SUGGESTED TOPICS FOR EXTRA CREDIT PAPER

The Paper: If you are interested, you may write an extra-credit paper on any topic related to cosmology, which will be due on Wednesday, December 12, the last day of classes. It should be roughly five pages in length. Depending on the quality of the paper, you will receive up to 3 extra credit points, which will be added to your final overall average for the course.

I expect these essays to be more or less at the Scientific American level, and below I have listed a number of Scientific American articles that you might use as starting points. You should include a (short) bibliography of your sources. (I would expect you to have at least 3 sources, but this might vary depending on the topic.)

I am also including some books in the suggested references below. If you wish, you can write a book review of any of these books or any other book related to cosmology that you might choose. (For a book review you do not need a bibliography. The book you are reviewing is enough.) Of course the recommended books can also be used as sources of information for papers on specific topics.

The history of cosmology is very interesting, so historically based papers will also be welcome.

I would recommend that you let me know in advance (by email) what you plan to write about, in case I have any additional suggestions for references or angles. But this is not required.

When you submit the paper, we strongly prefer submission by email, preferably in postscript, PDF, or MS Word. Please email your submission to all of the course staff: guth@ctp.mit.edu, zwiebach@mit.edu, and ymao@mit.edu.

Suggested Topics:

1) The Cosmic Microwave Background: Physics and/or summary of observational results.
   
   Possible reference: The Cosmic Symphony, Scientific American, February 2004; by Wayne Hu and Martin White; 10 page(s). (New observations of the cosmic microwave background radiation show that the early universe resounded with harmonious oscillations.)

2) The Cosmic Microwave Background: specific experiments. You can choose any one (or perhaps several if you want) of the following experiments:
   a) COBE (Cosmic Background Explorer, the first CMB satellite mission, launched 1990)
   b) WMAP (Wilkinson Microwave Anisotropy Probe, the current CMB satellite mission, launched 2001)
   c) Planck (the next CMB satellite mission, to be launched about 2007)
   d) Balloon experiments: for example, BOOMERANG (at the South Pole)
3) Dark matter

4) The accelerating universe and dark energy


5) String theory


6) The string theory landscape


7) The critics of string theory — what are their arguments, how valid are they?


8) Particle physics and symmetry


9) Extra dimensions


10) The universe from a computational point of view


11) Parallel universes

Possible reference: Parallel Universes, Scientific American, May 2003, by Max Tegmark; 12 page(s). (Not just a staple of science fiction, other universes are a direct implication of cosmological observations.)

12) Black holes


13) The black hole information paradox


14) Gravity Probe B: a satellite experiment to test frame dragging in general relativity. Currently in orbit.

15) The Sloan Digital Sky Survey: a mammoth, particle physics style collaboration of several hundred astronomers, undertaking the task of surveying about one quarter of the sky at optical wavelengths.

16) General relativity and time travel

Possible reference: There is an excellent chapter on time travel in the Kip Thorne book cited above.

Possible reference: Negative Energy, Wormholes and Warp Drive, Scientific American, January 2000; by Lawrence Ford and Thomas Roman; 8 page(s). (The construction of wormholes and warp drive would require a very unusual form of energy. Unfortunately, the same laws of physics that allow the existence of this “negative energy” also appear to limit its behavior.)

Possible reference: How to Build a Time Machine, Scientific American, September 2002; by Paul Davies; 6 page(s). (It wouldn’t be easy, but it might be possible.) (Comment by AHG: The previous parenthetical remark comes from Scientific American. I would recommend not counting on it, although nobody has ever proven that the laws of physics forbid the possibility of time machines. Davies also wrote a book with the same title.)
17) Eternal inflation

Possible reference: The Self-Reproducing Inflationary Universe, Scientific American, November 1994; by Andrei Linde; 8 page(s). (Recent versions of the inflationary scenario describe the universe as a self-generating fractal that sprouts other inflationary universes.)

18) Veneziano’s “pre-big bang” approach to cosmology

Possible reference: The Myth of the Beginning of Time, Scientific American, May 2004; by Gabriele Veneziano; 10 page(s). (String theory suggests that the big bang was not the origin of the universe but simply the outcome of a preexisting state.) (Comment by AHG: Veneziano is responsible for the Veneziano model of particle scattering, a theory that set off a chain of evolution that led to modern string theory. He is a former MIT faculty member. This version of cosmology is a minority report at present, but Veneziano is certainly a very solid theoretical physicist.)

19) The Ekpyrotic cyclic model of Paul Steinhardt and Neil Turok


20) History: Albert Einstein and Alexander Friedmann: why was Einstein so slow to accept the possibility of an evolving universe?

21) History: the discovery of the cosmic microwave background.

22) History: big bang nucleosynthesis, perhaps going back to George Gamow, Ralph Alpher, and Robert Herman.

23) Magnetic monopoles

Possible reference: Superheavy Magnetic Monopoles, by Richard A. Carrigan, Jr. and W. Peter Trower, Scientific American, April 1982. (In the Particle Physics in the Cosmos review book, on the recommended book list for this course.)

24) Grand unified theories

Possible reference: A Unified Theory of Elementary Particles and Forces, by Howard Georgi, Scientific American, April 1981. (In the Particle Physics in the Cosmos review book.)

Possible reference: The Decay of the Proton, by Steven Weinberg, Scientific American, June 1981. (In the Particle Physics in the Cosmos review book.)
25) The matter-antimatter asymmetry of the universe


