

Seminar: Philosophy of Black Holes

Christian Wüthrich and Saakshi Dulani

Spring 2023

Class schedule: Thursdays 16-18h, Salle PHIL 002
Website: https://wuthrich.net/teaching/_MA6_PhilPhys_2023.html
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Objectives

The philosophy of physics deals with methodological, epistemological, and metaphysical issues in physics. This seminar has the dual purpose of systematically introducing the background necessary to do research in philosophy of physics as well as discussing current research in the field.

Description

This seminar is co-taught by Christian Wüthrich and Saakshi Dulani and will be conducted entirely in English. While some background in physics, mathematics, and philosophy will be helpful, all necessary concepts will be introduced throughout the course, and we will not assume any specific knowledge beyond high school mathematics.

For the spring semester 2023, the focus is on the philosophy of black holes. Black holes are some of the most intriguing objects in physics and astronomy, the study of which has revolutionized our understanding of the universe and shaped the development of quantum gravity theories. In this seminar, we will investigate how a deeper understanding of black holes can bear on questions in metaphysics concerning the nature of space and time, causality, and more, as well as questions in philosophy of science concerning the application of thermodynamics and the role of guiding principles. We will also examine the philosophical dialectic surrounding the infamous black hole information loss paradox. (The exact list of topics will depend on pacing and interest.)

Course requirements and evaluation

Books

- Janna Levin, *Black Hole Survival Guide* (2020)
- Leonard Susskind, *The Black Hole War* (2008)
- Kip Thorne, *Black Holes & Time Warps* (1994)

Preparation includes both required and optional readings. Due to the specialized focus of this seminar, the required readings per session combine a chapter about black holes written by a physicist for general audiences and a philosophy article on the topic of the week. Students have the opportunity to flex their analytical skills to make interesting and insightful connections between the two genres of literature. Additionally, the optional readings are an important resource for presentations, term papers, and further interest. There are two categories of optional readings. The first category, denoted by an asterick (*) in the schedule below, indicates that the reading provides further clarification on that week's topic without technical details. The second category, denoted by a dagger symbol (†), indicates that the reading provides a more detailed, technical treatment of that week's topic. It usually builds upon or represents an opposing view to the assigned philosophy article.

Our expectation is that everyone prepares the assigned readings ahead of time, actively participates in the seminar, and accepts a reasonable share of presentation duties. Please contact us if you need credit in physics or another program. For credit in philosophy:

1. *MA6*: written research work with defense (approx. 25 pages, 50,000 characters)
2. *MA8 (half-module)*: written research work (approx. 12 pages, 24,000 characters) or oral presentation during the seminar

Seminar presentations

We expect everyone to present on the required readings for (at least) one session, although the inclusion of optional readings is also welcome. When it is your turn, please keep the following points in mind:

- While you will be the leader for the seminar on this day, including the discussion, the initial presentation should last (if given without interruption) no more than 45 minutes.
- It is important to stick to the main thesis, argument, and ideas of the author(s), rather than giving a complete or chronological list of points raised in the reading(s).
- We encourage you to use some visual complement (whiteboard, powerpoint slides, handout), and to see this seminar as an opportunity to get some experience with this.
- Make sure to read the article sufficiently ahead of time, so that we have time to make an appointment if you want to meet and discuss it before your presentation.
- Do not stress out if there is something in the article you do not understand after having made an effort to grasp it. In this case, try to articulate precisely what it is that you don't understand—and it may well become the topic of our seminar discussion.

Schedule

All of the readings will be made available on Moodle: <https://moodle.unige.ch/course/view.php?id=14538>. For each session, the listed readings must be read in advance; readings with an asterick (*) or dagger (†) are optional.

Feb. 23: Cosmic Voyage

Course Overview and Introduction

Kip Thorne (1994), “Prologue”

Mar. 2: Introduction to Black Holes in General Relativity

Lecture

- Janna Levin (2020), “Chapter 2: Space” and “Chapter 3: Horizons”
- Kip Thorne (1994), “Chapter 2: The Warping of Space and Time”
- †Sean Carroll (2022), “Chapter 8: Gravity” and “Chapter 9: Black Holes”

Mar. 9: Observing Black Holes and Insights from Quantum Gravity

Guest Lecture – Claus Kiefer

- Eckart et al (2017), “The Milky Way’s Supermassive Black Hole: How good a case is it?” (Sections 1, 2, 5, 8)
- †Claus Kiefer (2020), “Aspects of Quantum Black Holes”

Mar. 16: Introduction to Black Hole Evaporation and Information Loss

Guest Lecture – Erik Curiel

- Erik Curiel (2019), “The many definitions of a black hole”
- *Kip Thorne (1994), “Chapter 12: Black Holes Evaporate” (pp. 422-27, 435-48)
- *Leonard Susskind (2008), “Chapter 10: How Stephen Lost His Bits”
- *Sabine Hossenfelder (2020), “The Black Hole information loss problem is unsolved.”
<http://backreaction.blogspot.com/2020/11/the-black-hole-information-loss-problem.html>

Mar. 23: No Hair and Super-Substantivalism

- Janna Levin (2020), “Chapter 4: Nothing”
- Dennis Lehmkuhl (2015), “The Metaphysics of Super-Substantivalism”
- *Janna Levin (2020), “Chapter 7: Perfection”
- †Patrick Duerr and Claudio Calosi (2021), “The general-relativistic case for super-substantivalism”

Mar. 30: Horizons and Eternalism

- Janna Levin (2020), “Chapter 5: Horizons”
- Sam Baron and Baptiste Le Bihan (forthcoming), “Trouble on the Horizon for Presentism”
- *Kip Thorne (1994), “Chapter 12: Black Holes Evaporate” (pp. 412-19)
- †Geurt Sengers (2017), “Presentism and black holes”

Apr. 6: Wormholes and Time Travel

- Kip Thorne (1994), “Chapter 14: Wormholes and Time Machines” (pp. 483-507, p. 521)
- Chris Smeenk and Christian Wüthrich (2011), “Time Travel and Time Machines” (Sections 1, 3, 5)
- †Juliusz Doboszewski (2022), “Rotating black holes as time machines”
- †Kristie Miller (2017), “Is Some Backwards Time Travel Inexplicable?”

Apr. 13: No Class (Easter Break)

Apr. 20: Status of Singularities

- Janna Levin (2020), “Chapter 6: TARDIS”
- John Earman (1996), “Tolerance for Spacetime Singularities”
- *Craig Callender and Carl Hoefer (2002), “Philosophy of Space-Time Physics” (pp. 185-89)
- †Vincent Lam (2007), “The Singular Nature of Spacetime”

Apr. 27: Guiding Principles and Singularity Resolution

- Karen Crowther and Sebastian de Haro (2021), “Four Attitudes Towards Singularities in the Search for a Theory of Quantum Gravity” (skip Section 3 on QFT)
- †Karen Crowther (2018), “Defining a crisis: the roles of principles in the search for a theory of quantum gravity”

May 4: Black Holes and Information

- Leonard Susskind (2008), “Chapter 8: Wheeler’s Boys”
- Christian Wüthrich (2019), “Are black holes about information?”
- *Leonard Susskind (2008), “Chapter 7: Energy and Entropy”
- †Rawad El Skaf and Patricia Palacios (2022), “What Can we Learn (and not Learn) from Thought Experiments in Black Hole Thermodynamics?” (Sections 3, 4.1, 4.2)

May 11: Black Hole Complementarity

- Leonard Susskind (2008), “Chapter 15: The Battle of Santa Barbara”
- Heather Demarest (Under Review), “It Matters How You Slice It: Causal Processes Depend on Frames of Reference”
- †Peter Bokulich (2005), “Does Black Hole Complementarity Answer Hawking’s Information Loss?”

May 18: No Class (Ascension Day)

May 25: Black Holes and Baby Universes

Lausanne-Geneva Workshop at UNIL – Saakshi Dulani and Baptiste Le Bihan

- Saakshi Dulani and Baptiste Le Bihan (Draft), “The Phantom Menace: Why Black Hole Information Loss is Truly Paradoxical” (Sections TBD)

References

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- [4] Sean M. Carroll. *The biggest ideas in the universe: Space, time, and motion*. Dutton, New York, New York, 2022.
- [5] Karen Crowther. Defining a crisis: the roles of principles in the search for a theory of quantum gravity. *Synthese*, 198:3489–3516, 2021.

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- [9] Juliusz Doboszewski. Rotating black holes as time machines: An interim report. In Antonio Vassallo, editor, *The Foundations of Spacetime Physics*, chapter 5. Routledge, New York, 2022.
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- [12] Andreas Eckart, Andreas Hüttemann, Claus Kiefer, Silke Britzen, Michal Zajaček, Claus Lämmerzahl, Manfred Stöckler, Monica Valencia-S, Vladimir Karas, and Macarena García-Marín. The milky way’s supermassive black hole: How good a case is it?: A challenge for astrophysics and philosophy of science. *Foundations of physics*, 47(5):553–624, 2017.
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- [15] Claus Kiefer. Aspects of quantum black holes. *Journal of Physics*, 1612(1):012017, 2020.
- [16] Vincent Lam. The singular nature of spacetime. *Philosophy of science*, 74(5):712–723, 2007.
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- [20] Geurt Sengers. Presentism and black holes. *European journal for philosophy of science*, 7(1):1–15, 2017.
- [21] Chris Smeenk and Christian Wuthrich. Time travel and time machines. In Craig Callender, editor, *The Oxford Handbook of Philosophy of Time*, pages 577–630. Oxford University Press, 2011.
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