

## History of Science 326 History of Physics: The Modern Period Spring 2005

11:00 a.m. MWF, 4308 Social Sciences Building

Instructor: Richard Staley

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Office Hours: 1-3 p.m. W

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. By setting the discipline in social context we 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. Charting 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?) allows us to approach a number of questions. How has the nature of our knowledge of the physical world been changed by the dynamic interplay between theory and experiment, the tensions between national and international interests, and the stresses and opportunities of hot and cold wars?

### **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)

**Course Reader:** Available for \$28.00 from the History of Science Department Office, 7143 Social Science. Note that the office is open from 7:30 a.m. - 3:00 p.m. daily (with extended hours through Wed. January 26), and there are no refunds on the reader.

### **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 18; due February 25.

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

Final Take-Home Exam (30%): Distributed May 6; due Thursday, 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 6 and is worth 20% of the overall grade.

**Discussion Pieces**

As part of your section participation grade (which is worth 25% of the final grade), in the course of the semester I would like you to write 6 short discussion pieces of 1-2 pages (double spaced).

You are to write two in each five week segment of the course, between the dates of February 18; April 1; and May 6.

The discussion piece is to be submitted to me before Friday's discussion class, preferably by Wednesday, so that we can incorporate the questions and topics you raise as appropriate. If you can't give it to me at lecture, please leave a copy in my mailbox by noon on Thursday.

**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 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.

The task will help focus our class discussions on Fridays 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://jumpgate.acadsvcs.wisc.edu/~mcburney/>] 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. 19 Introduction: The Inaugural International Congress of Physics

**Kragh**, chaps. 1 and 2.

#### Jan. 21 Discussion: Introductions

#### Jan. 24 The Discoveries: Cathode Rays, X-rays and Radioactivity

**Kragh**, chap. 3

W.C. Roentgen, "On a New Kind of Rays," *Nature* 53 (23.1.1896), 274-276 and A.A.C. Swinton, "Professor Röntgen's Discovery," *Nature* 53 (23.1.1896), 276-277.

#### Jan. 26 The Discoveries: Electron Physics

J.J. Thomson, excerpt on "Cathode Rays," *Philosophical Magazine* 44 (1897), 293 ff. as cited in W.F. Magie, *A Source Book in Physics* (Cambridge, MA: Harvard University Press, 1963), "The Electron," pp. 583-597.

#### Jan. 28 Discussion: The Rise of Microphysics

#### 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.

#### Feb. 2 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. 4 Discussion: Quantum Theory and Knowledge Paradigms

#### Feb. 7 Einstein's Path to (Special) Relativity

**Kragh**, chaps. 7 and 8.

Albert Einstein, "On the Electrodynamics of Moving Bodies," as translated in Arthur I. Miller, *Albert Einstein's Special Theory of Relativity: Emergence (1905) and Early Interpretation (1905-1911)* (Reading: Addison-Wesley, 1981), pp. 392-415, especially pp. 392-396.

Arthur I. Miller, "The Special Theory of Relativity: Einstein's Response to the Physics of 1905," in Gerald Holton and Yehudah Elkana, eds. *Albert Einstein: Historical and Cultural Perspectives* (Princeton: Princeton University Press, 1982), pp. 3-26.

*Feb. 9 Relativity in the German Physics Community*

Max Planck, "The Place of Modern Physics in the Mechanical View of Nature," in *A Survey of Physical Theory*, transl. by R. Jones and D.H. Williams, (New York: Dover, 1960), pp. 42-70.

*Feb. 11 Discussion: Einstein's Relativity*

*Feb. 14 From Special to General Relativity*

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

*Feb. 16 Constructing a Crucial Test: The Eclipse Results*

John Earman and Clark Glymour, "Relativity and Eclipses: The British Expeditions of 1919 and Their Predecessors," *Historical Studies in the Physical Sciences* 11 (1980), 49-85.

Loren R. Graham, "The Reception of Einstein's Ideas: Two Examples from Contrasting Political Cultures," in Holton and Elkana, eds. *Albert Einstein*, pp. 107-136.

*Feb. 18 Discussion: Testing Relativity*

Note: 2<sup>nd</sup> Discussion Piece Due; First Take-Home Exam Distributed

Part 2: Quantum Mechanics and Nuclear Physics

*Feb. 21 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.

*Feb. 23 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. 25 Discussion: Atomic Models*

Note: First Take-Home Exam Due

*Feb. 28 Quantum Mechanics and Culture*

**Kragh**, chaps. 10 and 11.

*Mar. 2 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.

*Mar. 4 Discussion: Quantum Mechanics: Physics and Social Forces, Physics and Philosophy*

*Mar. 7 Nuclear Physics*

Kragh, chaps. 12 and 13.

Jeff Hughes, “‘Modernists with a Vengeance’: Changing Cultures of Theory in Nuclear Science, 1920-1930,” *Studies in History and Philosophy of Modern Physics* 29 (1998), 339-363.

*Mar. 9 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.

*Mar. 11 Discussion: Nuclear Physics*

**Part 3: Physics and War**

*Mar. 14 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.

*Mar. 16 The “Uranium Club”*

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.

*Mar. 18 Discussion: The “Uranium Club”*

**March 19-27 Spring Recess: No Class**

*Mar. 28 Organized Science: The Manhattan Engineer District*

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.

*Mar. 30 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.

*Apr. 1 Discussion: Building Bombs*

Note: 4<sup>th</sup> Discussion Piece Due; Second Take-Home Exam Distributed

Part 3: Big Science

*Apr. 4 Physics in the Universities and the Legacy of War*

Kragh, chaps. 19-22.

*Apr. 6 Particle Pedagogy and the Cold War*

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

*Apr. 8 Discussion: Post-War Physics in the U.S.*

Note: Second Take-Home Exam Due

*Apr. 11 Landmarks of Changing Scale: Comparative Particle Physics*

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.

Dominique Pestre and John Krige, "Some Thoughts on the Early History of CERN," in *ibid.*, pp. 78-99.

*Apr. 13 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.

*Apr. 15 Discussion: The Anthropology of the Laboratory*

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

*Apr. 18 Global Geophysics*

R.E. Doel, "The Earth Sciences and Geophysics," in John Krige and Dominique Pestre, eds. *Science in the Twentieth Century* (Amsterdam: Harwood Academic, 1997), pp. 391-416.

*Apr. 20 Big Projects: The Superconducting Super Collider & the Human Genome Project*

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.

*Apr. 22 Discussion: Big Physics and Politics*

*Apr. 25 Astrophysics and the Renaissance of General Relativity*

Kragh, chap. 23.

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

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.

*Apr. 27 Inflationary 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.

*Apr. 29 Discussion: Cosmology*

*May 2 Physics and the Humanities*

Kragh, chap. 26.

Bruno Latour, "A Relativistic Account of Einstein's Relativity," *Social Studies of Science* 18 (1988), 3-44.

*May 4 Physicists on History and the Future*

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.

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.

*May 6 Discussion: Reflections on Physics and History*

Note: 6<sup>th</sup> Discussion Piece Due; Final Take-Home Exam Distributed

*Thursday May 12 Final Examination Due (2:45-4:45 P.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.