Course: Epistemology and philosophy of science (module II)

Syllabus and References -- Quantum mechanics [D. Romano]

1. LESSON 1

- Introduction: what is quantum mechanics? What quantum mechanics is about?
- QM: the standard view, the wave function, Born's statistical interpretation of the wave function
- Formalism of QM: vectors, superpositions, Dirac notation, observables and eigenstates

References

- Lessons' notes: part I [What QM is about?]
- Lessons' notes: part II [Formalism of QM]

[*] Bowman (2008): chapters [2,3,4,5,6]

2. LESSON 2

- Formalism of QM II: the uncertainty principle; theory of measurement, the collapse of PSI
- The measurement problem (standard formulation)
- Examples: 2-slit experiments; the Schrödinger's cat (slides on 2-slit experiments)

References

- Lessons' notes: part II [The uncertainty principle]
- Bowman (2008): chapter 7 [Commutators and uncertainty relations]
- Lessons' notes: part III [The theory of measurement, the measurement problem]
- Norsen (2017): chapter 3 [The measurement problem]

[*] Maudlin (2019): chapter 2 [The quantum recipe]

3. LESSON 3

- De Broglie-Bohm theory [Bohm's theory, Bohmian mechanics]
- The ontology of the wave function (nomological view, field in 3N-D, multi-field in 3D)

References 1 (Bohm's theory)

- D. Bohm (1952): A suggested interpretation in terms of "hidden" variables I, *Physical Review*.
- Stanford Encyclopedia of Philosophy: "Bohmian mechanics"

References 2 (ontology of the wave function) [articles 2013 in Albert & Ney (2013)]

- Goldstein & Zanghì (2013): Reality and the role of the wave function in quantum theory
- Allori (2013): Primitive ontology and the structure of fundamental physical theories
- Albert (2013): Wave function realism
- Wallace (2013): A prolegomenon to the ontology of the Everett interpretation
- Hubert and Romano (2018): The wave function as a multi-field, *EJPS*
- Romano (2020): Multi-field and Bohm's theory, *Synthese.*

4. LESSON 4

- J. Bell: "Speakable and unspeakable in quantum mechanics" (in-class reading and discussion)
- GRW theory [Stanford encyclopedia / Norsen (book) / Maudlin (book)]
- MWI theory (Stanford Encyclopedia / Norsen (book) / Maudlin (book)]

References

- J. Bell (1987): Speakable and unspeakable in QM (paper in Bell (1987)).
- Stanford Encyclopedia: "Everett's relative-state formulation of quantum mechanics" [J. Barrett]
- Stanford Encyclopedia: "Collapse theories" [G. Ghirardi & A. Bassi]

[*] Maudlin (2019): chapter 4 [Collapse theories and the problem of local beables]

[*] Norsen (2017): chapter 9 [The spontaneous collapse theory]

5. LESSON 5

- Decoherence theory and the quantum-to-classical transition
- The meaning of decoherence in Bohm's theory, GRW theory and MWI theory

References 1 (decoherence theory)

- E. Joos, Elements of environmental decoherence (introductory article on decoherence theory)
- W. Zurek (2002), Decoherence and the transition from quantum to classical—Revisited.
- M. Schlosshauer (2019), Quantum decoherence, *Physics Reports* [sections 1 and 2].

[an extended version of the topics discussed in this article can be found in Schlosshauer (2007)]

References 2 (interpretation of decoherence theory)

- Stanford Encyclopedia: "The role of decoherence in quantum mechanics" [G. Bacciagaluppi].
- E. Crull (2021), Quantum decoherence, in *The Routledge Companion to Philosophy of Physics.*
- D. Romano (2022), The unreasonable effectiveness of decoherence, in *Allori* (ed.): "Quantum Mechanics and Fundamentality, *Synthese Library*, Springer, 2022.

Book references

- D. Albert & A. Ney (eds.): *The Wave Function: Essays on the Metaphysics of Quantum Mechanics*, Oxford University Press, 2013.
- V. Allori (ed.): *Quantum Mechanics and Fundamentality*, Synthese Library, Springer, 2022.
- J. S. Bell: *Speakable and Unspeakable in Quantum Mechanics*, Cambridge Univ. Press, 1987.
- G. E. Bowman: *Essential Quantum Mechanics*, Oxford University Press, 2008.
- E. Knox & A. Wilson (eds.): *The Routledge Companion to Philosophy of Physics*, Routledge, 2021.
- T. Maudlin: *Philosophy of Physics: Quantum Mechanics*, Princeton University Press, 2019.
- T. Norsen: *Foundations of Quantum Mechanics*, Springer, 2017.
- M. Schlosshauer, *Decoherence and the Quantum-to-Classical Transition*. Springer, 2007.