Writing-Intensive Quantum Mechanics

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materials related to this talk can be found at:

fsweb.berry.edu/academic/mans/ttimberlake/wiqm/

Outline

- The course
- The goal of the writing assignments
- The supplemental reading
- The major writing assignments
- The minor writing assignments
- Feedback

The Course

- One-semester Junior/Senior level Quantum Mechanics course
- All students have taken one semester of Modern Physics.
- Text: Griffiths' *Intro. to Quantum Mechanics*
- Most of the course focuses on developing the mathematical formalism of quantum mechanics.
- Writing-Intensive (part of Berry's Writing Across the Curriculum Program)

Goal of the Writing Assignments

- Make students aware of some of the conceptual difficulties of quantum mechanics.
- Introduce students to various interpretations of quantum mechanics.
- Focus students' attention on the **experimental foundations** of quantum mechanics.
- Improve students' writing skills.

Supplemental Reading

- Over the course of the semester students read all of David Lindley's *Where Does the Weirdness Go?*
  - Does not lean toward more exotic interpretations of quantum mechanics.
  - Focuses on experimental results.
  - Discusses decoherence.
- Other readings for specific writing assignments.

Stern-Gerlach Experiment

- Students conduct a prescribed sequence of experiments with a simulated Stern-Gerlach apparatus using the SPINS Java applet.
- Sequence of experiments is designed to illustrate the impossibility of simultaneous eigenstates of spin along different axes. Also introduces the idea of describing a quantum state using a basis of eigenstates.
- Students also design, run, and interpret their own experiment using SPINS.
- Shows how experiments force us into some of the strange ideas of quantum mechanics.

Double-Slit Experiment

- Introduction to the measurement problem
- Readings from Lindley and from Wheeler's "Law Without Law"
- Questions force students to grapple with Wheeler's statement that "no elementary phenomenon is a phenomenon until it is an observed phenomenon".
- What constitutes an "irreversible act of amplification"? Does consciousness play any role?

EPR Experiment

- Readings from Lindley about the EPR thought experiment and an article by Aspect on recent realizations
- Possibilities in light of the experimental evidence for quantum entanglement:
  - loophole in experiment
  - non-local realism (deBroglie-Bohm theory)
  - non-realism (Copenhagen view or similar)

Decoherence

- Readings from Lindley and from a website by Zeilinger, et. al. describing a decoherence experiment using thermal radiation from buckyballs.
- Students are asked to analyze various aspects of the experiment and reach conclusions about the phenomenon of decoherence.
- How does decoherence apply to macroscopic objects (superpositions are prohibited in practice, but not in principle)?

Short Essays

- Questions focus on readings in Lindley.
- Ensure that students are reading regularly and that they comprehend what they read.

Student Feedback

- Comments were almost uniformly positive.
- “I thought the writing assignments were a key factor in my understanding of the concepts presented in this course.”
- “The writing assignments were a good opportunity to step back from the Math and explore one’s understanding of Quantum Mechanics. … I also thought it was good to base the writing assignments off of actual papers and works.”

Bibliography

- Lindley, David. *Where does the weirdness go?* (Basic Books, 1996).
- SPINS applet: www.physics.orst.edu/~mcintyre/ph425/spins/spinsapplet.html, and see AJP **61**, 798-805 (1993).
- Wheeler, John "Law without law," in *Quantum Theory and Measurement* ed. by Wheeler & Zurek (Princeton Univ. Press, 1983).
- Aspect, Alain. "Bell's inequality test: more ideal than ever," Nature *398*, 189-190 (1999).
- "Decoherence by the emission of thermal radiation": www.quantum.univie.ac.at/research/matterwave/thermaldeco/