Philosophical Foundations of Physics 146

Nature of Space and Time

Fall 2015, TuTh 12:30
Center Hall 217A

Prof Craig Callender

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 the history of science and philosophy, e.g., Descartes, Galileo, Newton, Leibniz, Kant, Reichenbach, Einstein, Gödel. We'll focus on many deep questions, including the following: Are space and time (or spacetime) genuine substances? Does time "flow"? Does relativity prove that it doesn't? What is the "shape" of space? Is physical geometry conventional in some sense? Is time travel possible or paradoxical? Tackling these questions will help one better understand both the physics of spacetime and the philosophy of science.

There is no prerequisite for the course. A tolerance for math is important, however, as we'll dive into relativistic physics. Every effort will be made to present the physics as cleanly and accessibly as possible. Students without technical backgrounds can and do thrive in this course, so long as math anxiety is left behind.

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Instructor

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Final Exam

12/11/2015, Friday, 11:30-2:29

Reading

Geroch's *General Relativity from A to B*
Sklar's Space, Time and Spacetime
Free journal articles

Attendance

I guarantee that every single lecture will contain material not found in the reading—indeed, typically there will be a lot of such material. Given all the quizzes, anything short of regular attendance will severely damage your grade.

Grade

8 short assignments/quizzes (8x5=40%), participation (5%), a midterm (25%) and a final examination (30%).

Fine Print

In your assignments, 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. 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, quizzes and homework may 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. The University's Policy on Integrity of Scholarship at www.senate.ucsd.edu/manual/appendices/app2.htm. Students who wish to take a make-up exam or hand in material late must inform me (by phone or email) well ahead of 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, facebook, etc., during lecture is not allowed. For the most up-to-date schedule of readings, go to: philosophyfaculty.ucsd.edu/faculty/ccallender/

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Ancient and Classical Spacetimes. After warming up with Zeno's famous paradoxes of motion, students will be introduced to the necessary mathematical and physical concepts (especially the distinctions among topological, affine, and metrical transformations). We'll focus on how physics determines spatiotemporal structure, in particular, how properties of Aristotelian and Newtonian dynamics demand particular types of spatiotemporal structure. We'll then tackle two big philosophical topics, (a) Leibniz versus Clarke on whether space is a substance, and (b) Kant on handedness and space.

Class 1	Zeno's Paradoxes, Huggett, "Zeno's Paradoxes"
Class 2	Metrics, Topology, and All That Geroch, 3-36
Class 3	Newtonian Physics, Newtonian Spacetime, Galilean Spacetime Newton, *The Principia*, Scholium Geroch, 37-52
Class 4	Leibniz versus Newton I The Leibniz-Clarke Correspondence, selections Sklar, 161-206 (for this class and next)
Class 5	Leibniz versus Newton II The Leibniz-Clarke Correspondence, selections
Class 6	Kant, Hands, Space Kant, "Concerning the ultimate ground of the differentiation of directions in space" Sklar, "Incongruous Counterparts, Intrinsic Features, and the Substantiviality of Space"

Minkowski Spacetimes. In 1905 Einstein discovered the special theory of relativity. His supervisor, Minkowski, later developed the spacetime appropriate to this physics, Minkowski spacetime. After learning this theory, focusing especially on its basic assumptions and puzzles, e.g., the "twin paradox," we'll briefly revisit the Leibniz-Clarke debate and then turn to the question of whether time flows.

Class 7	Special Relativity Einstein, "The Problem of Space, Ether and the Field in Physics" Geroch, 53-112, Sklar 56-62
Class 8	Special Relativity, Clocks, Barns, Twins, and All That Geroch, 53-112, Sklar, 56-62, 206-210
Class 9	The Philosophy of Time Callender, "The Problem of Time" Putnam, "Time and Physical Geometry" Is Time Real?
Class 10	Does Time Flow? Zimmerman, "The Privileged Present" Hartle, "The Physics of Now"
Class 11	MIDTERM

General Relativistic Spacetimes. Between 1912-1917 Einstein developed a theory that handles gravitational phenomena as well as electromagnetic phenomena. Crucially, gravitational "forces" are understood to be aspects of spatiotemporal curvature. Unlike special relativity, this theory is technically challenging — but we can obtain a great understanding of the causal structure of general relativistic spacetimes via Geroch even if leave the fancy differential geometry to another course. The rich variety of possible spacetimes permitted by GR raises many deep philosophical questions, new and old.

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Class 12 Gaussian Curvature and Non-Euclidean Geometry
Sklar, 13-46

Class 13 General Relativity
Geroch, 159-185, Sklar, 65-78

Class 14 Black Holes
Geroch, chapter 8

Class 15 The Epistemology of Geometry
Sklar, 79-103
(Ray, "A Conventional World?")

Class 16 The "Shape" of Space and the "Uniformity" of Time
Sklar, 109-112, 297-317
Magnus, "Reckoning the Shape of Everything"
(Luminet, "A Cosmic Hall of Mirrors")

Class 17 Time Travel: Conceptual Issues
Lewis, "The Paradoxes of Time Travel"

Class 18 Time Travel: Gödel Spacetime and Time
Gödel, "A Remark About the Relationship between Relativity Theory and Idealistic Philosophy"

Class 19 Leibniz versus Newton: The Final Round?
Callender & Hoefer, "Philosophy of Spacetime Physics"
Sklar,210-224

Class 20 Review for Final