6AANB054 Philosophy of Physics
Syllabus – Academic year 2014/15

Basic information

Credits: 15
Module Tutor: Eleanor Knox
Office: PB413
Consultation time: 3:30-4:30 Mondays, 11:00-12:00 Wednesdays
Semester: 2
Lecture time and venue: 9:00-10:00 Mondays, K4.31 (weeks 1-7, weeks 8-10 will be rescheduled).
Class time and venue: Please see your personal timetable.

Module description (plus teaching arrangements, aims and objectives)

Quantum mechanics is the most successful physics theory ever postulated, and yet its interpretation remains a matter of much debate; all viable interpretations have surprising and counter-intuitive consequences. This course will introduce the structure of quantum mechanics and the measurement problem, and will consider various ways of interpreting or changing quantum mechanics to make it more satisfactory, and the metaphysical consequences of each of these. We’ll also look at the strange non-locality that seems to be a consequence of the theory, and consider how it arises, and exactly what form it takes.

Nb. Materials, including readings and lecture notes, will be posted on the KEATS site for the module. Students should ensure they have access to this.

Assessment methods and deadlines

- **Formative assessment**: 2x1500 word essays
  - 1st formative essay due: 5pm Friday 20th February.
  - 2nd formative essay due: 5pm Friday 3rd April.

  Essays may answer any of the questions suggested below. Please answer the question *exactly as written* unless you have explicit permission from the module tutor to do otherwise.

  Any essays received past the deadline without prior permission or an extremely good excuse will not be given feedback.

- **Summative assessment**: 2 x 2,500-word essays due noon, Thursday 14th May 2015. Please hand
Books and Resources

**General Textbooks**

*Introductory:*

*More advanced:*
- J.S. Bell, *Speakable and unspeakable in quantum mechanics*, (Cambridge, 1987)

**General Resources**
- [Stanford Encyclopedia of Philosophy](https://plato.stanford.edu/)
Lecture Schedule

- **Week One**: The Theory: Introduction
- **Week Two**: The Measurement Problem
- **Week Three**: Non-locality: The Einstein-Podolsky-Rosen Paradox and Bell’s Inequalities
- **Week Four**: The Copenhagen Interpretation
- **Week Five**: Decoherence

READING WEEK – FIRST FORMATIVE ESSAY DUE 5pm Friday 20th February

- **Week Six**: The Philosophy of Probability
- **Week Seven**: Collapse Theories: GRW
- **Week Eight**: Hidden Variables: The de-Broglie-Bohm Pilot Wave Theory
- **Week Nine**: The Everett Interpretation: Overview.
- **Week Ten**: The Everett Interpretation: Probability in Everett

SECOND FORMATIVE ESSAY DUE 5pm Friday 3rd April

Detailed Lecture Outline (including suggested essay topics and readings):

Some notes on the readings and essays:

- Required reading is just that – required! You should come to class having read this in detail and be able to give a summary of its content if asked.
- Although it’s not required, it’s highly advisable to be reading at least one additional text each week, and you will need to read several more when you come to write your essays.
- That said, there’s more material listed below than could reasonably be covered in a term; don’t feel that you should be on top of all the questions, or all the readings.
- Links to required reading will be posted on KEATS, or in some cases a copy of the book will be placed on reserve at the Maughan library.
- Some of the articles below have hyperlinks to online content – even where not linked, most journal articles are available online – [google scholar](https://scholar.google.com) is a helpful resource.
- In case of (genuine!) difficulty obtaining any readings, please email me.
**Week One: The Theory: Introduction**

**Questions:**
- There are no formal essay questions for this week, but you should come out of the reading having some idea how the following play a part in the formalism of quantum mechanics (if you're only reading the Albert, he doesn't quite use all these terms – if you still don't know what they mean by week two’s lecture, please ask!):
  - Superposition
  - Operator
  - Schrödinger equation
  - Wave function
  - Quantum state
  - Commutator
  - Configuration space
  - Born rule
  - Collapse of the wavefunction
  - Hilbert space

**Required reading:**
- For those who are new to physics: David Albert, *Quantum Mechanics and Experience*, ch1-2 pp1-60
- For physics and maths students (and anyone else who wants to have a go): David Wallace’s notes on quantum formalism, available on KEATS.

**Additional reading:**

**Week Two: The Measurement Problem**

Please note, the required reading this week is minimal in order to give you a chance to really get to grips with the formalism. Please use the time to investigate the extra readings from week one, as well as some week 2 readings.

**Questions**
- How should we best express the quantum measurement problem? Is it necessary to provide a solution?

**Required reading:**
- D. Albert, *Quantum Mechanics and Experience* (Harvard University Press, 1992), Chapter 4 (pp. 73-79) and part of chapter 5 (pp. 80-92).

**Additional reading:**
- A. Rae, *Quantum Physics: Illusion or reality?*, ch4
**Week Three: Non-locality:** The Einstein-Podolosky-Rosen Paradox and Bell’s Inequalities

**Questions:**
- Outline the Bell nonlocality theorem. What does it tell us about the interpretation of quantum theory?

**Required Reading:**

**Additional Reading:**
- T. Maudlin, *Quantum non-locality and relativity*. (Blackwell, 1994), especially chapters 1 (pp.6-28), 5 (pp.125-161), 7 (pp.189-222).
- D. Albert, *Quantum Mechanics and Experience* (Harvard University Press, 1992), Ch4 pp61-72

**Week Four: The Copenhagen Interpretation**

**Questions:**
- What is the most coherent view amongst those that have been called ‘The Copenhagen Interpretation’. Can it be defended?

**Required Reading:**

**Additional Reading:**
- Bub, J. *Interpreting the Quantum World* (Cambridge, 1997), chapter 7 (pp. 189-211), esp. section 7.1 (7.2 focusses on much more technical, formal results).
- Cushing, J. *Quantum Mechanics: Historical Contingency and the Copenhagen Hegemony*, (University of Chicago Press, 1994) chapter 3 (pp. 24-41) & possibly also chapters 5-6 (pp. 90-122).
**Week Five: Decoherence**

**Questions:**
- How should an awareness of the physics of decoherence change the way we think about the measurement problem? Can decoherence provide a solution?

**Required Reading:**
- If you have not already read it, have a go at reading D. Wallace’s “Formalism of QM II” notes, available on KEATS.

**Additional Reading:**
- T. Maudlin, “Can the world be only wavefunction?”, in Many Worlds? Saunders, Barrett, Kent and Wallace eds (OUP, 2010).

**Week Six: The Philosophy of Probability**

**Questions:**
- Explain and evaluate one account of physical probability (not credence).

**Required reading:**

**Additional Reading:**
- For a very simple intro, you may wish to review Part III of David Papineau’s Philosophical Devices. (This material was covered in your first year methodology course.
- Richard von Mises, 'The Definition of Probability'
- Alan Hájek, ""Mises Redux" Redux: 15 Arguments Against Finite Frequentism'
- Alan Hájek, ‘15 Arguments Against Hypothetical Frequentism’
- Paul W. Humphreys, 'Why Propensities Cannot be Probabilities’
- Barry Loewer, 'David Lewis’ Humean Theory of Objective Chance’
**Week Seven: Collapse Theories:** GRW

**Questions:**
- Does the Ghirardi-Rimini-Weber theory solve the measurement problem satisfactorily?

**Required Reading:**

**Additional Reading:**

**Week Eight: Hidden Variables:** The de-Broglie-Bohm Pilot Wave Theory

**Questions:**
- How satisfactory is the de Broglie-Bohm theory as a resolution of the measurement problem?

**Required Reading:**

**Additional Reading:**
- D. Wallace, "Hidden-Variable Theories", section 6 of *The Philosophy of Quantum Mechanics*, in the Ashgate Companion to Philosophy of Physics (pre-print of this article available on blackboard). Especially sections 6.1, 6.2 and 6.4.

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**Week Nine: The Everett Interpretation: Overview**

**Questions:**
- What is the most satisfactory formulation of the Everett interpretation, and how successful is it as a resolution of the measurement problem?

**Required Reading:**
- D. Albert, Quantum Mechanics and Experience (Harvard University Press, 1992). First part of chapter 6 (pp. 111-119).

**Additional Reading:**
- D. Wallace, The Emergent Multiverse, OUP 2012. – The most comprehensive contemporary defence of Everett.
- Saunders, Barrett, Kent and Wallace eds, Many Worlds? Everett, Quantum Theory and Reality. (OUP 2010) – this is a very up to date collection of Everett articles – see especially articles in sections 1,3 and 4. Available at: http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199560563.001.0001/acprof-9780199560563
**Week Ten: The Everett Interpretation:** Probability in Everett

**Questions:**
- What is the most satisfactory formulation of the Everett interpretation, and how successful is it as a resolution of the measurement problem?

**Required Reading:**
- Wallace, D, *The Emergent Multiverse*, Ch.4 and 5.

**Additional Reading:**