Introduction to Philosophy of Physics

Christian Wüthrich Spring 2018

Class schedule:	Room 402, main building
Website:	`http://wuthrich.net/teaching/_2018USI_PhilPhys.html`
Contact:	`christian.wuthrich@unige.ch`, office hours by appointment only

This course offers an introduction to the philosophy of physics, which deals with methodological, epistemological, and metaphysical issues in physics. It consists of four parts offering a rich menu in philosophically deep questions arising in modern physics: space, time, quantum mechanics, and advanced topics of contemporary physics.

The first part on space treats Zeno's paradoxes of motion, and questions concerning the topology, dimensions, and geometry of space, as well as the nature of space itself. The second part on time deals with traditional questions in the philosophy of time and with time travel. It also introduces spacetime, and its nature according to special and general relativity. The third part focuses on the vexing issues arising in quantum mechanics, such as the measurement problem and quantum non-locality, and includes a discussion of determinism and indeterminism in modern physics. The fourth—shorter—part addresses the more advanced topics of fine-tuning and anthropic reasoning in cosmology as well as of the disappearance of space and time in quantum gravity.

Accessibility and Prerequisites. I intend the course to be self-contained. While some background in physics, mathematics, and philosophy will be helpful, I will not assume any specific knowledge beyond high school mathematics. In the part on quantum mechanics, we will go through some of the technicalities necessary to understand foundational questions. In particular, I will assume you can follow the formalism developed in chapter 2 of David Albert's textbook, which covers some very basic linear algebra, most of which is really not that hard.

Required texts

- Nick Huggett. *Everywhere and Everywhen: Adventures in Physics and Philosophy.* Oxford University Press (2010).
- David Z Albert. *Quantum Mechanics and Experience.* Harvard University Press (1992).
- Most readings are available at icorsi at `https://www.icorsi.ch/course/view.php?id=6570#section-0`.

Course requirements and evaluation

The grade for this course will be determined by the total points a student earns from the three types of evaluation indicated below.

1. *Homework* (30 points): There will be **six homework assignments** due at the beginning of each meeting block (except for the first), each worth 5 points.

2. *Short class presentation* (20 points): Each participant is expected to give at least one **class presentation** of 15 minutes, introducing a particular problem or argument. It is expected that the presenters will use some visuals (powerpoint, handout, blackboard) to aid their presentation. I will offer topics for presentations below.

3. *Final exam* (50 points): There will be a **final exam**, consisting of short identifications, one-paragraph-answer questions testing your comprehension of important arguments, as well as a question asking for an essay-length answer for which you must synthesize material. The final exam is cumulative, covering all the material of the course.

Tentative schedule

Readings: for each session, the listed readings must be read in advance; the readings with an asterisk are background reading which will not be examined in the final exam.

1 Organization and introduction: what is philosophy of physics?

Monday, 26 February 2018, 13:30-15:00, 15:45-17:15

Readings:

- Huggett, Ch. 1

2 Space: Zeno's paradoxes and supertasks

Tuesday, 27 February 2018, 9:30-11:00, 11:30-13:00

Readings:

- Huggett, Ch. 2 and 3

3 Space: topology and dimensions

Thursday, 22 March 2018, 13:30-15:00, 15:45-17:15

Readings:

- Huggett, Ch. 4, 5, and 6
- *George Ellis. The shape of the universe. *Nature* **425** (2003): 566-567.
- *G J Whitrow. Why physical space has three dimensions. *British Journal for the Philosophy of Science* **6** (1955): 13-31.
- *Stephen Hawking. *A Brief History of Time*. Bantam (1988), Ch. 10.

Presentation topics:

- Argument for a Poincaré dodecahedron universe
- How to determine the dimension of a space
- Whitrow's or Hawking's explanation of why space has three dimensions

4 Space: geometry and its nature

Friday, 23 March 2018, 8:30-10:00, 10:45-12:15 (note the earlier time)

Readings:

- Huggett, Ch. 7, 8, and 9 (and *Ch. 16 for Kant's argument)
- *Roger Penrose. *The Road to Reality.* Vintage Books (2007), §§2.6-2.7, pp. 42-49.

Presentation topics:

- Poincaré's three-dimensional ball
- Kant's handedness argument for the substantiality of space

5 Time: introducing time

Monday, 26 March 2018, 13:30-15:00, 15:45-17:15

Readings:

- Huggett, Ch. 10 and 11

Presentation topics:

- Presentism: definition and arguments for it
- McTaggart's argument

6 Time: time travel

Tuesday, 27 March 2018, 9:30-11:00, 11:30-13:00

Readings:

- Huggett, Ch. 12 and 13
- *Michael Dummett. Bringing about the past. *Philosophical Review* **73** (1964): 338-359.
- *David Lewis. The paradoxes of time travel. *American Philosophical Quarterly* **13** (1976): 145-152.
- *Frank Arntzenius and Tim Maudlin. Time travel and modern physics. *Royal Institute of Philosophy Supplement* **50** (2002): 169-200.

Presentation topics:

- The bilking argument against the possibility of time travel
- Lewis's argument for the possibility of time travel
- Consistency constraints and fixed-point theorems

7 Time: spacetime and relativity

Monday, 9 April 2018, 13:30-15:00, 15:45-17:15

Readings:

- Huggett, Ch. 14
- Michel Janssen. Appendix: special relativity. In Michel Janssen and Christoph Lehner (eds.), *The Cambridge Companion to Einstein*. Cambridge (2014), pp. 455-506 (excerpts).

Presentation topics:

- The relativity of simultaneity
- Twin paradox

8 Time: general relativity

Tuesday, 10 April 2018, 9:30-11:00, 11:30-13:00

Readings:

- Tim Maudlin. *Philosophy of Physics. Space and Time.* Princeton University Press (2012), Ch. 6 (pp. 126-152).

Presentation topics:

- The hole argument

9 Quantum mechanics: introduction

Monday, 23 April 2018, 13:30-15:00, 15:45-17:15

Readings:

- Albert, Ch. 1 and pp. 17-38 of Ch. 2

Presentation topics:

- The principles of quantum mechanics

10 Quantum mechanics: measurement problem

Tuesday, 24 April 2018, 9:30-11:00, 11:30-13:00

Readings:

- Albert, Ch. 4
- *Tim Maudlin. Three measurement problems. *Topoi* **14** (1995): 7-15.

Presentation topics:

- Two-path experiments
- Collapse theories
- Bohmian mechanics
- Everettian or many-worlds interpretations

11 Quantum mechanics: non-locality

Monday, 7 May 2018, 13:30-15:00, 15:45-17:15

Readings:

- Albert, Ch. 3
- N David Mermin. Is the moon there when nobody looks? Reality and the quantum theory. *Physics Today*, April 1985, pp. 38-47.
- *Tim Maudlin. *Quantum Non-Locality and Relativity.* Blackwell Publishing (^{2}2002), Appendix to Ch. 1, pp. 24-27 ('The GHZ scheme').

Presentation topics:

- The Greenberger-Horne-Zeilinger scheme

12 Quantum mechanics: determinism and indeterminism

Tuesday, 8 May 2018, 9:30-11:00, 11:30-13:00

Readings:

- Carl Hoefer. Causal determinism. In Ed Zalta (ed.), *The Stanford Encyclopedia of Philosophy.* `https://plato.stanford.edu/entries/determinism-causal/`. §§1-5.
- *Christian Wüthrich. Can the world be shown to be indeterministic after all?. In Claus Beisbart and Stephan Hartmann (eds.), *Probabilities in Physics*, Oxford University Press (2011), 365-389.

Presentation topics:

- (In)determinism in classical physics: space invaders
- (In)determinism in classical physics: Norton's dome
- (In)determinism in quantum mechanics
- The Free Will Theorem

13 Cosmology, fine-tuning, and anthropic reasoning

Monday, 28 May 2018, 13:30-15:00, 15:45-17:15

Readings:

- Simon Friederich. Fine-tuning. In Ed Zalta (ed.), *The Stanford Encyclopedia of Philosophy.* `https://plato.stanford.edu/entries/fine-tuning/` (2017).
- *Ian Hacking. The inverse gambler's fallacy: the argument from design. The anthropic principle applied to Wheeler Universes. *Mind* **96** (1987): 331-340.

Presentation topics:

- The strong and weak anthropic principles
- The inverse gambler's fallacy charge

14 The disappearance of spacetime in quantum gravity

Tuesday, 29 May 2018, 9:30-11:00, 11:30-13:00

Readings:

- Nick Huggett and Christian Wüthrich. Emergent spacetime and empirical (in)coherence. *Studies in History and Philosophy of Modern Physics* **44** (2013): 276-285.

Presentation topics:

- The charge of empirical incoherence
- Lewis on the meaning of theoretical terms