

The Quantum Moment:
Quantum Mechanics in Philosophy, Culture, and Life

PHI 382

PHY 382

Physics P-112

T 5:20-8:20

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Course Description

This course explores the implications and influence, real and alleged, of quantum mechanics on fields other than physics. For an introduction, see also <http://physicsworld.com/cws/article/print/35621>. Our title was inspired by an exhibition and book, entitled "The Newtonian Moment," that charted a 250-year period during which ripples from Newton's discoveries, especially in mechanics and gravity, radiated out first to a small school of specialists, and then in successively larger circles, eventually penetrating all niches of human life from art to commerce. It is now over 80 years since the inception of quantum mechanics, and more than 100 years since a crucial contribution by Einstein to its foundations, and it seems worthwhile to look at what kinds of ripples have come from a development in some ways much more startling and hard to swallow than Newton's work. What have been the reactions to quantum mechanics in worlds outside the physical sciences? How, if at all, have such reactions reflected back on what hard-core practitioners in this field do – and think about what they do?

Such questions will be at the focus of this course. How has quantum mechanics permeated culture to offer what seem to be significant new perspectives on the human condition? What does it mean, if anything, for philosophy, ethics, biology, and social behavior? We shall explore how quantum mechanics fits, or does not fit, with traditional models of science, and with more recent accounts such as social constructivism. We shall discuss some of the important debates at the founding of quantum mechanics, such as the Einstein-Bohr debate on the possibility of hidden variables, the Bohr-Heisenberg debate on the interpretation of complementarity, and the probabilistic interpretation of quantum mechanics. We shall look into the "double-slit" experiment with single electrons, the "most beautiful experiment in science." We may also discuss such issues as nonlocality, hidden variables, new dimensions of the debate of free will versus determinism, scientific perception and measurement theory. Required and suggested readings include texts that claim to find a connection between quantum mechanics and Faulkner's novels, surrealist paintings, Christian thought, Eastern mysticism, and the theatre of Bertolt Brecht and Richard Foreman. The course will not involve technical mathematics. The introduction to quantum mechanics provided by the instructors will be aimed at non-science students. Besides readings, the course will also involve plays including "Copenhagen," films, and guest speakers.

One purpose of this course is to seek out appearances of quantum mechanics that are recent or unknown to us. Students will be expected to work in groups to lead in-class discussions of literature outside physics -- history, science fiction, philosophy -- that involves references to quantum mechanics. While we shall suggest some examples of such literature, we encourage students to seek out their own. Students will be expected to work on a final project, to be presented in class.

Syllabus

Jan. 26: **Introduction**

The nature of physics and of philosophy, and of the challenges posed by quantum mechanics to each, according to the different perspectives of the instructors.

Feb. 2 **Outline of Characters, Plot, and Dramatic Conflict**

G. Segrè, *Faust in Copenhagen* (entire)

Feb. 9 **The Pre-Quantum Picture**

The physics and philosophy of motion and mechanics in the Aristotelian world, and in the Newtonian world, with special attention to the behavior of light.

I. B. Cohen, *Birth of a New Physics*, 1-184

Holton and Brush, *Introduction to Concepts and Theories*, pp. 31-37, 79-91

Feb. 16: **The Blackbody Crisis and the Quantum Idea**

A crisis arises in understanding black-body radiation. Light's behavior is apparently insoluble in Newtonian terms. Planck proposes the quantum idea, which lies fallow for 5 years, then is nurtured by Einstein. But puzzles lie latent.

D. Lindley, *Uncertainty*, chs. 1-10.

Holton and Brush, *Introduction to Concepts and Theories*, pp. 427-44, 470-90

E. Segrè, *From X-Rays to Quarks* (on reserve), ch. 4, "Planck, Unwilling Revolutionary: The Idea of Quantization"

Feb. 23 **The Development of Quantum Mechanics**

The development of quantum mechanics: Heisenberg and matrices, Schrödinger and waves, Einstein-Bohr debates, uncertainty principle. The puzzles become explicit.

D. Lindley, *Uncertainty*, chs. 11-18

Holton & Brush, *Introduction to Concepts and Theories*, pp. 491-501

E. Segrè, *From X-Rays to Quarks*, ch. 8, "A True Quantum Mechanics At Last"

March 2 **Laser Teaching Center Excursion**

R. Crease, *Prism and Pendulum*, Chs. 6, 10

Feynman, *Lectures on Physics*, excerpts; other readings to be assigned

March 9 **The Copenhagen Interpretation**

N. Bohr, "Discussion w. Einstein on Epistemological Problems in Atomic Physics"

Einstein, Podolsky, and Rosen, "Can Quantum-Mechanical Description of Reality Be Considered Complete?" and reply by Bohr, in Toulmin, *Physical Reality*

G. Holton, "The Roots of Complementarity"

Title and 1-sentence tentative project description due.

Mar. 16 **Copenhagen: The Play**

Discussion of Michael Frayn's play, *Copenhagen*.

M. Frayn, *Copenhagen*

Mar. 23 **Philosophical Implications**

What have philosophers made of complementarity and quantum mechanics? Why has complementarity attracted mystics?

P. Grim, ed., "Quantum Mysticism" section from *Philosophy of Science and the Occult*, 2nd ed.:

P. Grim, "Conflicting Notes from Einstein and Bohr;" F. Capra, "The Unity of All Things;" G. Zukav, "Einstein Doesn't Like It;" R. Crease & C. Mann, "The Yogi and the Quantum;" N. D. Mermin, "Quantum Mysteries for Anyone;" M. Spector, "Mind, Matter and Quantum Mechanics"

M. Beller, "The Sokal Hoax: At Whom Are We Laughing?" *Phys. Today*, S 1998.

P. Anderson, "Thinking Big," *Nature* 29 Sept. 2005, p. 625

Brush, "The Chimerical Cat: Philosophy of Quantum Mechanics in Historical Perspective." *Social Studies of Science* 10: 393-447

One-page description of final project due

Mar. 30:

NO CLASS!!!

SPRING VACATION!!!

Ap. 6: **Quantum Mechanics in the Visual Arts**

Students will divide into groups, each giving a presentation on a book about the impact of science on art. Possibilities include Gavin Parkinson's *Surrealism, Art, and Modern Science* (2008); Elizabeth Leane's *Reading Popular Physics* (2008); Linda Henderson's *The Fourth Dimension and Non-Euclidean Geometry in Modern Art* (1983, repr. 2010); Arthur I. Miller, *Imagery in Scientific Thought*, etc. Or individuals can deliver a presentation on an article. Possibilities include:

J. Haas, "Complementarity and Christian Thought: An Assessment," *Journal of the American Scientific Affiliation* (1983): 145-51, 203-9.

R. Nadeau, *Readings from the New Book on Nature: Physics and Metaphysics in the Modern Novel*.

Virginia Williams, "Surrealism, Quantum Philosophy, and World War I," PhD diss, Duke, 1981.
 S. Ryan, "Faulkner and Quantum Mechanics," *West. Hum. Rev.* 33 (1979), 329-39.
 Honner, "Niels Bohr and the Mysticism of Nature," *Zygon* 17, 243-53.
 Honner, "The Transcendental Philosophy of Niels Bohr, SHPS 13:1-29.
 D. Harrison "What You See is What You Get!" *AJP* 47 (1979): 576-82; "Teaching the Tao of Physics" *AJP* 47 (1979), 779-83.
 R. Schlegel, "Quantum Physics and the Divine Postulate," *Zygon* 14 (1979): 163-5.
 A. Hye, "Bertolt Brecht and Atomic Physics" *Science/Technology and the Humanities* 1 (1978): 157-70.
 F. Falk, "Physics and the Theatre: Richard Foreman's Particle Theory," *Educational Theatre Journal* 29 (1977): 395-404.

Ap. 13: **Quantum Mechanics in Science Fiction**

Students will divide into groups, each giving a presentation discussing selected science fiction in which the quantum plays a significant plot role. Students will be divided into groups to discuss selected science fiction in which the quantum plays a significant plot role. Possibilities include: Stephenson, *Anathem*; Samosa, *Zig-Zag*; books by Gregg Egan, etc.

Rough draft of final project due.

Ap. 20: **Quantum Mechanics in Historical Context**

Students will divide into groups, each giving a presentation discussing a book that examines the history of the quantum revolution and its various aspects in somewhat greater depth than the readings thus far. Possibilities include Louisa Gilder, *The Age of Entanglement*, Guido Bacciagaluppi and Antony Valentini, *Quantum Theory at the Crossroads: Reconsidering the 1927 Solvay Conference*, and Graham Farmelo, *The Strangest Man: The Hidden Life of Paul Dirac, Mystic of the Atom*.

Ap. 27: **Presentations of Student Projects I**

All students have to work on a project, either individually or in collaboration. This project cannot be on one of the required readings (it may involve a suggested reading), and must explore some implication of quantum mechanics for philosophy, culture, or life. A starting point can be found in Brush's *The History of Modern Science*, essentially an extensive bibliography, though we hope students will find other sources. A project may consist of a summary and evaluation of a reading on the subject that we have not discussed. Or it may consist of discovering other kinds of influences of quantum mechanics: on literature or art, for instance. Or it may consist of producing an illustration of quantum mechanical principles in some arena other than physics -- say, a musical analogue of the double-slit experiment in which discernable rhythms eventually emerge out of randomly produced notes. Or it may consist of works -- music, fiction -- inspired by your perceptions of the quantum concept.

We encourage you to start working on the project as early as possible. Its form will be determined by agreement between student and instructors. You must provide the instructors with a title and 1-sentence description by March 9, a 1-page description by March 23, and a first draft (or appropriate form for non-written work) by April 13, leaving room for further development before in-class presentations on April 27 and May 4. You are encouraged to discuss your thoughts with the instructors at all stages

May 4: **Presentations of Student Projects II**

Books

The required articles will be handed out, or left in either the Philosophy or Physics offices for students to copy. The following books are to be purchased:

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| I. B. Cohen | <i>The Birth of a New Physics</i> |
| M. Frayn | <i>Copenhagen</i> |
| D. Lindley | <i>Uncertainty: Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science</i> |
| L. Gilder | <i>The Age of Entanglement: When Quantum Physics was Reborn</i> |
| G. Segrè, | <i>Faust in Copenhagen</i> |

Course Structure

For most classes, the instructors, or guest, speak for the first half, followed by a break for dinner, and on our return students will present and discuss material. The material discussed by the students may be part of the assigned readings for that week, a

suggested reading for that week, or another reading suggested by the student that has been approved by the instructors.

Requirements

You are required to attend all classes, and to participate in the discussions and Blackboard assignments. You must complete the readings on time, by the date listed on the syllabus. You are responsible for making up any work missed for any reason. Grading is based on class participation class presentation, and the course project.

Disability Support Services (DSS) Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact Disability Support Services (631) 632-6748 or <http://studentaffairs.stonybrook.edu/dss/>. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential. Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information see: <http://www.stonybrook.edu/ehs/fire/disabilities/asp>.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instance of academic dishonesty to the Academic Judiciary. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at <http://www.stonybrook.edu/uaa/academicjudiciary/>

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, and/or inhibits students' ability to learn.

Blackboard

Access class information on-line at: <http://blackboard.sunysb.edu>. If you used Blackboard in the Fall, your login information is unchanged. If you've never used Blackboard, your initial password is your SOLAR ID# and your username is your SBU (sparky) username, generally your first initial and the first 7 letters of your last name. For help or more information see: <http://www.sinc.sunysb.edu/helpdesk/docs/blackboard/bbstudent.php> For problems logging in, go to the helpdesk in the Main Library SINC Site or the Union SINC Site, or call 631-632-9602 or e-mail helpme@ic.sunysb.edu