Philosophy of Physics 146

This quarter the course will focus on the philosophical foundations of spacetime physics, both classical and relativistic. This topic is an exceptionally rich one, for it has attracted some of the all-time greatest thinkers in philosophy and physics, e.g., Descartes, Galileo, Newton, Leibniz, Kant, Reichenbach, Einstein, Gödel, and others. We'll focus on a diverse array of deep questions: is space (time) real? if so, what kind of thing is it? are physical geometry and topology conventional in some sense? how do we know the physical geometry of space? does relativity prove that time does not flow? that time travel is possible? what does $E=mc^2$ really mean? Tackling these questions will help one better understand both the physics of spacetime and the philosophy of science.

Instructor — Professor Craig Callender
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Grader: Brandi Bernoskie; bbernoskie@ucsd.edu

Coordinates — Sequoia 148, TuTh 3:30-4:50

Prerequisites — Most or all of the math/physics needed will be presented in class, but I will assume some very basic calculus. The emphasis will be on the conceptual side of the equations, and every effort will be made to present the *technicalia* as cleanly as possible. Students with non-technical backgrounds have succeeded in this course in the past, although it takes work. That said, if you are math-o-phobic, this is not the course for you.

Reading — The bulk of the reading will come from articles in journals and books. These are found at

- Jstor.org, reserves.ucsd.edu, and other online sources.

The web addresses are indicated on the syllabus. I have ordered one inexpensive book for the course:

- Geroch, General Relativity from A to B. This book is accessible to absolutely everyone, but it is still quite sophisticated. It is written by one of the foremost authorities on general relativity in the world today.

We will also use:

- John Norton's *Einstein for Everyone*, http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/index.html

mostly for background. If you're nervous going without a general guide for the whole course, then I suggest purchasing Dainton's Time and Space. It covers many of the topics we will. Also, I recommend supplemental reading at times (dubbed "extra" on the syllabus). Doing this occasionally will more than repay the effort.

Attendance

I guarantee that every single lecture will contain material not found in the reading—indeed, typically a lot of material not in the reading. Anything short of regular attendance will severely damage your grade.

Grades

The grade will be determined by an in-class midterm examination (30%), final examination (30%) and other assignments (40%) consisting of homeworks, small essays, and participation/ attendance. Homework will be assigned in class on a more or less random schedule depending on where we are in the material. Attendance will be taken.

Fine Print

In your essays, homework, and so on, all sources, including discussions with classmates, must be appropriately acknowledged. All answers given must be in your own wording. Closely paraphrasing or simply copying the work of others (such as authors of books or articles, or classmates, or Wikipedia) is not allowed and will be severely penalized. You must ask me in case you are uncertain whether something constitutes plagiarism. Plagiarism, the stealing of an idea or actual text, and other forms of academic dishonesty will be immediately reported to the Academic Integrity Office. Students agree that by taking this course all required papers will be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site. You should read the University's Policy on Integrity of Scholarship at www.senate.ucsd.edu/manual/appendices/app2.htm. Make-up exams (for midterm and final) will only be given under the most dire circumstances. The student who wishes to write a make-up exam must inform me (by phone or email) ahead of the time. In order to qualify for a make-up exam, appropriate evidence of the most severe circumstances must be produced by the student. I will determine, in consultation with the student, what qualifies as appropriate evidence. Finally, texting, emailing, etc., during lecture is not allowed.

Classical Space and Time

9/24 **Coordinates, Manifolds and Metrics: The Building Blocks**

GRAB, 3-10
Extra: Norton, "What is a Four-Dimensional Space Like?"

9/29 **Aristotelian & Newtonian Spacetimes**

GRAB, 11-36
Isaac Newton's *Scholium*,
www.anselm.edu/homepage/dbanach/newton.htm

10/1 **The Leibniz-Clarke Debate**

Leibniz's Letters and Clarke's Replies, especially L's 4th letter, C's 4th reply, and L's 5th: www.earlymoderntexts.com/leibclar.html

Extra: http://plato.stanford.edu/entries/newton-stm/

10/6 **Galilean Space, the Debate Continued…**

GRAB, 37-52.

Maudlin, "Buckets of Water and Waves of Space: Why Spacetime is Probably a Substance" *Philosophy of Science* 60, 1993, 183-203. JSTOR Read sections 1-4

Extra: http://plato.stanford.edu/entries/spacetime-theories/

10/8 **Can 'Handedness' Tell Us about Space?**

Kant, "Concerning the Ultimate Foundation of the Differentiation of Regions in Space", in *Kant: Selected Precritical Writings and Correspondence with Beck*, pp. 36-43, edited by Kerford and Walford, books.google.com

Huggett, manuscript

'Hand'-out (sorry)

Special Relativity

10/13 **Special Relativity I**

Norton, Origins
GRAB, 53-112
Norton, Special Relativity

10/15 **Special Relativity II**

GRAB, keep reading!
Norton, Spacetime

Extra: Luminet, "Time, Topology and the Twin Paradox"

10/20 **Does Special Relativity Eliminate the Whoosh of Time?**

Putnam, "Time and Physical Geometry"
Journal of Philosophy **64** (1967): 240-247. JSTOR.

Extra: Savitt, "Being and Becoming in Modern Physics"
http://plato.stanford.edu/entries/spacetime-bebecome/
Extra: Callender, "Shedding Light on Time"
Philosophy of Science 67, 2000, S587-S599

10/22 **Is Simultaneity Conventional?**

"Section 5.11: Malament's Result"
http://www.pitt.edu/~jdnorton/papers/PST-3.pdf

Extra: http://plato.stanford.edu/entries/spacetime-convensimul/

10/27 **Is Time Uniform?**

Poincaré, "The Measure of Time"
http://en.wikisource.org/wiki/The_Measure_of_Time (hit 'pdf version' on left)

10/29 **What Does *E=mc*^{2} *Really* Mean?**

Norton, *E=mc*^{2}
Lange, "The Most Famous Equation"
http://www.jstor.org/pss/2678382

11/3 **Midterm!**

General Relativity

11/5 **Curved Spaces**

Norton, Non-Euclidean Geometry
Norton, Spaces of Variable Curvature

11/10 **General Relativity**

Geroch, GRAB, 159-185
Background: Norton, General Relativity

Extra: John Baez's GR Tutorial:
http://math.ucr.edu/home/baez/gr/gr.html
Advanced Extra: David Malament's notes:
www.lps.uci.edu/malament/FndsofGR/GR.pdf

11/12 **Is It *All* Conventional?**

Christopher Ray, ""A Conventional World?" in *Time, Space and Philosophy. Reserves.ucsd.edu*

Could Space Be Topologically Dodecahedral?

"A Cosmic Hall of Mirrors" *Physics World* 2005
physicsworld.com/cws/article/print/23009

11/17 **Quine, Duhem, and Underdetermination**

Psillos, "Underdetermination Thesis, Quine-Duhem Thesis" *Encyclopedia of Philosophy*,
phs.uoa.gr/~psillos/Publications_files/Underdetermination.pdf

11/19 **Relationism versus Substantivalism: the Final Battle?**

Maudlin, "Buckets of Water and Waves of Space: Why Spacetime is Probably a Substance" *Philosophy of Science* 60, 1993, 183-203. JSTOR. Sections 5 and 6.

Weingard, "On the Ontological Status of the Metric in General Relativity *The Journal of Philosophy*, Vol. 72, No. 14, (Aug. 14, 1975), pp. 426-431. JSTOR.

11/24 **Is Time Travel Possible?**

Weingard, R. "General Relativity and the Conceivability of Time Travel" *Philosophy of Science* 46 (2):328-332. JSTOR

12/1 **Is Time Travel Possible?**

Arntzenius, F. "Time Travel: Double Your Fun" *Philosophical Compass*, 2006. E-library.

12/3 **The Disappearance of Time?**

Gödel, "A remark on the relationship between relativity theory and idealistic philosophy", *Albert Einstein: Philosopher-Scientist* (Library of Living Philosophers), P. Schilpp (ed.), La Salle, IL: Open Court, 1949, pp. 555–562. Reserves.ucsd.edu

Callender, manuscript

Extra: Rindler, "Gödel, Einstein, Mach, Gamow, and Lanczos: Gödel's Remarkable Excursion into Cosmology" *American Journal of Physics* 77, 498–510, June 2009. http://scitation.aip.org.

12/7 **Final Exam**
Monday, 3-6, location tba

More? The following are some useful books/chapters in philosophy of spacetime physics.

Introducing Time by Craig Callender, Totem, 3rd ed, 2005.
This is a silly little book, but it might help if you're in trouble.
Time and Space by Barry Dainton, 2001.
Nice readable book that you may wish to purchase.
Foundations of Spacetime Physics by Michael Friedman.
Advanced, but excellent in all ways.
World Enough and Spacetime, John Earman.
Best advanced source on substantivalism issue
Bangs, Whimpers,Crunches and Shrieks, John Earman.
Advanced and excellent; e-copy in library
Space, Time, and Spacetime, Larry Sklar.
Medium-advanced, just about the right level for this course
Space From Zeno to Einstein, Nick Huggett.
Classic readings with insightful and readable commentary.
Blackwell Guide to the Philosophy of Science,
Ch. 9 on spacetime by Craig Callender and Carl Hoefer.