

History of Science 326

History of Physics: The Modern Period

Spring 2008

2:30-3:45 p.m. TR, 6102 Social Sciences

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Office Hours: 11 TW

At the dawn of the twentieth century physicists won a new world view from the measurement of space and time and new theories of matter; by mid century they had delivered a weapon that shadowed an era; and at century's end cosmologists sought ways to describe the first seconds of evolution on the basis of astronomical observations. This course will explore the span of physics from the laboratory bench to the congressional lobbyist, and by setting the discipline in social context will investigate the changing relations between modern science and modern culture. In addition to tracing the unfolding philosophical and technological implications of physics, we will examine the nature of its debts to industry, military concerns and government, and explore the perspective that anthropologists and sociologists have offered on its practices. We chart the rise of the physics discipline from the opening of microphysics in the 1890s to its status as the pattern for big science (and beyond?) at the present. Our aim is to understand how the dynamic interplay between theory and experiment; the tensions between national and international interests; and the stresses and opportunities of hot and cold wars have all changed the nature of our knowledge of the physical world.

Book List (University Bookstore and Underground Textbook Exchange)

Helge Kragh, *Quantum Generations: A History of Physics in the Twentieth Century* (Princeton: Princeton University Press, 1999). Required.

Course Reader: Available for \$35 from the History of Science Department Office, 7143 Social Science. Note that the office is open from 8-3 M-R (with extended hours in the first two weeks of semester), and there are no refunds on the reader. Required.

Both the book and reader are also available on reserve at the College Library.

Assessment

Assessment is through three take-home essay exams written on selected topics (75% of the total grade), and discussion participation (25%). The participation grade will test your comprehension of both lectures and readings (see Discussion Pieces, below).

First Take-Home Exam (20%): Distributed February 21; due February 28.

Second Take-Home Exam (25%): Distributed April 1; due April 8.

Final Take-Home Exam (30%): Distributed May 1; due Monday, May 12.

Honors Assessment

Honors students will submit in addition a paper – and may give a presentation to the class as a whole – on a topic of their own choice. This to be completed by May 1 and is worth 20% of the overall grade.

Discussion Pieces

As part of your discussion participation grade (which is worth 25% of the final grade), in the course of the semester I would like you to post 6 short discussion pieces of 1-2 paragraphs in length to the class discussion forum on the course website (on Learn@UW).

You are to post two discussion pieces in each five-week segment of the course, between the dates of February 21; April 1; and May 8.

The discussion piece is to be posted by 8 PM on Monday or Wednesday in the relevant week, so that we can incorporate the questions and topics you raise in class discussion the following day.

Content

The discussion piece should be a forum for discussing the content and the significance of particular readings and ideas raised in class. It could involve analysis of one or more of the assigned readings; discussion of a topic raised in lectures or discussion; or a mixture of both. Write about something you find interesting, describing the argument an author has presented and evaluating the evidence they have offered. Do you agree with their point of view? Support your own opinions with concrete examples from the course materials.

You will also have the opportunity to respond appropriately to discussion pieces from others, but the two pieces required in each five-week segment should open up substantive questions rather than simply comment on someone else's posting.

The task will help focus our class discussions and will also provide helpful practice in writing.

Participation and Performance

If you have a conflict between an academic requirement and any religious observance, please notify me of the specific dates concerned within the first two weeks of the course and I will find an alternative means for you to fulfill the requirement. Such requests are confidential.

In compliance with the Americans with Disabilities Act, I will make every effort to honor requests for reasonable accommodations made by individuals with disabilities. (If you think you qualify for accommodation, please contact the McBurney Disability Resource Center [263-2741; <http://www.mcburney.wisc.edu/>] to establish your eligibility for services.) Requests for accommodation can be responded to more effectively if I receive them as far in advance as possible, preferably at the beginning of the semester. Such requests are confidential.

If any problems arise, either academic or personal, that might jeopardize your performance in the course, you must try to inform me of the problem at the next available office hour, or by leaving a message with the Department of the History of Science (262-1406).

Syllabus

Apart from references to **Kragh's** *Quantum Generations*, all material is in the Course Reader. The readings listed are core material and ideally should be read before the relevant lecture.

Part I: Experiment and Theory circa 1900: The Rise of Microphysics

Jan. 22 Introduction: The Inaugural International Congress of Physics

Jan. 24 Physics circa 1900

Kragh, chaps. 1 and 2.

Discussion: Introductions

Jan. 29 The Experimental Discoveries

Kragh, chap. 3

Theodore Arabatzis, "The Birth and Infancy of the Representation of the Electron," in *Representing Electrons: A Biographical Approach to Theoretical Entities* (Chicago: Univ. of Chicago Press, 2006), pp. 70-111.

Jan. 31 Black-Body Radiation and Planck's Theory

Kragh, chap. 5.

J.L. Heilbron, *The Dilemmas of an Upright Man: Max Planck as Spokesman for German Physics* (Berkeley: University of California Press, 1986), pp. 1-28.

Discussion: The Rise of Microphysics

Feb. 5 Einstein's Quantum Theory

Thomas S. Kuhn, "Afterword: Revisiting Planck," in *Black Body Theory and the Quantum Discontinuity 1894-1912* (Chicago and London: University of Chicago Press, 1987 [1978]), pp. 349-370.

Martin J. Klein, "Einstein and the Development of Quantum Physics," in *Einstein: A Centenary Volume*, ed. A.P. French, (Cambridge, MA: Harvard University Press, 1979), pp. 133-151.

Feb. 7 Einstein, the Cultures of Time and Space, and the Foundations of Physics circa 1905

Kragh, pp. 87-93 and chap. 8.

Peter Galison, "Einstein's Clocks: The Place of Time," *Critical Inquiry* 26 (2000), 355-389.

Discussion: Quantum Theory and Knowledge Paradigms

Feb. 12 Relativity in the German Physics Community

Selections from Albert Einstein, "On the Relativity Principle and the Conclusions Drawn From It," *Jahrbuch der Radioaktivität und Elektronik* 4 (1907): 411-462, in *The Collected Papers of*

Albert Einstein: Vol. 2. *The Swiss Years: Writings, 1900-1909*, transl. by Anna Beck, (Princeton: Princeton Univ. Press, 1989), pp. 252-255 and 301-311.

Richard Staley, "On the Histories of Relativity: The Propagation and Elaboration of Relativity Theory in Participant Histories in Germany, 1905-1911," *Isis* 89 (1998): 263-299.

Feb. 14 From Special to General Relativity

Kragh, pp. 93-104.

John Stachel, "The Genesis of General Relativity," in *Einstein from 'B' to 'Z'* (Boston, Basel and Berlin: Birkhäuser, 2002), pp. 233-244.

Discussion: Einstein's Relativity

Feb. 19 Constructing a Crucial Test: The Eclipse Results

Matthew Stanley, "'An Expedition to Heal the Wounds of War': The 1919 Eclipse and Eddington as Quaker Adventurer," *Isis* 94 (2003): 57-89.

Feb. 21 Atomic Models: Rutherford and the Scattering Paradigm

Kragh, chap. 4.

W. Kay, "Recollections of Rutherford. Being the Personal Reminiscences of Lord Rutherford's Laboratory Assistant Published for the First Time," *Natural Philosopher* 1 (1963), 129-155.

Note: 2nd Discussion Piece Due; First Take-Home Exam Distributed

Discussion: Testing Relativity

Part 2: Quantum Mechanics and Nuclear Physics

Feb. 26 Bohr's Quantum Theory of the Atom

John L. Heilbron, "Bohr's First Theories of the Atom," in A.P. French and P.J. Kennedy, eds. *Niels Bohr: A Centenary Volume* (Cambridge: Harvard University Press, 1985), pp. 33-49.

Feb. 28 Quantum Mechanics and Culture

Kragh, chaps. 10 and 11.

Note: First Take-Home Exam Due

Discussion: Atomic Models

March 4 Quantum Causality

Kragh, chap. 14.

Niels Bohr, "The Bohr-Einstein Dialogue," in French and Kennedy, eds. *Niels Bohr*, pp. 121-40.

N. David Mermin, "Quantum Mysteries for Anyone," *Journal of Philosophy* 78 (1981), 397-408.

Richard Staley, "The Einstein, Podolsky, Rosen Paradox, The Bell Inequality and Quantum Causality: An Overview," HS 326 Course Materials, Spring 2008.

March 6 From Radioactivity to Nuclear Physics

Kragh, chaps. 12 and 13.

Discussion: Quantum Mechanics: Physics and Social Forces, Physics and Philosophy

March 11 The Rise of American Physics

Kragh, chap. 17.

Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America*, 2nd ed. (Cambridge: Harvard University Press, 1987 [1978]), pp. 222-235.

Part 3: Physics and War

March 13 The Discovery of Fission and Physics in Nazi Germany

Kragh, chap. 16.

Selections from Klaus Hentschel, ed. and Ann M. Hentschel, ed. assistant and translator, *Physics and National Socialism: An Anthology of Primary Sources* (Basel, Boston and Berlin: Birkhäuser, 1996), pp. 18-24, 100-109 and 152-161.

Discussion: Nuclear Physics

March 15-23 Spring Recess: No Class

March 25 The “Uranium Club” and the German War Project

Jeremy Bernstein, “Report 4,” in *Hitler’s Uranium Club: The Secret Recordings at Farm Hall* (Woodbury, NY: American Institute of Physics, 1996), pp. 117-160.

March 27 From “The World Set Free” to the Manhattan Project

Kragh, chap. 18.

Lawrence Badash, *Scientists and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty, 1939-1963* (New Jersey: Humanities Press, 1995), pp. 22-47.

Michael B. Stoff, Jonathon F. Fanton and R. Hal Williams, eds. *The Manhattan Project: A Documentary Introduction to the Atomic Age* (Philadelphia: Temple University Press, 1991), pp. 17-59.

Discussion: The “Uranium Club”

April 1 Los Alamos, Trinity, Hiroshima and Nagasaki: Physics and Statesmanship

J. Robert Oppenheimer, “Speech to the Association of Los Alamos Scientists, November 2, 1945,” in Alice Kimball Smith and Charles Weiner, eds. *Robert Oppenheimer: Letters and Recollections* (Cambridge: Harvard University Press, 1980), pp. 315-25.

Badash, *Scientists*, pp. 48-62.

Note: 4th Discussion Piece Due; Second Take-Home Exam Distributed

April 3 The Legacies of War

Kragh, chaps. 19-20.

Discussion: Building Bombs

Part 3: Big Science

April 8 Politics, Particles and Pedagogy and the Cold War Era

Kragh, chaps. 21-22.

David Kaiser, "Nuclear Democracy: Political Engagement, Pedagogical Reform, and Particle Physics in Postwar America," *Isis* 93 (2002), 229-268.

Note: Second Take-Home Exam Due

April 10 Radiosotopes Crossing Borders

Angela N.H. Creager, "Tracing the Politics of Changing Postwar Research Practices: The Export of 'American' Radioisotopes to European Biologists," *Studies in History and Philosophy of the Biological and Biomedical Sciences* 33C (2002): 367-388.

Class visit with Angela Creager

Discussion: Science and Politics, Physics and Biology in the Post-War U.S.

April 15 Comparative Particle Physics and The Anthropology of the Laboratory

Sharon Traweek, "Pilgrim's Progress: Male Tales Told During a Life in Physics," in *Beamtimes and Lifetimes. The World of High Energy Physicists* (Cambridge: Harvard University Press, 1988), pp. 74-105.

April 17 Images of Changing Scale: The Profusion of Particles and Feynman Diagrams

Alvin M. Weinberg, "Impact of Large-Scale Science on the United States," *Science* 134 (1961): 161-164.

Peter Galison, "The Many Faces of Big Science," in Peter Galison and Bruce Hevly, eds. *Big Science: The Growth of Large-Scale Research* (Stanford, CA: Stanford University Press, 1992), pp. 1-17.

Peter Galison, "The Collective Author," in Mario Biagioli, and Peter Galison, eds. *Scientific Authorship: Credit and Intellectual Property in Science* (New York/London: Routledge, 2003), pp. 325-355.

Discussion: Big Science and the Anthropology of the Laboratory

Part 4: (Inter)disciplinary Issues: Physics Beyond the Cold War

April 22 Physics on a Global Scale and Big Projects: Global Warming and the Superconducting Super Collider

P.W. Anderson, "More Is Different," *Science* 177 (1972): 393-396.

Spencer R. Weart, *The Discovery of Global Warming* (Cambridge, MA: Harvard Univ. Press, 2003), pp. 160-201.

Daniel J. Kevles, "Big Science and Big Politics in the United States: Reflections on the Death of the SSC and the Life of the Human Genome Project," *Historical Studies in the Physical and Biological Sciences* 27 (1997), 269-297.

April 24 Cosmology on the Borderlines: General Relativity and Cosmology

Kragh, chap. 23.

David Kaiser, "A Psi is just a Psi? Pedagogy, Practice and the Reconstitution of General Relativity, 1942-1975," *Studies in the History and Philosophy of Modern Physics* 29 (1998), 321-338.

Discussion: Beyond the Cold War: The New Faces of Big Physics

April 29 Astrophysics the Borderlines: The Solar Neutrino Problem

Harry Collins and Trevor Pinch, *The Golem: What You Should Know about Science* (Cambridge: Canto, 2nd ed. 1998), pp. 121-138.

May 1 The Inflationary Universe: High-Precision Cosmology

Alan H. Guth, "Inflationary Universe," in Norriss S. Hetherington, ed. *Cosmology: Historical, Literary, Philosophical, Religious, and Scientific Perspectives* (New York and London: Garland, 1993), pp. 411-445.

Kragh, chap. 27.

Note: Final Take-Home Exam Distributed

Discussion: Cosmology

May 6 Physicists on the Humanities and History

Kragh, chap. 26.

Collins and Pinch, *The Golem*, pp. 151-180.

Steven Weinberg, "Physics and History," in Jay A. Labinger and Harry Collins, eds. *The One Culture? A Conversation about Science* (Chicago and London: University of Chicago Press, 2001), pp. 116-127.

May 8 Conclusions: Physicists on the Future

Lee Smolin, "The Future of the Nature of the Universe," in John Brockman, ed. *The Next Fifty Years: Science in the First Half of the Twenty-First Century* (New York: Vintage, 2002), pp. 3-17.

Note: 6th Discussion Piece Due

Discussion: Reflections on Physics and History

Monday May 12 Final Examination Due (9:45 A.M.)

Grading Criteria for Essays

- A: For outstanding essays only. The thesis and argument are clear, thought-provoking, and based on correctly understood facts. Material used to support the argument synthesizes ideas from different parts of the course (readings, lectures, discussions from different weeks). The relationships drawn between facts and ideas are sophisticated, subtle, and/or original. The writing is grammatically correct and succinct, and the argument flows well from point to point. Not a word is wasted!
- AB: For very good essays that for some reason fall short of the criteria described above. The argument may be murky at one point; information may be presented that doesn't directly or clearly contribute to the argument; the writing style may be awkward occasionally, or flawed by one or two consistent (if minor) grammatical errors.
- B: The basic good grade. The essay may pursue a straightforward but not particularly deep or sophisticated argument; it is okay as far as it goes, but doesn't penetrate into the material very far. It may have a flash of brilliance that isn't brought to fruition, because it is counterbalanced by a weakness in argumentation, minor grammatical problems, and/or a significant misunderstanding of events or chronology.
- BC: The essay shows some of the basics of the ideal essay, but is weakened by a lack of serious thinking, or by writing problems. It may make superficial connections without offering sufficient evidence to make the connections plausible or persuasive, or it may have what is in principle a good argument supported by incorrect facts or chronology. Alternatively, it may provide a fairly solid argument with minor flaws, from which the reader is continually distracted by awkward or ungrammatical prose.
- C: A grade signifying some serious problem in essay writing. It may deliver facts without a recognizable thesis or argument; it may wander away from the point; or it may be a thoughtful attempt so weakened by writing problems (grammar, punctuation, word choice) that it is difficult for the reader to understand a crucial point you are trying to make.
- D: A marginal grade. There may be enough here to show that you have attended a few lectures and/or done some of the reading, but the essay indicates no attempt at synthesis or thinking on your own, or shows a serious misunderstanding of the nature of the material and/or the assignment. Also used for essays that are just barely coherent.
- F: For unacceptable essays. An essay may be judged unacceptable if it contains plagiarism; if it consists primarily of content inappropriate to the question or the material for this course; if it shows a complete misunderstanding of the course content; or if the writing fails to meet standard college-level requirements of basic communication in English.

Plagiarism is grounds for automatic failure on an assignment. If you use three or more words in a row from another source, the phrase must be placed in quotation marks and footnoted. Otherwise it is plagiarism. For more on what constitutes plagiarism and how to avoid it, consult *A Pocket Style Manual* by Diana Hacker, or the UW-Madison Writing Center website.