AGPhil 2: Quantum Theory 1

Time: Tuesday 11:00–13:15 Location: H4

Invited Talk AGPhil 2.1 Tue 11:00 H4

Quantum Metaphysics — •Alastair Wilson — University of Birmingham, Birmingham B15 2TT, UK

Philosophy, specifically natural philosophy, used to be our main route to understanding the deep underlying structure of reality. Physics emerged out of natural philosophy during the Scientific Revolution, and over the past few centuries it has come to seem as though physics is all we need to understand the natural world. But is there still any role for philosophy to play? In this talk I argue that philosophy and physics can work together to help us understand some of the deepest mysteries of nature: in particular, chance, possibility and necessity. I suggest that the Everett interpretation of quantum mechanics - if correct - can cast light on many core questions of metaphysics, while embedding the Everettian approach in a suitable metaphysical framework can strengthen it in turn. The overall method I advocate is 'naturalistic metaphysics' - theorizing about the most general aspect of reality in a way informed and constrained by our best physics - and I will end by asking how far this naturalistic approach can be taken.

AGPhil 2.2 Tue 11:45 H4

The Representation and Determinable Structure of Quantum Properties — •Samuel C. Fletcher and David E. Taylor — University of Minnesota, Twin Cities

Let us begin with a puzzle. Consider an electron with a two-dimensional Hilbert state space, and the properties of having spin in the x- and y-directions, respectively. On the one hand, it is standard to represent these as the Pauli operators σ_x and σ_y, whose eigenvalues represent the values of spin-up and spin-down in their respective directions. And it is well-known that these operators do not commute. On the other hand, it is also commonly acknowledged that projection operators, as self-adjoint operators, can also represent these quantities, whose eigenvalues represent the property obtaining or not. But each of these quantities is only plausibly represented by the identity operator on the Hilbert space, and these operators obviously commute. Operators commute iff the properties they represent are compatible. So the spin-x and spin-y properties are both compatible and not compatible: a contradiction. We propose to resolve this puzzle by denying that self-adjoint operators represent properties simpliciter: rather, they represent a determinable property, whose extension is the domain of the operator, **plus** a particular level of specification with associated determinates, which are named by the eigenvalues. So the different operators in the puzzle actually reflect different levels of specification of one and the same property. Thus it is not the properties of a quantum system which are incompatible in a non-classical way, but rather the levels of specification.

AGPhil 2.3 Tue 12:15 H4

Spatial Separation of Magnetic Moment and Location as an Argument for a Trope-Ontological Interpretation of Quantum Field Theory — •Karim Baraghith[1] and Nina Nicolin[2] — [1]Heinrich Heine Universitaet Duesseldorf, GER — [2]Heinrich Heine Universitaet Duesseldorf, GER

It has been suggested to interpret particles in quantum field theory (QFT, in particular AQFT) as bundles of tropes, see e.g. Kuhlmann (2010). In this reading, a *thing* (like a particle) does not *have* its properties, it is the specific combination of the properties which constitute the thing in the first place. We will present an empirical matter-wave interferometer experiment (Denkmayr et. al. [2014]), which shows that one can indeed separate a particle*s properties, experimentally (Chesire Cat phenomenon). It indicates that when sending neutrons through a silicon crystal interferometer, while performing weak measurements in or-der to probe the location of the particle and its magnetic moment, the system behaves as if the neutrons go through one beam path, while their magnetic moment travels along the other. Following a specific interpretation of these observations, it seems to be the case that what we call a *property* may exist fundamentally and independently of its particle (or at least can be isolated from it). We argue that a trope theoretical interpretation of quantum particles * which sees the particle*s properties and not the particle itself as fundamental * is probably the most com-patible ontological interpretation of this phenomenon.

AGPhil 2.4 Tue 12:45 H4

The Unactualized Certainty-Actuality Correspondence — •Armin Nikkhah Shirazi — University of Michigan, Ann Arbor, USA

This talk investigates the correspondence between unactualized certainties and actualities. It does this first through the lens of a recently proposed enrichment of axiomatic probability which makes it possible to distinguish mathematically between actualities and unactualized possibilities, including those which are certain. Two kinds of unactualized certainties are considered: those due to the sample space being a singleton, and those involving a sample space with more than one element.

After comparing standard axiomatic probability with the enrichment in regards to how they represent the distinction, attention is then focused on quantum mechanics. There, the correspondence will be examined through the lens of a recently proposed modification of the standard formalism, the Heisenberg Interpretation, which, unlike the standard quantum formalism but like the enriched axiomatization of probability, also permits formal distinctions between unactualized possibilities and actualities. Two situations are found to exemplify the correspondence there: one involving partially measured entangled systems and the other involving the Born rule.