Time, Being and Cosmos: Introduction to Philosophy of Cosmology

PHIL 576—Spring 2019

MWF: 1-1.50 PM

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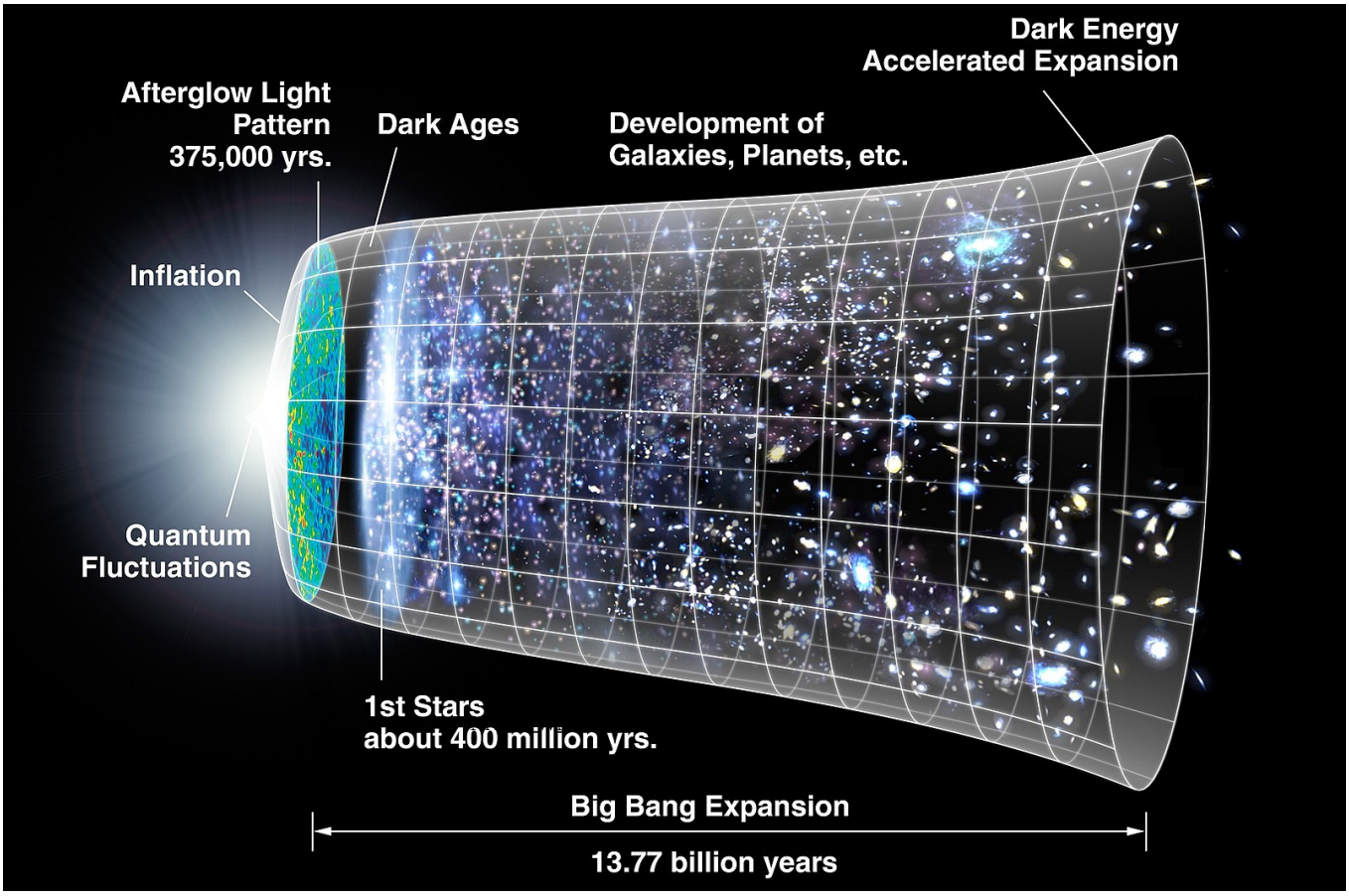
Office Hours: Wednesday 2-4PM.

All science is cosmology, I believe, and for me the interest of philosophy, no less than of science, lies solely in the contributions which it has made to it.
Karl Popper



Course Description:

This class is a non-technical introduction to the philosophy of cosmology: Modern cosmology provides us with a vivid picture of the universe, supported by precision measurements in astrophysical experiments, using both ground based and in space instruments.. In this class, we aim to probe the scientific claims of modern cosmology from a philosophical perspective. We will begin by laying out the basic cosmological picture that modern science gives us, i.e., an expanding/accelerating universe filled with dark matter and dark energy that began with a "Big Bang." On this basis, we will examine questions such as: what kind of epistemic and ontological strategies need to be deployed to reach such a conclusion, or what does this picture of the universe imply for certain major metaphysical and epistemological questions such as: *what is time, is space a substance, what is the nature of quantum reality, is multiverse hypothesis scientifically testable?* Main topics that we will examine include: justification for the anthropic principle, the emergent multiverse, ontology of the ultimate constituents of the universe, beginning of time with the Big Bang, the search for the quantum description of gravity, and (time permitting) the aim (telos) of the universe.

The philosophy of cosmology is not a standardized sub-discipline of philosophy (such as ethics, or the philosophy of language) so our approach will be inevitably eclectic. As the majority of concepts in contemporary cosmology are based on the quantum and the relativity theories, we will spend due amount of time thinking about the foundations of these two major pillars of modern physics.

Learning Outcomes:

Upon successful completion of this course, students will:

1. Obtain a working understanding of modern cosmology, by studying the history of the formation of the recent ideas on the universe since the early modern era. They will gain a broader perspective on fundamental issues such as the ideas of space and time in Newtonian physics, and examine how these ideas were transformed by the relativity and quantum revolutions that applied them to the universe as a whole. Approaching the issues historically from the maturation of physical sciences from the 18th century beginning with Newton and Leibniz, to the 20th century theories, students will learn that science is built on various complex assumptions that needs to be philosophically examined and justified.
2. Gain mastery over key concepts and debates in contemporary cosmology including the cosmological principle, the concepts of *cosmic microwave background radiation*, *dark matter*, *dark energy*, the Big Bang model, and the multiverse.
3. Learn to think philosophically about scientific knowledge, and to apply this knowledge in clarifying the metaphysics and epistemology of science.
4. Understand arguments for and against contentious views in cosmology, and gain and apply an in-depth knowledge of the fundamental arguments presented by the key authors in the field, including, Hawking, Penrose, Carroll and Smolin.
5. Express their critical thinking on the issues through class discussions, written assignments, and exams.

Course Evaluation

10%: **Participation**: This includes short blog posts (a few sentences) on Blackboard, and in-class participation. You are asked to write one blog post each week on a topic of your choice. This could be a question on a text or a remark on a philosopher's views. Students can have two "joker" weeks in which they do not post.
25%: **Midterm test**: This is a short midterm test, where you will be assessed on the extent to which you mastered and able to apply to concrete situations several key concepts in philosophy of cosmology.
30%: **Short paper** (1500–2000 words): The aim of the paper is to critically engage with and evaluate a philosophical issue concerning the foundational questions in cosmology.
35%: **Final Paper**

- *Undergraduate students* are asked to write a (8-10) page response paper. I will provide a set of (10) questions, and you will pick one question to write on.
- *Graduate_students* are asked to write a (15-20) page research paper. The topic of the paper will be determined in consultation with me.

Accommodations

The learning environment should be accessible to all. SDSU provides reasonable accommodations in the following situations:

Disability: If you are a student with a disability and believe you will need accommodations for this class, it is your responsibility to contact Student Ability Success Center at (619) 594-6473. To avoid any delay in the receipt of your accommodations, you should contact Student Ability Success Center as soon as possible. Please note that accommodations are not retroactive, and that accommodations based upon disability cannot be provided until you have presented your instructor with an accommodation letter from Student Ability Success Center. Your cooperation is appreciated. http://go.sdsu.edu/student_affairs/sds/Default.aspx

Religion: By the end of the second week of classes, students should notify the instructors of affected courses of planned absences for religious observances.

Official university activities (e.g., Athletics): Within the first two weeks of classes, a student who expects to be part of an official university event or activity shall notify the instructors of affected courses. At that time, the student shall request accommodation for any missed examinations or other assignments. If scheduling changes occur, the student shall immediately notify the instructors.

Grading:

Ideally, your essays should:

• Present a problem/question in a compelling way and present a persuasive critical perspective.
• Develop a fresh, insightful thesis in a coherent, interesting way
• Thoughtfully reason with evidence
• Create an effective beginning, middle, and ending

• Supply your readers with explanations and background wherever they are necessary for your readers' understanding
• Address your readers respectfully in a graceful, conversational style
• Express your thoughts in clear, economical prose that correctly uses the conventions of grammar, usage, and punctuation.

A general guide to grading appears below. Pluses and minuses represent shades of difference, as do split grades (e.g., a B-/C+ is between a B- and a C+). I assign grades based on the essay submitted, not on effort or time spent.

A: The essay creates an impression of excellence in all the criteria listed above. This is an ambitious, perceptive essay that raises an interesting question and approaches it with transparent logic, appropriate evidence, and a healthy regard for counterargument. There is a context for all the ideas; someone outside the class would be enriched, not confused, by reading the essay. Its beginning sets up useful inquiry (though the thesis may appear in the beginning or the end) and its ending leads the reader out of the essay toward its implications, rather than simply summarizing the essay. The language is clear and precise. Finally, it's clear why it matters—why the writer wrote the essay on this topic, and why someone should read it.

B: This is a strong paper but falls short of an "A" paper in one of two ways: (a) The essay reaches high and achieves many of its aims, but some of the elements mentioned above are missing, or appear inconsistently. (b) The paper reaches less high than an "A" essay but thoroughly achieves its aims; it is a solid essay whose reasoning and argument may nonetheless be routine.

C There are again two kinds of papers in this category: (a) The essay has real problems in one of these areas: conception (the ideas of the paper are not clear, or not working for the paper); structure (either too simplistic or confusing); use of evidence (either it is insufficient or it is not well-contextualized or connected to the point the paper is making); language (unclear writing, including problems with diction, sentence structure, punctuation, grammar, and transitions). (b) The essay does not do the work of the assignment but rather is more of an "interpretative summary."

D or F These papers fall severely short of expectations.

Attendance and Deadlines

Attendance is important. More than three unexcused absences will result in a penalty. Legitimate excuses for missing a class, or a deadline are serious injury/accident, serious illness, religious observance, or family tragedy (and the like). Such an excuse may have to be verified in writing in certain cases.

In the unlikely event that you find yourself seeking an extension for an essay, you must request it at least one full day ahead of time. Unexcused late essays will immediately lose one third of a full letter grade (for example a B+ to B); they lose another for each 24 hours that they are late.

Academic Honesty

The University adheres to a strict policy regarding cheating and plagiarism. These activities will not be tolerated in this class. Any cheating or plagiarism will result in failing this class and a disciplinary review by Student Affairs. It is understood that all of your assignments are meant to be your own individual work unless indicated otherwise (e.g., group activities, peer editing etc.). Plagiarizing someone else's work (i.e. copying from books, the Internet or other sources) or asking a proficient speaker (e.g. tutor, friend, native speaker etc.) to complete or correct your work before it is evaluated is unacceptable and may result in disciplinary actions taken.

If you have questions on what plagiarism is, please consult the standards for standards for student conduct and this helpful plagiarism tutorial from the Library.

Technology in the classroom and civility in the digital era

Cellphones and computers have become ubiquitous in the classroom and while they can be useful for following the course online and taking notes, they are more often a distraction to those using them and to everyone else around them. Please be courteous to your classmates and instructors during the class time by SILENCING all electronic devices before entering and the class and NOT USING them during class, unless explicitly asked to do so by the instructor.

Please also note that SDSU's Student Conduct Code prohibits unauthorized recording, dissemination, or publication of academic presentations for commercial purposes.

Required Texts

Sean Carroll: *From Eternity to Here. The Quest for the Ultimate Theory of Time.* Dutton, 2010.

Delia Perlov and Alex Vilenkin: *Cosmology for the Curious.* Springer, 2017

Roberto Unger and Lee Smolin: *The Singular Universe and the Reality of Time.* Cambridge University Press, 2014.

In addition to these texts, we will make use of various entries in the Stanford Encyclopedia of Philosophy, and John Norton's online textbook *Einstein for Everyone.*

Schedule of Readings and Assignments:[1]

Abbreviations:
FEH: Sean Carroll: *From Eternity to Here.*
SUR: Roberto Unger and Lee Smolin: *The Singular Universe and the Reality of Time.*
CC: Delia Perlov and Alex Vilenkin: *Cosmology for the Curious.*

[1] This list of readings and the schedule is tentative and subject to change. All changes will be communicated via email by the instructor, as well as announced in class.

Week 1 (Jan 23-Jan 25): An Invitation to Modern Cosmology

1. Introduction and Overview: Basic Issues in Philosophy of Cosmology. A Broad Perspective. (no reading.)
2. Foundations: Early Observations. The Great Debate (https://apod.nasa.gov/htmltest/gifcity/cs_nrc.html). Hubble and the Expanding Universe (https://www.pnas.org/content/pnas/15/3/168.full.pdf).

Week 2 (Jan 28-Feb 1): The Newtonian Background: Leibniz-Clark Debate

1. Newton's Scholium. Absolute Space, Absolute Time. Newton's Bucket Experiment. (https://plato.stanford.edu/entries/newton-stm/, https://plato.stanford.edu/entries/newton-stm/scholium.html).
2. Absolute versus Relative Motion. Principle of Inertia. Leibniz-Clarke Debate. (https://www.earlymoderntexts.com/assets/pdfs/leibniz1715_1.pdf).
3. Gravity as Force. Action at a Distance. (https://plato.stanford.edu/entries/newton-philosophy/#MetIIPri).

Week 3 (Feb 4-Feb 8): Special Relativity I: Basic Concepts

1. Maxwell Equations, The Principle of Relativity, and the Concept of an Observer **(FEH 67-74)**, (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/Special_relativity_principles/index.html).
2. The Light Postulate, Lorentz Transformations, and the Relativity of Simultaneity. (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/Special_relativity_rel_sim/index.html)
3. A Four Dimensional Spacetime? (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/spacetime/index.html), **(FEH 74-77).**

Week 4 (Feb 11-Feb 15): Special Relativity II: Space and Time

1. Reality of Time in Special Relativity. The Concept of a Light-Cone. **(CC 47-58), (FEH 77-81)**
2. Time Dilation and the Twin Paradox. **(CC 42-46), (**https://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/spacetime_tachyon/index.html**)**
3. Is Time Special in Special Relativity? (Callender: *What Makes Time Special*, Chapter 6: The Differences Between Time and Space.)

Week 5 (Feb 18-Feb 22): General Relativity I

1. Curvature of Space and Curvature of Space*time*. Equivalence Principle. **(CC 59-71), (FEH 83-87).**
2. Einstein's Cosmology, Lemaître's "Big Bang" and the Friedman Universe. **(CC 83-96).**
3. Contemporary Cosmological Model: The Basics. (**CC 97-107).**

Week 6 (Feb 25-Mar 1): General Relativity II

1. Being and Becoming in Relativity: Ontological Implications. **(SUR 226-249).**
2. Gravity as Geometry. Understanding Einstein Equations. **(FEH 87,)** (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/general_relativity/index.html).
3. The Concept of a Black Hole and Spacetime Singularity. **(FEH 88-93)** (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/black_holes/index.html).

Week 7 (Mar 4-Mar 8): The Ontology of Spacetime: The Hole Argument

1. The Hole Argument: Determinism and Spacetime Substantivalism in General Relativity. (https://plato.stanford.edu/entries/spacetime-holearg/, Sections 1-7).
2. Responses to the Argument (Section 9).
3. The Significance of The Argument (Section 10).

Week 8 (Mar 11-Mar 15): Entropy and Time's Arrow

1. Reversible Processes and the Concept of Entropy **(FEH 128-142)**
2. The Past Hypothesis. **(FEH 176-178),** Thermodynamic Asymmetry in Time **(**https://plato.stanford.edu/entries/time-thermo/, Sections 1-2.1**)**
3. Maxwell's Demon, Entropy and Information **(FEH Chapter 9)**

Week 9 (Mar 18-Mar 22): The Fine Tuning Problem and the Anthropic Principle

1. What is *Fine Tuning* and why is it a problem? (https://plato.stanford.edu/entries/cosmology/#FineTuni)
2. The Anthropic Principle. Carter, Brandon, 1974, "Large number coincidences and the anthropic principle in cosmology."
3. Midterm

Week 10 (Mar 25-Mar 29): Being in Cosmology: Dark Matter and Dark Energy

1. What is Dark Matter? **(CC 131-137)**
2. The Accelerating Universe and Dark Energy **(CC 137-141),** Earman: "Lambda: The Constant that Refuses to Die." Archive for History of Exact Sciences January 2001, Volume 55, Issue 3, pp. 189–220.
3. Are dark matter and dark energy mere conventions? Merritt: "Cosmology and Convention" Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics, Volume 57, February 2017, Pages 41-52.

Week 11 (Apr 1-Apr 5): Spring Recess

NO CLASS

Week 12 (Apr 8-Apr 12): Quantum Physics: Foundations

1. Origins of Quantum Theory and Basic Concepts. (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/quantum_theory_origins/index.html)
2. Wave-Particle Duality. **(CC 141-145)**
3. The Superposition Principle and the Wave-Function Collapse (http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/quantum_theory_waves/index.html) (Short paper Due In Class.)

Week 13 (Apr 15-Apr 19): The Measurement Problem and Quantum Indeterminism.

1. The Measurement Problem. The Schrödinger's Cat Experiment. http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/quantum_theory_measurement/
2. Quantum Indeterminism: The EPR Paper http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/quantum_theory_completeness/index.html
3. Bell Inequality as a Refutation of Einstein. (previous reading continued)

Week 14 (Apr 22-Apr 26): Interpretations of Quantum Physics: Time and Free Will in Quantum Physics

1. Quantum Time **(FEH Chapter 11)**
2. Quantum Reality: Mermin: "Is the Moon There When Nobody Looks: Reality and the Quantum Theory" Physics Today 38, 4, 38 (1985).
3. Wheeler: The Delayed Choice Experiment. Quantum Free Will. Wheeler: "Law Without Law" in: *Quantum Theory and Measurement.* pp. 182–213.

Week 15 (Apr 29-May 3): The Concept of a Multiverse

1. Everett's Many-World Interpretation of Quantum Physics. (https://plato.stanford.edu/entries/qm-manyworlds/, Sections 1-3).
2. Many Worlds and Decoherence (https://plato.stanford.edu/entries/qm-decoherence/, Section 1, 3.3).
3. String Theory and Multiverse **(CC 291-298).**

Week 16 (May 6-May 10): Conclusion: Can Quantum Gravity solve the Problem of Time and Being?

1. Black Hole Information Paradox. **(FEH Chapter 12).**
2. Inflation and the Multiverse **(FEH Chapter 14).**
3. Concluding Discussion: Towards a Quantum Theory of Gravity? **(FEH Chapters 15-16).**