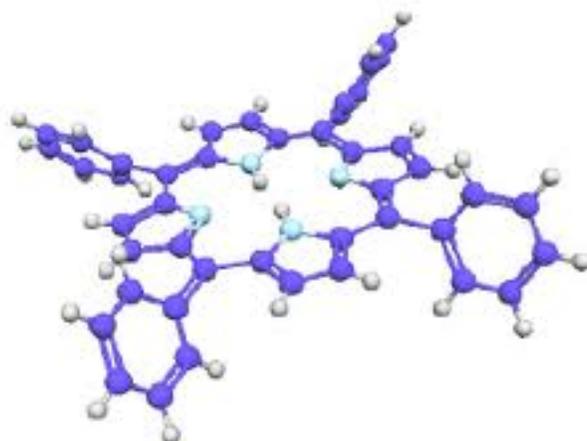


PHIL 245: Philosophy of Quantum Mechanics



Quantum theory is arguably the most accurate scientific theory ever produced. Yet ironically, what it is a theory *of* is not well understood. The ontology of a quantum world has been hotly disputed since the theory's inception. Many very distinct models of a quantum world have been proposed. Are the things we see emergent patterns in a high-dimensional wavefunction, Bohmian particles, constellations of GRW "flashes", or what? One goal of this course is to understand the measurement problem and its various solutions in some detail. This discussion should be of interest to anyone curious about metaphysics, philosophy of science (especially underdetermination), or the foundations of physics. After getting a grip on this material, we'll then turn our attention to some special topics, e.g., quantum non-locality (Bell's theorem), the meaning of the new PBR theorem, where the quantum state lives, and much more.

Instructor Professor Craig Callender
<http://philosophy.ucsd.edu/faculty/ccallender/>
Office: HSS 8077; Office hrs: Wed 1:30-2:30 and by appt
Contact: ccallender@ucsd.edu; 24911

Coordinates Fridays 1-3:50, HSS 7077

Background I'll adjust the technical level of the class to the students who take it. For students with no physics background curious whether they can take the course, the answer is: yes, but you'll have to learn some simple quantum mechanics. A good test is whether you're able to get through the chapter on the quantum formalism in

Albert's *Quantum Mechanics and Experience*. We'll go beyond this slightly, but you'll always get the gist of what's going on if you can handle this much. I'm aiming at the level used in RIG Hughes quantum mechanics book, but happy to go lower or higher as needed. Advanced undergraduates are welcome.

Topics We'll inevitably alter topics on the go. I'll send out a reading list soon. I'm also open to emphasizing special topics throughout if a majority voice interest in them. The main idea will be to give you the background to participate in modern conversations about the foundations of quantum mechanics.

Week 1 The Measurement Problem

The basic formalism; some history; Bohr, Heisenberg; Schrödinger; Schrödinger's cat; Maudlin on the measurement problem

Week 2 The Measurement Problem

Does quantum mechanics need an interpretation?; does decoherence automatically solve it anyway?; the quantum eraser; instrumentalism; realism

Week 3 Collapse Views

"Realistic" collapse theories have been developed by GRW, Penrose, Pearle and others; some curious features; mass density vs "flash" ontologies

Week 4 Everettian Views

Everett's original 1957 interpretation was originally "fixed" by the addition of many worlds, single worlds, many minds, single minds, etc. Now there are two recent interpretations that stand out: the Oxfordians 'emergent patterns' interpretation and Barrett's recent historically realistic deflationary Everettian.

Week 5 Everettian Views

The Everett theory faces at least three serious challenges: the recovery of probability, the recovery of apparently determinate outcomes (possibly through decoherence selecting a preferred basis), and their understanding of functionalism

Week 6 Bohmian Mechanics

Developed in fits and starts by Madelung, Einstein, de Broglie, Rosen, this interpretation reached maturity in its development by Bohm, Bell, Holland, and DGZ. We'll discuss how it avoids 'no hidden variable' proofs, effective wavefunctions, and some common experiments.

Week 7 **Bohmian Mechanics**

The rise of the operator formalism from the eyes of a Bohmian; the status of quantum equilibrium; typicality and probability; some challenges

Week 8 **Bell's Theorem and Non-locality**

EPR; Bell's theorem and Aspect's 1981 experiments seem to confirm that the world is non-local. We'll explain and investigate this claim, explaining how it is understood in our three interpretations.

Week 9 **Quantum State Realism?**

Many of the approaches surveyed take the wavefunction to be a real entity in the world. But the wavefunction lives in a high dimensional (seemingly) abstract state space, not three-dimensional space. Is this okay, and are there ways of avoiding this?

Week 10 **Spin, Loops and Space**

We'll look at some quantum mechanics inspired thought experiments by Aharonov; some metaphysical implications of gauge theories by Maudlin and Arntzenius, and more (or maybe less)