

AST007:
The Big Bang and Beyond

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[Syllabus version: 1 April 2007]

Pre-requisites:

Some high school physical science is useful, algebra (but no calculus), and an inquiring and curious mind.

Books:

- (a) 'Foundations of Modern Cosmology', Hawley & Holcomb
- (b) 'The First Three Minutes', Steven Weinberg
- (c) 'Labyrinths', Jorge Luis Borges

Handouts:

- (a) 'Meditations', Descartes
- (b) 'The Unreasonable Effectiveness of Mathematics in The Natural Sciences', Eugene Wigner
- (c) 'Mymosh the Self-Begotten', Stanislaw Lem

Exams:

There will be a midterm and a final exam.

Stargazing:

The quest to understand the universe begins with observations of the world around us. There will be two astronomical observatory sessions. Details and dates will be given later, and depend on when the relevant stars rise above the horizon (and on the weather!). You will be expected to sign up for one of two optional dates for each lab and complete a lab report. These projects also satisfy the University's 'quantitative data analysis' requirement.

Weekly Guiding Questions:

Most weeks, there will be a set of guiding questions drawn from Hawley and Holcomb. These are intended to help you to test your own understanding of the textbook. Many questions will be qualitative; limit answers to such questions to a few sentences at most. Sometimes the questions will be on material that has not yet been covered in class - this is intended to help you prepare for lecture by reading ahead.

Papers:

You will write a paper at midterm. This essay will respond to issues that we raise in class discussions.

Participation and Weekly Discussions:

Attendance is compulsory - I will take attendance in class. Classes will frequently involve student-led discussions. Participation in these discussions is an important component of the grade.

Grades:

- 2 lab projects (5% each): 10%
- 1 paper (due around midterm): 15%
- Weekly guiding questions: 30%
- 2 exams (20% each): 40%
- Attendance and participation: 10%

Other Policies:

Grades will not be discussed over email. Late labs, paper, homeworks or exams will not be accepted without a legitimate excuse.

INTRODUCTION

Week 1: In the beginning

Course logistics; Introduction to cosmology; Greek cosmology

Reading: HH Ch. 1,2,3

Guiding questions: Ch.1: 1,9; Ch.2: 4,6,7,10

Discussion topics:

- What is science? What is cosmology?
- Did the universe have a beginning in time?
- Religious and mythological traditions about creation.

Week 2: Who was whom, and were they only human too?

Copernicus, Brahe, Kepler, Galileo, Newton

Reading: HH Ch. 1,2,3

Handouts: Descartes readings

Discussion topic:

- Is simplicity a guide to truth?
- Religious systems are characterized partly by the need for 'faith' in some set of received knowledge. To what extent are scientific truths based on 'faith' vs. 'fact', and what do these terms mean? To what extent and in what sense are scientific facts dependent on the underlying theoretical framework of thought, and how does the process of scientific thought revise and refine 'facts' and 'theories'. Is this different in practice from religious thought?

Week 3: Why I hate physics

Newtons Laws; Gravity, Light, Energy, Heat

Reading: HH Ch. 3, 4

Guiding questions: Ch.3: 3,4,7; Ch.4: 2,5

Discussion topics:

- Descartes and natural law.
- Does the determinism of physics leave room for a god? Free will?

Week 4: And why I'm not a chemist either

Quantum Mechanics and the composition of matter

Reading: HH Ch. 4, 5

Guiding questions: CH.4: 9, 10; Ch.5: 4, 5, 6, 8, 9

Suggested discussion topic:

- Borges "Garden of Forking Paths"
- The many-worlds theory of quantum mechanics.

Week 5: A star is born

Why stars shine. Why should we care?

Reading: HH Ch. 6

Guiding questions: Ch.6: 1,3,7,8,9,10

Midterm Paper topic assigned

Week 6: The Simple Life? It isn't easy being a star

Life on the Main Line; White dwarfs; Supernovae

Discussion: The astrophysics of extinction

RELATIVITY

Week 7: The Special Relativity of space and time

Time dilation, length contraction; simultaneity.

Reading: HH

Guiding questions: Ch.7: 3,4,6,7,8,10

Discussion:

-Simultaneity. Time travel.

-Social and moral relativity.

Week 8: That's so warped-up: General Relativity

The equivalence principle; Curved geometries; Black Holes

Reading: HH Ch. 8

Guiding questions: Ch.8: 2,3,4,5,6,10

Discussion: Gravitational lensing

THE BIG BANG ...

Week 9: The expanding universe

Far away = long ago; Standard candles and rods

Midterm Paper Due Oct. 30th

Reading: HH Ch. 8, 10

Guiding questions: Ch. 10: 3,4,5,7,10,11

Discussion: Acceleration? It won't stop going and it won't slow down.

Week 10: Describing the universe

Homogeneous cosmologies; The standard cosmological model

Reading: HH Ch. 10, 11; Weinberg Ch. II

Guiding questions: Ch.11: 2,3,4,5,8,9

Handout: Wigner, 'Unreasonable effectiveness of mathematics ...'

Week 11: The primordial soup

How stuff was made

Reading: HH Ch. 12,13; Weinberg Ch. III,IV

Guiding questions: Ch.13: 2,5,6,7,8,10

Handouts: Texts on reality and illusion

Suggested discussion topic:

-‘Mymosh’ by Lem; ‘The Circular Ruins’ by Borges

-How do we know that the world as we observe it is real?

Week 12: Echoes from the Big Bang?

The Cosmic Microwave Background

Reading: HH Ch. 12,13; Weinberg Ch. III,IV

Guiding questions: Ch. 12: 3,5,6,8,10,11

Handouts: Readings on science and religion - see course website

Suggested discussion topic:

-Magic, science and religion

-‘The Library of Babel’ by Borges

Week 13: Dark matters and the shape of the Universe

Cosmic capitalism and Large scale structure

Book: HH Ch. 14; Weinberg Ch. VI,VII

Guiding questions: Ch. 14: 1,3,4,5,7,10

Discussion: How outdated is ‘The First Three Minutes’?

... AND BEYOND**Week 14: Inflation: The solution or the problem?**

The horizon, flatness, structure and relic problems

Book: HH Ch. 15; Weinberg Ch. VIII

Guiding questions: Ch.15: 2,3,5,6,7,9

Suggested discussion topic:

-This is the way the World will end, Not with a bang but a whimper.