

Phil 362: The Aim and Structure of Cosmological Theory

Draft of January 3, 2022

Meeting time: Tu/Th 13:30-15:00

Location: 460-301

Instructor: James Weatherall

Office Hours: By appointment

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This seminar will consider several philosophical and foundational issues as they arise in contemporary physical cosmology. The organizing theme of the seminar will be a book manuscript by Chris Smeenk (UWO) & Weatherall called *The Aim and Structure of Cosmological Theory*, which considers the role that metaphysical and epistemological principles concerning, for instance, the structure of scientific theories, the assessment of evidence, the status of laws of nature, and the causal structure of the world have played in shaping contemporary cosmology.

Roughly, the course will be split between lecture-style meetings in which the instructor will present background material in cosmology and seminar-style meetings that will consider the arguments raised in the philosophical readings.

Assessment / Course Requirements:

All students enrolled in the course are asked to contribute regularly to seminar discussions and to lead discussion during one 90 minute course meeting, including a brief presentation of course readings. Students who would like a letter grade (as opposed to C/NC) are also asked to produce some writing. The details of the writing assignment(s) are flexible, but should be about approximately 12-15 pages in total, either in the form of two or three short, highly focused papers on different topics or a longer term paper engaging with a topic in greater depth. These will be weighted as follows.

- Participation (20 %)
- Presentation (30 %)
- Paper(s) (50 %)

Useful texts

Here are a few good texts introducing aspects of the Standard Model of cosmology:

- Peebles, P.J.E. (1993). *Principles of Physical Cosmology*. Princeton: Princeton University Press. [Out of date, but still valuable.]
- Dodelson, S. (2003). *Modern cosmology*. New York: Academic Press.
- Mukhanov, V. (2005). *Physical Foundations of Cosmology*. Cambridge: Cambridge University Press.
- Ellis, G.F.R., et al. (2012). *Relativistic Cosmology*. Cambridge: Cambridge University Press.

Recent surveys of philosophy of cosmology, with different emphases from ours:

- Ellis, G. F. R. (2007), "Issues in the philosophy of cosmology." In Earman, J. & Butterfield, J. (eds.) *Handbook for the Philosophy of Physics* Amsterdam: North Holland, pp. 1183 - 1286.
- Ellis, G. F. R. (2014) "On the philosophy of cosmology" *Studies in History and Philosophy of Modern Physics* **46**: 5-23.
- Smeenk, C. (2013), "Philosophy of Cosmology" in *Oxford Handbook for the Philosophy of Physics*, ed. by Batterman. Oxford: Oxford University Press, pp. 607-652.
- Smeenk, C. and Ellis, G. F. R. (2017), "Philosophy of Cosmology" in the Stanford Encyclopedia of Philosophy.

Tentative Schedule

Week 1: Introduction: Philosophy and Cosmology

Tuesday [4 January]: Introductions [Meet on Zoom]

Readings:

- McMullin, E. (1981), “Is Philosophy Relevant to Cosmology?” *American Philosophical Quarterly* **18**(3): 177-189.
- Falck, B. (2018), “Why cosmology without philosophy is like a ship without a hull”. *AEON* [<https://aeon.co/ideas/why-cosmology-without-philosophy-is-like-a-ship-without-a-hull>].

Thursday [6 January]: Cosmology 101 [No meeting / Lecture Videos & Discussion Board]

Readings:

- Ratra, B. and Fogeley, M. S. (2008), “The Beginning and Evolution of the Universe”. *Publications of the Astronomical Society of the Pacific* **120**(865): 235-265.
- Scott, Douglas E. (2018), “The Standard Model of Cosmology: A Skeptic’s Guide”. arXiv:1804.01318 [astro-ph.CO].

Week 2: Cosmological Models

Tuesday [11 January]: FLRW Spacetime [No meeting / Lecture Videos & Discussion Board]

Readings:

- Weatherall notes

Optional:

- Malament, D. (2012), “Friedmann Spacetimes”, in *Topics in the Foundations of General Relativity and Newtonian Gravitation Theory*. Chicago: University of Chicago Press, pp. 183-194.
- Wald, R. (1984), “Homogeneous, Isotropic Cosmology”, in *General Relativity*. Chicago: University of Chicago Press, pp. 91-117.

Thursday [13 January]: Questions & Discussion

Readings: None

Week 3: The Symmetric Universe / Cosmological Principles

Tuesday [18 January]: Homogeneity and Isotropy

Readings:

- *ASCT*, Chapter 2.
- Torretti, R. (2000), “Spacetime Models of the World”. *Studies in History and Philosophy of Modern Physics* **31**(2):171–186.
- Hamilton, J.-Ch. (2013), “What Have We Learned from Observational Cosmology?” *Studies in History and Philosophy of Modern Physics* **46**(1):70-85. **(Read §1 only!)**

Thursday [20 January]: Assessing Principles, Copernican and Otherwise

Readings:

- Carter, B. (1974), “Large number coincidences and the anthropic principle in cosmology”. In Longair,

- M. (ed.), *Confrontation of cosmological theories with observational data*. Dordrecht: D. Reidel, pp. 291-298.
- Earman, J. (1987), “The Sap Also Rises: A Critical Examination of the Anthropic Principle”, *American Philosophical Quarterly* **24**(4):307-317.
 - Roush, S. (2004), “Copernicus, Kant, and the anthropic cosmological principles”, *Studies in History and Philosophy of Modern Physics* **34**(1):5-35.

Week 4: Evidence for Unobservables?

Tuesday [25 January]: Molecular Reality

Readings:

- Salmon, W. (1984), “The Common Cause Principle and Molecular Reality”, in *Scientific Explanation and the Causal Structure of the World* Princeton:Princeton University Press, pp. 213-227.
- van Fraassen, B. (2008), “The Perils of Perrin, in the hands of philosophers”. *Philosophical Studies* **143**: 5-24.
- Maddy, P. (2021), “On the Question of Realism”, in *A Plea for Natural Philosophy, and Other Essays*. Oxford: Oxford University Press, pp. 49-91.
- Mwakima, D. (202?), “On the Quality of Perrin’s Evidence”. Unpublished manuscript.

Optional:

- Smith, G. & Seth, R. (2020), *Brownian Motion and Molecular Reality*. Oxford: Oxford University Press. Especially SS7.1-7.4.

Thursday [27 January]: **No Meeting**

Week 5: The Case of the Missing Mass, or, Reichenbach Falls?

Tuesday [1 February]: Dark Matter

Readings:

- ASCT, Chapter 3, Part 1

Optional:

- Peebles, J. (2015), “Dark Matter”. *Proceedings of the National Academy of Sciences* **112**(40): 12246-12248.

Thursday [3 February]: Modified Gravity

Readings:

- Milgrom, M. (2020), “MOND vs. dark matter in light of historical parallels”. *Studies in History and Philosophy of Modern Physics* **71**:170-195.
- Sanders, R. H. (2015), “A historical perspective on modified Newtonian dynamics,” *Canadian Journal of Physics* **93**(2): 126-138.
- Merritt, D. (2017) “Cosmology and Convention,” *Studies in History and Philosophy of Modern Physics* **57**:41–52.

Week 6: The Epistemology of Gravitational Systems

Tuesday [8 February]: Assessing Disagreement

- Massimi, M. (2018), “Three problems about multi-scale modelling in cosmology”. *Studies in History and Philosophy of Modern Physics* **64**: 26-38.
- de Baerdemaeker, S. & Boyd, N. (2020), “Jump ship, shift gears, or just keep on chugging: Assessing the responses to tensions between theory and evidence in contemporary cosmology”. *Studies in History and Philosophy of Modern Physics* **72**:205-216.

Thursday [10 February]: Testing Gravitation

Readings:

- Smith, G. “Closing the Loop”. In Biener, Z. and Schliesser, E. (eds) *Newton and Empiricism*. Oxford: Oxford University Press, pp. 262-351.

Week 7: His Dark Materials

Tuesday [15 February]: Closing the Loop

Readings:

- *ASCT*, Chapter 3, Part 2.

Thursday [17 February]: What are these Principles?

Readings:

- Friedman, M. (2009), “Einstein, Kant, and the Relativized A Priori”. In Bitbol M., Kerszberg P., Petitot J. (eds) *Constituting Objectivity*. The Western Ontario Series In Philosophy of Science, vol 74. Springer, Dordrecht. pp. 253-267.
- Padovani, F. (2016), “Measurement, coordination, and the relativized a priori,” *Studies in History and Philosophy of Modern Physics* **52**: 123–128.
- Stein, H. (2020), “Physics and Philosophy Meet: the Strange Case of Poincaré,” *Foundations of Physics* **51**: 69.

Week 8: Dark Energy

Tuesday [22 February]: The Universe Accelerates

Readings:

- *ASCT*, Chapter 4, Part 1

Optional:

- Peebles, P. J. E. & Ratra, B. (2003), “The cosmological constant and dark energy”, *Reviews of Modern Physics* **75**: 559.
- Bean, R. (2010), “TASI Lectures on Cosmic Acceleration”. arXiv:1003.4468 [astro-ph.CO].

Thursday [24 February]:

Readings:

- Steinhardt, P. (2003), “A quintessential introduction to dark energy”, *Philosophical Transactions of the Royal Society A* **361**(1812): 2497-2513.
- Bianchi, E. & Rovelli, C. (2010), “Why all these prejudices against a constant?” arXiv:1002.3966 [astro-ph.CO].

- Schneider, M. (2020), “What’s the Problem with the Cosmological Constant?” *87*(1): 1-20.

Week 9: Dark Energy / Inflation

Tuesday [1 March]: Assessing Dark Energy

Readings:

- *ASCT*, Chapter 4, Part 2
- Durrer, R. (2011), “What do we really know about dark energy?” *Philosophical Transactions of the Royal Society A* **369**(1957): 5102-5114.

Thursday [3 March]: Inflation: An Introduction

Readings:

- *ASCT*, Chapter 5, Part 1
- Guth, A. (2000), “Inflation and Eternal Inflation”. *Physics Reports* **333-4**:555-574.

Optional:

- Martin, J. (2018), “The Theory of Inflation”. arXiv:1807.11075 [astro-ph.CO].
- Guth, A. (1981), “Inflationary Universe”, *Physical Review D* **23**: 347.

Week 10: Inflation

Tuesday [8 March]: Once more into the breach!

Readings:

- Earman, J. and Mosterin, J. (1999) “A Critical Look at Inflationary Cosmology”, *Philosophy of Science* **66**(1):1-49. (**Read only SS1-3; 5-6; 8; 13**)
- Guth, A. et al. (2014). “Inflationary paradigm after Planck 2013.” *Physics Letters B* **733**: 112-119.
- Ijjas, A., et al. (2014), “Inflationary Schism”, *Physics Letters B* **736**: 142-146.
- Brandenberger, R. (2014) “Do we have a theory of early universe cosmology?” *Studies in History and Philosophy of Modern Physics* **46**(1):109-121.

Optional:

- Chowdhury, D. et al. (2019), “Assessing the scientific status of inflation after Planck”, *Physical Review D* **100**: 083537.

Thursday [10 March]: Outro

Readings:

- *ASCT*, Chapter 5, Part 2