Philosophy of Physics: Probability and Physics

Jill North

Many of our best physical theories posit probabilities: they contain laws that assign chances to different possible future states of a system given its current state. They then make predictions and give explanations of events by referring to those chances. These theories are empirically successful. Yet there are many conceptual and philosophical puzzles surrounding their use of probability. What are physical probabilities? Can we construe them as objective features of the world? If so, what features of the world are they? Is it possible to have a unified account that understands the probabilities of different physical theories in the same way? And what if the underlying dynamical laws are deterministic, as they are in classical statistical mechanics and Bohmian quantum mechanics: can we construe the probabilities of these theories as objective chances? That is, can there be objective chances other than 0 or 1 in a deterministic world? Finally, can we regard physical probabilities as fundamental features of the world, or should they be derived from something else seen as more fundamental? The focus of the class is objective chance, or physical probability, but we will also consider the relation between the chances given by physics and our degrees of belief.

Course requirements: You will have the option of one seminar paper, due at the beginning of the next semester, or two smaller assignments (one 10-page paper handed in the following semester, and either a 10-page paper or take-home exam during the semester).

I. Probability in Statistical Mechanics

Week 1: Overview: Why use probabilities? What are they?
Objective chance and subjective credence; why we use probabilities; standard philosophical accounts of probability; particular puzzles that arise for probability in statistical mechanics.

Week 2: Some background on the mathematics of probability
Axioms of the probability calculus; conditional probability; extensions to infinite sequences and spaces; relative frequency and randomness; countable additivity; probability and measure.
Reading: beginning of Sklar ch. 3

Week 3: Why use probabilities in describing nature?
When should we posit probabilities in order to explain the observed frequencies? Why use probabilities at all in describing nature?
Reading: Arntzenius, "Mirrors and the Direction of Time"

Week 4: Statistical mechanics
How, and why, are probabilities used in classical statistical mechanics?
Reading: Albert, *Time and Chance* ch. 3

Week 5: Philosophical interpretations of probability
The main philosophical accounts of probability and some standard objections; particular problems that arise for the probabilities of statistical mechanics.
Reading: Sklar, *Physics and Chance* ch. 3

Week 6: Objective chance and degrees of belief
What is the relation between objective chance and degrees of belief?
Reading: Lewis, "A Subjectivist's Guide to Objective Chance" plus appendices

Week 7: Determinism and Chance
Can there be objective chances other than 1 or 0 in a deterministic world?
Reading: Schaffer, "Deterministic Chance?"

Week 8: Symmetry and probability
What role, if any, do symmetries play in determining probabilities?
Reading: van Fraassen, *Laws and Symmetry* ch. 12; Strevens, "Inferring probabilities from symmetries"

Week 9: How should we understand the probabilities of statistical mechanics?
Readings will be some of the following: Leeds, "Statistical Mechanics – Two Approaches"; Jaynes, "The Well-Posed Problem"; Sklar, "Statistical Explanation and Ergodic Theory"; Lewis, "Humean Supervenience Debugged"

II. Probability in Quantum Mechanics

Week 10: Quantum mechanics
Reading: Albert, *Time and Chance*, pp. 134-150; Maudlin, "An Overview of Quantum Mechanics"

Week 11: Collapse theories
How should we understand the probabilities of indeterministic quantum theories?
Reading: Callender, "Is Time Handed in a Quantum World?"

Week 12: Collapse theories and statistical mechanics
Can fundamental indeterminism explain the probabilities of statistical mechanics?
Reading: Albert, "The foundations of quantum mechanics and the approach to thermodynamic equilibrium"; Price, "Boltzmann's time bomb"

Week 13: Bohmian quantum mechanics
How should we understand the probabilities of deterministic quantum theories?
Reading: Goldstein, "Boltzmann's Approach to Statistical Mechanics"

Week 14: Many-worlds
How do we make sense of probability in a theory which says that all possible outcomes occur?
Reading: Wallace, "Everettian rationality: defending Deutsch's approach to probability in the Everett interpretation"

(**Extra**, if there's time: probability in quantum statistical mechanics. Reading: Wallace, "Implications of quantum theory in the foundations of statistical mechanics".)