

Thursday, April 6, 2006

Agenda

- Announce:
 - Observation tonight?
 - What did you think of Science/Religion debate?
 - Hand back Part Deux of Projects
 - Extra Credit Projects next meeting
- Imagining the Universe
- Review Ch. 22
- Start Ch. 23
- Questions about Solar Lab (Due when we get back)

Feynman—*The Pleasure of Finding Things Out*

- "I have a friend who's an artist and he's sometimes taken a view which I don't agree with very well. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree, I think. And he says - "you see, I as an artist can see how beautiful this is, but you as a scientist, oh, take this all apart and it becomes a dull thing." And I think that he's kind of nutty.
- First of all, the beauty that he sees is available to other people and to me, too, I believe, although I might not be quite as refined aesthetically as he is; but I can appreciate the beauty of a flower.
- At the same time, I can see much more about the flower than he sees. I can imagine the cells in there, the complicated actions inside which also have a beauty. I mean it's not just beauty at this dimension of one centimeter, there is also beauty at a smaller dimension, the inner structure.
- Also the processes, the fact that the colors in the flower evolved in order to attract insects to pollinate it is interesting - it means that insects can see the color. It adds a question: Does this aesthetic sense also exist in the lower forms? Why it is aesthetic? All kinds of interesting questions which shows that a science knowledge only adds to the mystery and awe of a flower. It only adds; I don't understand how it subtracts."

- Scientists have discovered fossils of a 375 million-year-old fish, a large scaly creature not seen before, that they say is a long-sought "missing link" in the evolution of some fishes from water to a life walking on four limbs on land.
- One creationist Web site (emporium.turnpike.net/C/cs/evid1.htm) declares that "there are no transitional forms," adding: "For example, not a single fossil with part fins part feet has been found. And this is true between every major plant and animal kind."
- Dr. Novacek responded in an interview: "We've got Archaeopteryx, an early whale that lived on land and now this animal showing the transition from fish to tetrapod. What more do we need from the fossil record to show that the creationists are flatly wrong?"



From NY Times

Picturing the Universe

- What kind of Universe can you picture, and we'll start from there
 - Say a flat two dimensional Universe?
- A couple things to keep in mind:
 - Whatever the Universe is, one can always consider an extra dimension into which it curves (called "embedding")
 - You want to really blow your mind? Spacetime may not even be continuous...some theories assert that spacetime is itself some collection of small "loops" of spacetime!

Ch. 22—All things dark

- Write an essay describing
 - The evidence we have that the Universe abounds with dark matter.
 - What we know about the properties of dark matter.
 - The differences between dark matter and dark energy.

Extra credit: Describe three things in astronomy which we don't know but want to

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- In galaxies, spiral and elliptic
- In galaxy clusters

How do we measure dark matter?

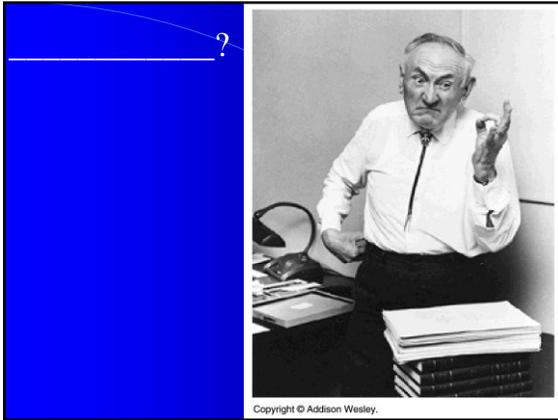
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 - In spirals, measure velocities of stars/gas in outer regions and use Kepler's Law to "weigh" galaxy
 - In ellipticals, get average orbital speeds via how broadened the absorption lines are
- In clusters:

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- In galaxies:
 - In spirals, measure velocities of stars/gas in outer regions and use Kepler's Law to "weigh" galaxy
 - In ellipticals, get average orbital speeds via how broadened the absorption lines are
- In clusters:
 - Measure orbital velocities of galaxies
 - Measure temperature of ICM ("hot gas")
 - Use grav. Lensing to weigh cluster



Properties of Dark Matter

- ### Properties of Dark Matter
- Interact only via gravity and weak force
 - Why not E&M or strong force?
 - Heavy and slow moving so that they would not escape galaxy

- ### Candidates for Dark Matter
- Baryonic:
 - MACHOs – e.g. brown dwarfs, dim stars
 - Grav. Lensing indicates not enough mass
 - Non-baryonic (exotic):
 - Neutrinos—have mass, weakly interacting, but move too fast
 - WIMPs—cold dark matter is the dominant theory right now

- ### Dynamics of Dark Matter
- Why does dark matter not fly away from galaxies/clusters?
 - Why doesn't dark matter collapse inward?

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- Why does dark matter not fly away from galaxies/clusters?
 - gravity
 - Why doesn't dark matter collapse inward?
 - Can't lose its energy/angular momentum because it is so weakly interacting

Importance of Dark Matter

- Roughly 30% of Universe is dark matter, it'd be nice to know more about it
- Apparently plays big role in formation of galaxies (most significant component by far)

What is structure formation?

The Universe's fate

- What two properties of the Universe oppose each other such that its fate literally

hangs in the balance!

The Creation of the Universe

Ch. 23 and the Big Bang Theory

"The Big Bang, that's just a theory, right?"

- Approach this with skepticism (likely next front for groups who pushed the teaching of creationism in science classes)
- And look for evidence
- And note when we simply say "we don't know" or "we can't know"
- Contrast evidence for Big Bang with the so-called "Steady State Universe"

How far back can we go?

- We can observe the Universe back to the CMBR
- That's **only** 380,000 years **after** the Big Bang!
- Can infer/speculate/model and see if these then are consistent with features we can observe

The First Instant

- Lot's of energy/mass, so need Einstein's GR
- Very small region, need quantum mechanics
- But, these disagree, so we can't deal

Jump ahead in time

- After the Planck time, Universe expands, cools a bit, energy densities shrink a bit
- We can start here
- What's the Planck time?

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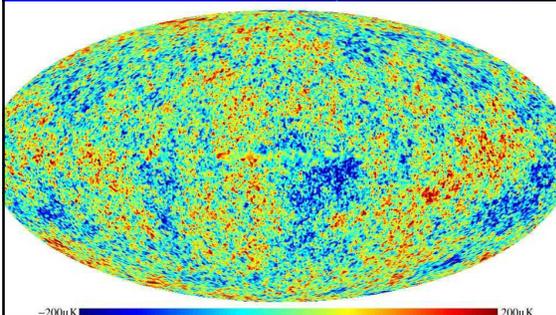
$$10^{-43} \text{ s}$$

Inflation

- Tremendous (exponential) expansion of the Universe
- In something like 10^{-36} s, Universe goes from size of a nucleus to size of the Solar System
- Helps explain:
 - Homogeneity problem
 - Flatness of Universe

Evidence for the Big Bang

- CMBR



More Evidence

- Hubble's Law and concomitant observations
- Large scale homogeneity/isotropy of the Universe
- Predictions of nucleosynthesis w/r/t helium

More Inflation

- Prior to 1980s, various unsolved problems:
 - Seeds of structure formation? I.e. from where did “density enhancements” come from?
 - How could the far side of Universe look pretty much the same as the other side?
 - Why is the Universe so close to flat/critical density?

- Have a good spring break