Review for Test #4

Topics:

- Our Milky Way Galaxy
- Galaxies, Normal and Active
- Cluster of Galaxies and Large Scale Structures
- Cosmology, the Beginning and The End of the Universe
- Life in the Universe

Methods

- Conceptual Review and Practice Problems Chapters 14 18
- Review lectures (on-line) and know answers to clicker questions
- Try practice quizzes on-line
- Bring:
- Two Number 2 pencils
- Simple calculator (no electronic notes)

Test #4 Review

How to take a multiple choice test

1) Before the Test:

- Study hard (~2 hours/day Friday through Monday)
- Get plenty of rest the night before
- 2) During the Test:
- Draw simple sketches to help visualize problems
- Solve numerical problems in the margin
- Come up with your answer first, then look for it in the choices
- If you can't find the answer, try process of elimination
- If you don't know the answer, Go on to the next problem and come back to this one later
- TAKE YOUR TIME, don't hurry
- If you don't understand something, ask me.





Molecular gas clouds pushed together in arms too => high density of clouds => high concentration of dust => dust lanes.

Also, squeezing of clouds initiates collapse within them => star formation. Bright young massive stars live and die in spiral arms. Emission nebulae mostly in spiral arms.

So arms always contain same types of objects, but individual objects come and go

Sample of Galaxies











Interactions and mergers can be simulated by computers.



Yellow = stars Blue = gas

Mihos et al.

Schematic of galaxy formation



Subsequent mergers of large galaxies also important for galaxy evolution.

Galaxy formation a very difficult problem because we must look to great distances (back in time to the early universe) to see it happening.

An Active Galaxy

M87 HST Image

M87 Distance = 15 Mpc Jet length = 2 kpc

Components of an AGN



"core" contains the central engine

Why are there more Elliptical Galaxies in Rich Clusters?

One explanation: denser environment => more mergers => more ellipticals made as bulges grew. Most mergers happened long ago when galaxies were closer together.

At cluster centers lie the largest ellipticals: "cD" galaxies. They have digested many companions. Masses up to 10^{14} solar masses (remember: Milky Way about 6 x 10^{11} solar masses)!





So by getting the <u>spectrum</u> of a galaxy, can measure its <u>redshift</u>, convert it to a <u>velocity</u>, and determine <u>distance</u>.

Results from a mid 1980's survey.



Assumes $H_0 = 65 \text{ km/}$ sec/Mpc. Note how scale of structure depends on this.

Hubble's Law now used to unveil <u>Large Scale Structure</u> of the universe. Result: empty <u>voids</u> surrounded by <u>shells or filaments</u>, each containing many galaxies and clusters. Like a froth.

The Cosmic Microwave Background Radiation

A <u>prediction</u> of Big Bang theory in 1940's. "Leftover" radiation from early, hot universe, <u>uniformly</u> filling space (i.e. isotropic, homogeneous). Predicted to have perfect black-body spectrum.

Photons stretched as they travel and universe expands, but spectrum always black-body. Wien's Law: temperature decreases as wavelength of brightest emission increases => T much lower now.

 $T \sim 3 K$ predicted.





Timeline for the Universe



The Geometry of the Universe determines its fate



The Five Ages of the Universe

- 1) The Primordial Era
- 2) The Stelliferous Era
- 3) The Degenerate Era
- 4) The Black Hole Era
- 5) The Dark Era

What is Life?

Seven tests for life

- 1. Complex Organization
- 2. Convert food to energy
- 3. Reproduce
- 4. Growth and Development
- 5. Respond to stimuli
- 6. Adapt to Environment
- 7. Show individual variation

Now Define Intelligent Life

Intelligent Life:

- 1. Ability to use tools
- 2. Language
- 3. Ability to learn

The Drake Equation

X

number of technological, intelligent civilizations in the Milky Way

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rate at which new stars are formed fraction of stars having planetary systems

X

X

average number of habitable planets within those planetary systems

Xfraction of those
habitable planets
on which life
arisesX

fraction of those life-bearing planets on which intelligence evolves fraction of those
planets with
intelligent life
that develop
technological
society

average lifetime of a technological civilization

Each term is less certain than the preceding one!

$\mathbf{N} = \mathbf{R}_* \mathbf{f}_{\mathbf{p}} \mathbf{n}_{\mathbf{e}} \mathbf{f}_{\mathbf{l}} \mathbf{f}_{\mathbf{i}} \mathbf{f}_{\mathbf{c}} \mathbf{L}$

In the zone ...

