Seminar I: Common Misconceptions about Modern Cosmology

1. General instructions

This document provides preparation instructions for the first of the two seminars forming part of the examination for the 2005 version of the graduate-level course *Modern Cosmology, 5 points*. The topic of this seminar is common misconceptions about cosmology. While some of the misunderstandings that will be covered are found mostly among the public, others are common amongst professionals, and some can even be found reproduced in textbooks.

The point of this exercise is to:

- Improve your own understanding about modern cosmology and learn to avoid some of the most common pitfalls
- Practice discussing cosmology
- Prevent you from conveying common misconceptions about cosmology onto the public or your own future students

In preparing for the seminar, you should try to:

- Prepare to clear up a number of common misconceptions about modern cosmology in front of the class. The use of the blackboard or overhead projector is highly encouraged. In some cases, numerical calculations could be useful.

You are perfectly welcome to collaborate with your classmates when preparing for the seminar, but once there – everyone is on their own. This means that you are not supposed to rely on the calculation, notes, viewgraphs etc. of others.

2. Suggested reading

Here are a couple of good places to start:

- Davis, T., & Lineweaver, C. 2004, PASA, 21, 97
- J. P. Leahy's Bad Cosmology website (http://www.jb.man.ac.uk/∼jpl/cosmo/bad.html)
- N. Wright's Frequently Asked Questions in Cosmology website (http://www.astro.ucla.edu/∼wright/cosmology_faq.html)

The recommended article databases are:

- http://adsabs.harvard.edu/abstract_service.html (published papers only)
- http://arxiv.org (preprints)

3. Common misconceptions

Here is a list of statements/questions which either reveal some sort of misconception about modern cosmology, or which relies on some implicit and possibly dubious cosmological assumptions. Prepare to clear up these misconceptions or explain what hidden assumptions these statements rely on. Please note that all the misconceptions listed below are *not* covered by the references listed above. Some you will simply need to sit down and think about for yourself, or find information about elsewhere.

The Big Bang

- "Time and space were created in the Big Bang."
- "Isn't it embarrassing that cosmologists have failed to pinpoint the site in the sky where the Big Bang explosion took place?"
- "The Big Bang was like a bomb going off in an previously empty space. The galaxies that we observe today represent the fragments of that explosion."

Cosmic curvature

- "If we live in a curved Universe with 3 spatial dimensions, there must be a fourth spatial dimension outside, in which the curvature takes place."
- "In a closed (positively curved) universe (as illustrated in many textbooks with a picture of a 3-dimensional sphere with a triangle on its surface), we live inside a thin layer on a surface of an otherwise empty sphere. This implies that space should be more extended in certain directions (tangentially along the surface of the sphere) than in others (radially)."[1]

Expansion of the Universe

- "Regardless of what geometry the Universe has, the expansion implies that our Universe is simply a sub-Universe located inside an even greater volume (sometimes referred to as the Multiverse). Otherwise, there would be no space for our Universe to expand into."
- "The expansion of the Universe is like a carpet that is being unfolded in all directions at once. While the expansion has stopped in our part of the Universe, it continues to this day at the outer boundary of the observable Universe. Hence, the Universe continuously grows."
- "During the radiation-dominated era, the expansion of the Universe is driven by the enormous radiation pressure of the tightly-packed photons present at that time."
- "The expansion of the Universe causes a Doppler shift in the spectra of distant galaxies. By measuring the redshift, we can estimate the recession velocities v of these objects. At low redshifts, the formula to use is $z \approx v/c$. Since no objects can move away from us faster than the speed of light, this relation does however break down as z approaches unity. At high redshifts, we should instead use the relativistic Doppler formula $v = c\frac{(1+z)^2-1}{(1+z)^2+1}$, as suggested by Hubble himself."
- "Since space grows due to the expansion of the Universe, objects like galaxies and even humans may become larger over the course of time" (Note: Be careful – this is *not* as easy to debunk as most scientists seem to think.)
- "If the Universe is accelerating now, and the Hubble parameter measures the expansion rate of the Universe, then H must have been smaller in the past, right? And in the future it will be bigger than its present value?"

Size of the Universe

- "Since the WMAP results indicates that we live in a flat (critical) Universe, the Universe has infinite extent."
- "I have heard cosmologists say that the Universe was once the size of golf ball, but that it is infinite now. How can that be? Inflation expanded the Universe by a large factor, but surely not by an infinite one?"

[1] There is a similar, perhaps even more widespread misconception stemming from the picture of a balloon with coins glued onto its surface, which is used to illustrate the expansion of the Universe.

Distances in cosmology

- "If the Universe is 13.7 Gyr old, as indicated by the WMAP data, the most distant objects that we can see today are 13.7 billion light years away."
- "I have found a paper, where it says that a certain gas cloud is 100 light-years across. But since the authors are not cosmologists, this result is not to be trusted. To calculate this properly, one should take cosmological parameters into account and calculate e.g. the light-travel time across the object."

If you know of other common (or not so common) misconceptions about cosmology, you are more than welcome to present them in the seminar as well.

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