PHI 514 – From Physics to Metaphysics

Weeks 4–6, 10–12: Indeterminacy in Quantum Mechanics (Halvorson)

1. Logic and probability in classical physics [Bub97, pp. 13–22], [Var85, Chap. 1]

2. The uncertainty relations and their interpretation [UH01], [Jam74, Chap. 3].

   (a) Some thought experiments

   (b) The epistemic interpretation. Heisenberg's disturbance interpretation [Hei30, pp. 13-20].

   (c) The statistical interpretation (Popper) [Pop82, pp. 52-64, 144ff.], [Jam74, pp. 448–453]

   (d) The conceptual interpretation (Bohr); complementarity

3. From uncertainty to indeterminacy: Operationlism, positivist criteria of meaning

   (a) Operationalist definitions of concepts [Bri27]

   (b) Historical fact: Bohr doesn't infer indeterminacy from uncertainty [Grü57], [Mur87, pp. 139–154], [How00].

4. Logic and probability in quantum mechanics

   Resources: Clifton's notes [Cli96] are thorough and self-contained. There are shorter introductions in [Ism00], [Alb92, pp. 17–60], [Red89, pp. 5–32, 170–178], and [Bub97, pp. 23–39, 246–274]. For a more in-depth treatment, see [Hug89, Chaps. 1–5] or [van92, pp. 139–237].

5. Against the disturbance interpretation

   (a) (For a technical critique – making use of details of the gamma-ray microscope – see [BR81]. I do not plan to discuss this in the seminar.)

   (b) The "no hidden variables" theorems of von Neumann and Kochen-Specker [Red89], [Hea79]

   (c) The Einstein-Podolsky-Rosen Argument

6. Contextual hidden variables; de-occamization [Shi93a]

7. Which quantities are real?

   (a) Eigenstate-Eigenvalue Link (This is what Fine [Fin87] calls the "rule of silence" and "rule of law."); Collapse of the Wavefunction

   (b) Booleanism

   (c) The problem of the non-maximal observable

   (d) Definability and the Bub-Clifton theorem [BC96]

8. What is the status of the *other* quantities?

   (a) 3-Valued Logic: Reichenbach [Rei44, Rei53, Fey81b]

   (b) Potentialities (Heisenberg, Shimony)

   (c) Not really quantities (Bohm); Dispositions (Bohm)

9. Positionism – For and Against

   According to "positionism," the position of a physical object (at a time) is its only intrinsic property (see [AL89].) Alternatively, position is the only quantity that is ever directly observed or measured: "... in physics the only observations we must consider are position observations, if only the positions of instrument pointers. ... If you make axioms, rather than definitions and theorems, about the 'measurement' of anything else, then you commit redundancy and risk inconsistency" [Bel87, p. 166].

   Positionism provides the philosophical motivation for Bohm's hidden variable theory. (For an elementary introduction to Bohm's theory, see [AL89, pp. 169–179] or [Alb92, Chapter 7]. For a shorter, but more demanding introduction, see [Bel87].)

   (a) How to explain away other quantities, and purported measurements thereof [DDGZ96, PC95, Bed98]

   (b) A "Sellarsian" argument for positionism [Mau97]

   (c) Independent reasons for doubting the fundamentality of momentum [Arn00]

   (d) Both position and momentum are secondary qualities; the wavefunction is the primary quality [Pri89]

   (e) A no-go theorem for precise positions in quantum mechanics [Tel79]. A go theorem for precise positions in quantum mechanics [Hal01a, Hal01b].

(f) A plea for other quantities – most particularly, energy and momentum. (The connection between causality and conserved quantities [Dow96, Fai79])

(Technical Aside: There are arguments that Bohmian particles must be regarded as fictional objects; see [Bar00] and [Kra97].)

10. Bohr on defining quantities

    (a) What is a context? [Hoo72]

    (b) How can a context condition our ability to define concepts (or theoretical terms)? [Zin62, Hoo72, MA65, Boh87]

    (c) Who determines what is real – do we or does the world? [Fin87]

    (d) Formal explications of contextualism [Hee71, Hee70] and of complementarity [Bub97], [CH02], [Hal01a].

Note on Obtaining Articles: Unless otherwise noted, articles and books will be available in the Marx Hall reading room. I note cases where articles are available from one of the following online sources:

JSTOR = `http://www.jstor.org`

PhilSci Archive = `http://philsci-archive.pitt.edu`

PHI514 Website = `http://blackboard.princeton.edu` (Go to "PHI514" and then look under "course material")

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