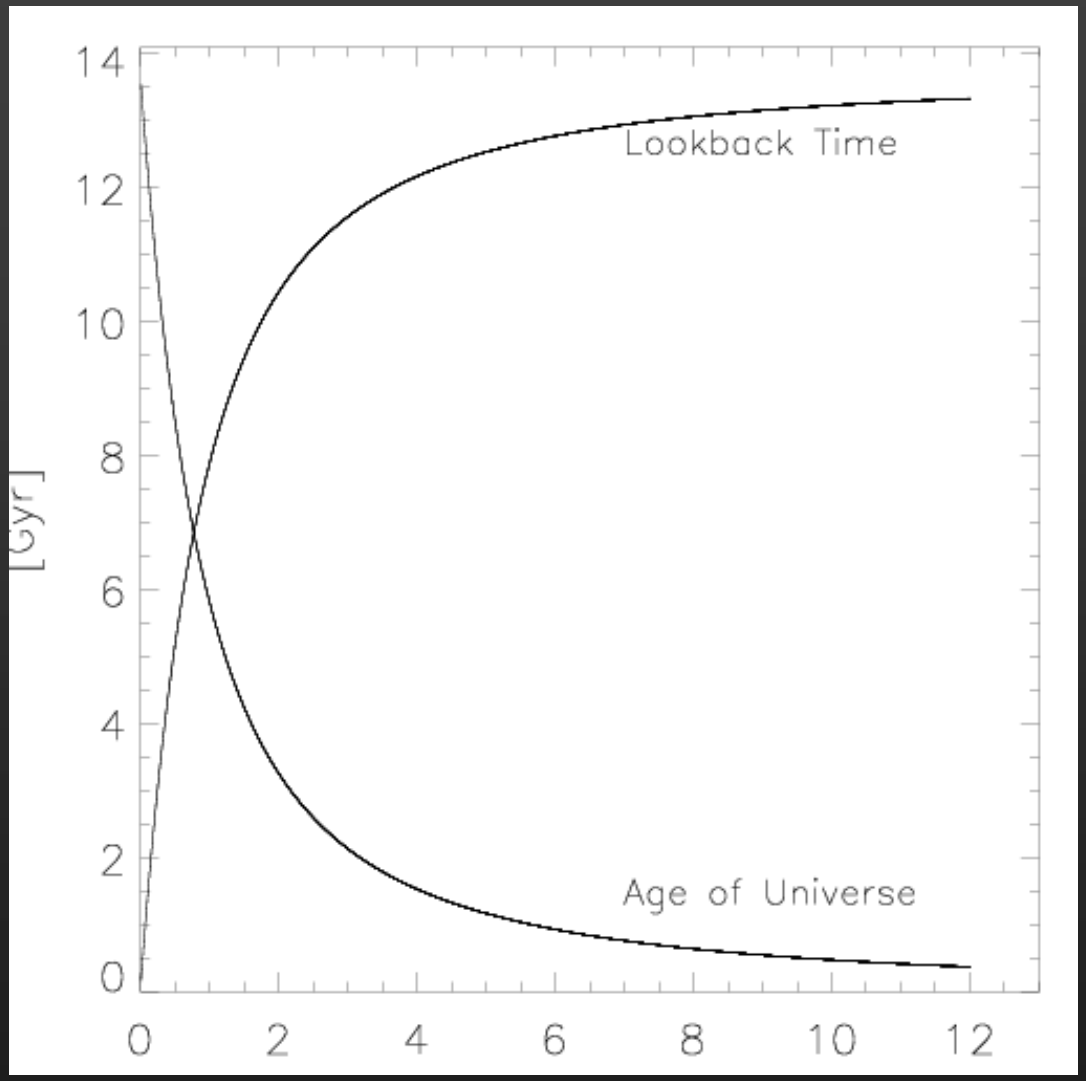
-- by nearby galaxies only recently

Use ground telescopes to get redshift z of each galaxy .See in-class equations

- Cosmological vs Doppler Redshift
- Friedmann equation of motion to derive age t(z) of Universe at
- Angular diameter distance



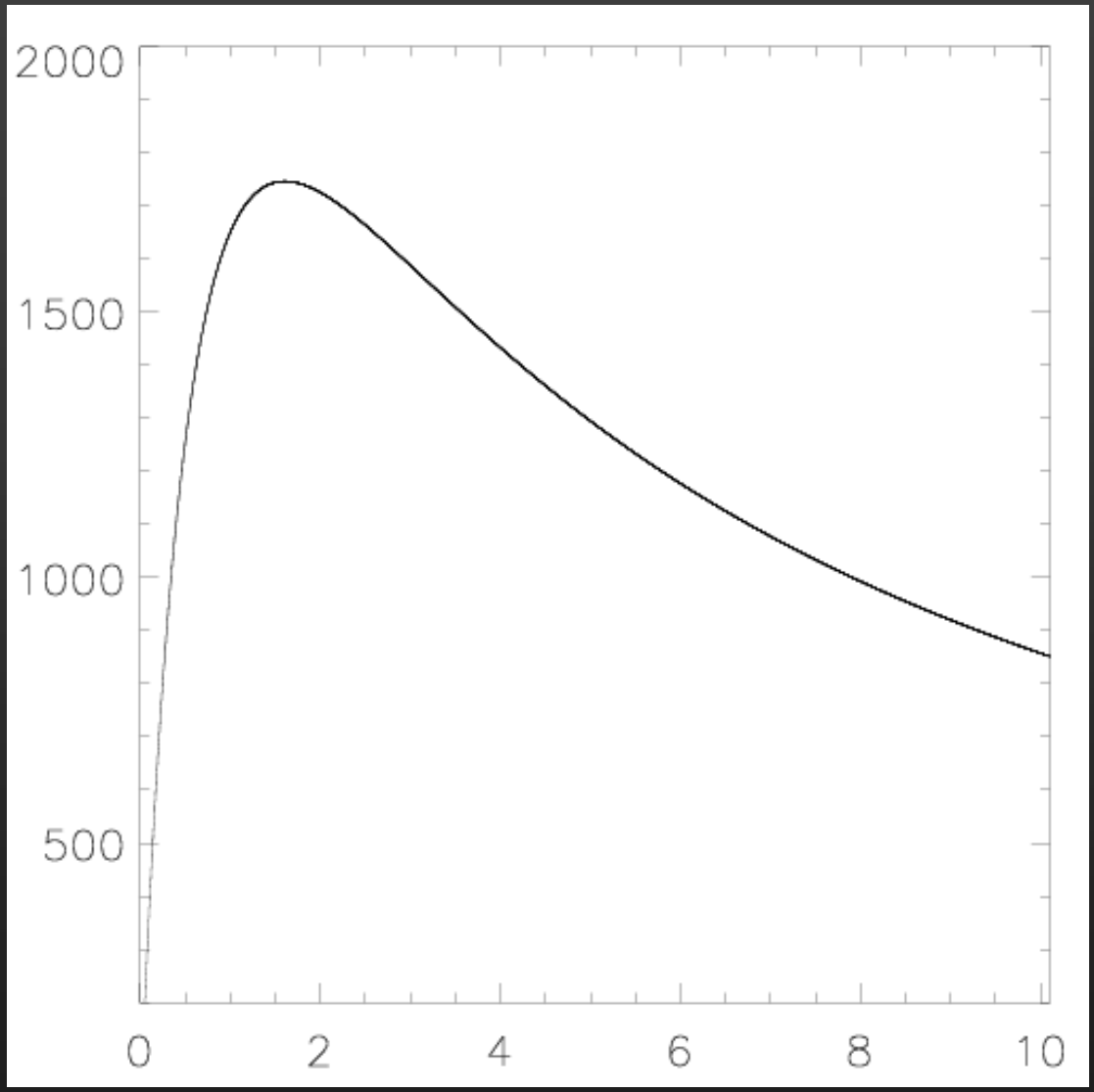
Age as a function of cosmological redshift z



See in-class equations
- Cosmological versus Doppler redshift
- Friedmann equation of motion to derive age of Universe as a function of redshift z

Age in Gyr vs cosmological redshift z in a cosmological model with Ω_m =0.3, Ω_Λ=0.7, Ω_k =0, H0=70

Angular Diameter Distance as a function of cosmological redshift z



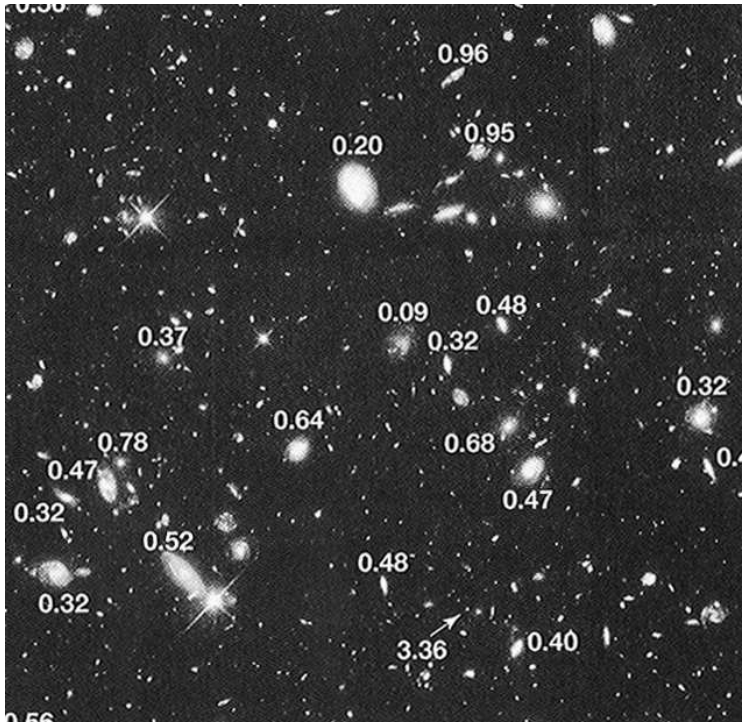
See in-class equations

- Angular Diameter Distance and the conversion from arcsecond to kpc at different redshifts

Angular Diameter Distance in Mpc vs cosmological redshift z in a cosmological model with Ω_m =0.3, Ω_Λ=0.7, Ω_k =0, H0=70

Important criteria for a powerful galaxy survey

What are the 4 criteria that a galaxy survey should satisfy in order to be effective, and why?
See in-class notes



Latest Galaxy Surveys: GEMS, GOODS, HUDF

Early galaxy surveys,including the famous Hubble Deep Field (HDF) in 1996 used the old WFPC2 camera aboard HST . WFPC2 ad a very small field of view

The Advanced Camera for Surveys (ACS) installed in 2002 is 10 times more powerful than WFPC2

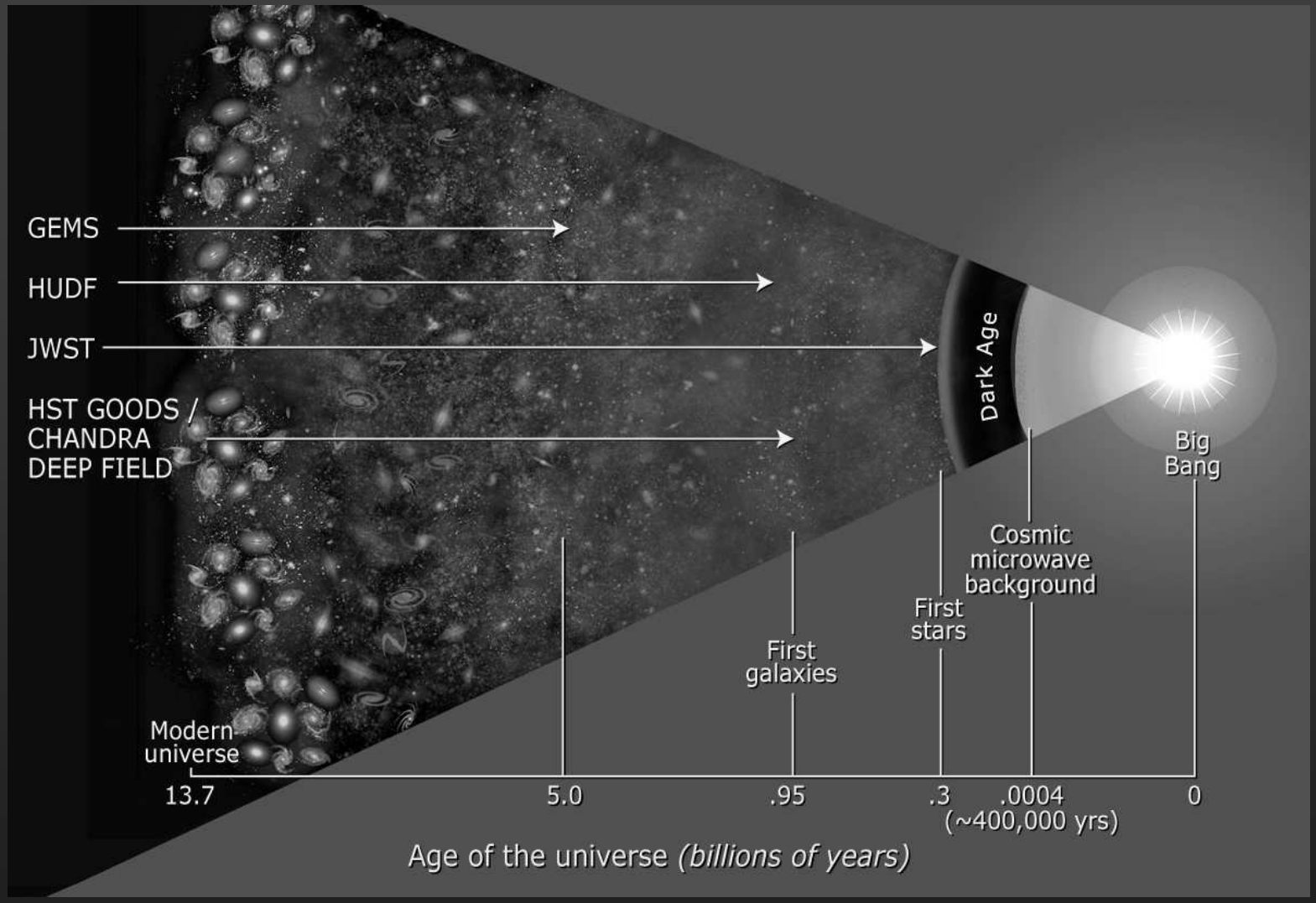
- à has a larger field of view (60 times larger)
- à more sensitive
- à higher angular resolution

It has allowed several state-of-the art surveys of galaxy evolution in 2004

- à the GEMS survey
- à the GOODS survey
- à the HST Ultra Deep Field (HUDF)

-- See in-class notes for comparison of GEMS vs HUDF : area, depth, lookback times

Probing Early Cosmic Epochs with GEMS and HUDF



GEMS surveys galaxies out to lookback times of 9 Gyr, when Univ was 4.7 Gyr old

HUDF surveys galaxies out to lookback times of 13 Gyr , when Univ was 0.7 Gyr old