Philosophy of Cosmology
Philosophy 9200, AKA: LPS 241

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A number of challenging questions arise in contemporary cosmology, and philosophers can contribute constructively to answering them. Over the past century cosmologists have debated whether, for example, this field requires a distinctive methodology due to the unusual nature of its subject matter. In what sense is cosmology a "special case," in terms of its aims, the nature of cosmological theories, or the ability to establish theories empirically? What, if anything, constrains theorizing about the early universe or regions of space and time so remote as to be beyond our observational ken? When should observational anomalies be taken as evidence that existing theory is incorrect, and when do they signal the discovery of new entities consistent with existing theory? How should we understand "spacetime geometry" in alternative theories of gravitation, or in theories according to which spacetime "emerges"? This seminar will provide a survey of several central questions, with some topics explored in more depth. The organizing theme of the seminar will be a new book manuscript by Smeenk & Weatherall called *The Aim and Structure of Cosmological Theory*. In addition to that manuscript, we will discuss background literature, alternative positions, and adjacent topics in other areas of philosophy of physics and philosophy of science.

This will be a joint seminar co-organized by Chris Smeenk and Jim Weatherall, with students in Western's Department of Philosophy and UC Irvine's Department of Logic and Philosophy of Science.

Evaluation:

- Participation (20 %): participation during the seminar, and contributions to online discussions of assigned readings (due Wednesday before class at 5:00 pm).
- Paper(s) (80 %): either a research paper due at the end of the semester, or a series of three shorter papers (ca. 8 pages each) handed in over the course of the seminar.

The option of three shorter papers is meant to accommodate students who do not plan to pursue research in philosophy of physics. Overall we aim to run the course with two tracks, with ample material accessible to students without a physics background along with some material for those planning to do further research in philosophy of physics.

Tentative Schedule (... to be updated)

Meeting 1: Introduction: Philosophy within Cosmology / Newtonian Cosmology

Readings:
Handout; no required reading for first meeting
Optional: Howard Stein, "Newtonian Spacetime"
Optional: Eleanor Knox, "Newtonian spacetime structure in light of the equivalence principle"

Meeting 2: Cosmology 101: General Relativity and Cosmological Models

Readings:
Handout
Primer on Relativity: Geroch (Chapters 5-7) *or* Penrose, *Road to Reality* (Chapters 17-19), *or* ...
(choose from the list below based on background knowledge)
Einstein, "Cosmological Considerations"

Meeting 3: The Symmetric Universe

Readings:
ASCT, Chapter 2
Torretti, "Spacetime Models of the World"
Optional: Roush, "Copernicus, Kant, and the anthropic cosmological principles."
Optional: Hamilton, "What have we Learned from Observational Cosmology?"

Meeting 4: Origins: Inflationary Cosmology

Readings:
Excerpts from Guth (1981), "Inflationary Universe" and (2000) "Inflation and Eternal Inflation"
Penrose, *Road to Reality* (chapters 27-28)
Martin, "The Theory of Inflation"
Optional: Mukhanov, *Physical Foundations of Cosmology*, chapters 5,8

Meeting 5: Inflationary Cosmology Redux

Readings:
Earman and Mosterin, "A Critical Look at Inflationary Cosmology"
ASCT, Chapter 3
Brandenberger, "Do we have a Theory of Early Universe Cosmology?"
Optional: Ijjas, Steinhardt, and Loeb, "Inflationary Schism"

Meeting 6: Interlude: Evidence for the Unobserved

Readings:
Smith, "Closing the Loop";
Excerpts from Smith & Seth, *Brownian Motion and Molecular Reality*
van Fraassen, "The perils of Perrin, in the hands of philosophers"
Excerpt from Maddy, *Second Philosophy*

Meeting 7: The Case of the Missing Mass, or, Reichenbach Falls?

Readings:
ASCT, Chapter 4, Part 1;
Peebles, "Dark Matter";
Merritt, "Cosmology and Convention".
Optional: Jacquart, "Dark Matter and Dark Energy".

Meeting 8: Dark Matter vs. Modified Gravity

Readings:
ASCT, Chapter 4, Part 2;
Sanders, "A Historical Perspective on the Dark Matter Problem";
Massimi, "Three problems about multi-scale modelling in cosmology".
Optional: Sanders & McGaugh, "Modified Newtonian Dynamics as an Alternative...";
Very Optional: Famaey and McGaugh, "Modified Newtonian Dynamics (MOND)...";
Actively discouraged: Milgrom, "MOND vs. dark matter in light of historical parallels".

Meeting 9: Small Scale Problems and the Epistemology of Simulation

Readings:
Ruphy, "Limits to Modeling";
Smeenk & Gallagher, "Validating the Universe in a Box";
Gueguen, "On Robustness in Cosmological Simulations";
de Baerdemaeker & Boyd, "Jump Ship, Shift Gears, or Keep Chugging...";
Optional: Bullock & Boylan-Kolchin, "Small-Scale Challenges..."

Meeting 10: The Universe Accelerates

Readings:
ASCT, Chapter 5, Part 1;
Durrer, "What do we really know about dark energy?";
Bianchi & Rovelli, "Why all these prejudices against a constant?"
Optional: Bean, "Lectures on Cosmic Acceleration".

Meeting 11: Once More, with Feeling! & Outroduction

Readings:
ASCT, Chapter 5, Part 2;
Joyce et al. "Dark Energy vs. Modified Gravity".

For further sources, ideas of possible paper topics, see also: our bibliography (link), John Norton's seminar (link). See also the extensive collection of .pdf's in physics and philosophy on Erik Curiel's website.

Background

Here are a few texts introducing general relativity and/or aspects of the Standard Model of cosmology (listed, roughly, in order of technical background assumed):

- Geroch (1981), *General Relativity from A to B*. University of Chicago Press. Beautifully executed introductory text regarding general relativity.
- Penrose (2003), *Road to Reality* (primarily Chapters 17-19, 27-28). Clear discussion, intermediate level (technical details not essential to exposition).
- Dodelson, S. (2003). *Modern cosmology.* New York: Academic Press. A good textbook treatment, not presuming knowledge of general relativity and covering a variety of topics in addition to relativistic models.
- Malament, D. (2007). "Classical General Relativity," in *Handbook for the Philosophy of Physics*, J. Earman and J. Butterfield, eds., Elsevier, 2007; and (2012). *Topics in Foundations of General Relativity and Newtonian Gravitation Theory*. Masterful treatments of foundations of the theory, with assorted special topics. (Both available online here.)
- Wald, R. (1984). *General Relativity*. Chicago: University of Chicago Press. Exemplary graduate level physics textbook.

Recent surveys of philosophy of cosmology might also be useful, although they do not cover the same topics we will discuss:

- Ellis, G. F. R. (2007). "Issues in the philosophy of cosmology." In *Handbook for the Philosophy of Physics*, J. Earman and J. Butterfield, Elsevier, pp. 1183 - 1286; and "On the philosophy of cosmology" *SHPMP* **46**: 5-23.
- Smeenk's "Philosophy of Cosmology" in *Oxford Handbook for the Philosophy of Physics*, ed. by Batterman. Oxford: Oxford University Press (2013), pp. 607-652.
- Smeenk and Ellis, "Philosophy of Cosmology" in the Stanford Encyclopedia of Philosophy.