Week 6 Notes
Astro 2 (Discussion Section 101)

Department of Physics: University of California, Santa Barbara

Updated May 2, 2011

Administrative Tasks

Stargazing The first (and possibly only) stargazing night will be a week from Monday, which is May 9. We'll meet by the elevators on the ground floor of Broida at 9:00 PM. For those who went last quarter, it will be a similar to that. Students will break up into two groups. One group will observe various objects (likely Saturn and some other points of interest) through the telescope while the other spends some time with Vardha, who will run you through a brief program (she's quite good!). Currently this event is not worth any extra credit. It should last about an hour.

Midterm Wrap-Up

If students have questions about the midterm, I'll go over solutions in class and cover other material as time warrants.

Review

Questions about Class Material

Q: What evidence do we have that the Big Bang Theory is correct?

A: Hubble's Law tells us that the universe is expanding, which is predicted by the Big Bang Theory. Additionally, the Cosmic Microwave Background Radiation (CMB) reflects an ambient temperature in the universe that is almost exactly equal to what the Big Bang Theory predicts.

Q: What do the words **isotropic** and **homogeneous** mean in the context of Cosmology?

A: Something is **isotropic** when it is invariant under any rotation. That is, if we took something and rotated it some random angle about some axis, would we be able to tell a difference? For instance, a sphere is isotropic.

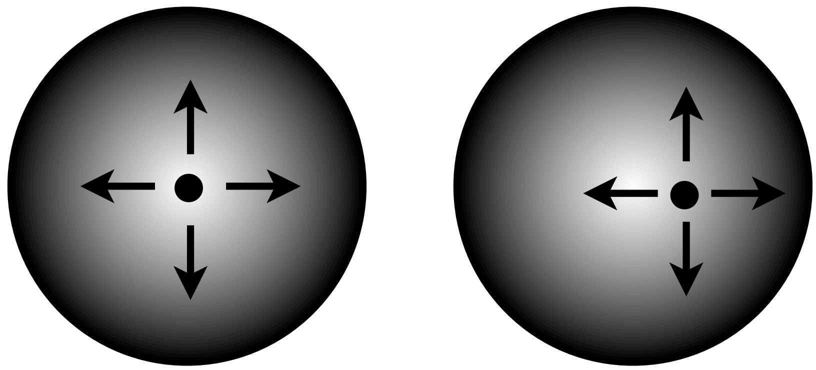
Something is **homogeneous** if translating in any direction (no rotations) leaves it unchanged. That is, if we look at a large object, and we move anywhere in the object and still look in the same direction, will we notice a difference? Real-life examples are a little harder for this, but up to a point, most parts of the ocean could be considered homogeneous. At many depths, translational symmetry is present. That is, if you moved 1 mile west in the ocean at a depth of 100 feet, you wouldn't notice that you've moved a mile.

Q: Why do we expect the universe to be isotropic?

A: If the universe were not isotropic, we would be able to detect preferred directions, indicating that there would be a *center* of the universe, which is not predicted by the Big Bang Theory. A center of the universe is still possible if we measure an isotropic universe, but it would imply that we are at (or at least near) the center, which scientists dismiss as highly unlikely (this is the Copernican Principle in action).

Q: Why do we expect the universe to be homogeneous?

A: Again, if the universe were not homogeneous, we would deduce from the fact that it is isotropic that we are at the center of the universe. That is, since all things look the same in all directions (isotropic), but translating our position breaks this isotropy, we must then conclude that Earth is at a special place in the universe, which violates the Copernican principle.



(a) Isotropic, Inhomogeneous

(b) Anisotropic, Inhomogeneous

Figure 1: Why the universe cannot be isotropic yet inhomoegenous

Inflation Theory

Our **Cosmic Horizon** is the furthest out in the universe that we can see. It's essentially given by the speed of light by the age of the universe:

$$d_{\text{Horiz}} = \frac{c}{H_0}$$

If the universe were expanding at a rate less than the speed of light, then we would expect all parts of the universe to be in each others' horizons, and yet we make measurements now of objects' that are within our own cosmic horizon that cannot possibly be in each others' horizons. The only way for this to have happened is if the universe expanded at superluminal speeds for a period of its evolution. We call this the **inflationary period**. This is not yet proven, but it is one possible solution to this problem.

Questions on this week's homework

Other Questions