AGPhil 6: History and Philosophy of Physics

Time: Wednesday 17:00–18:15 Location: HS XVII

AGPhil 6.1 Wed 17:00 HS XVII

Louis de Broglie and the Five Dimensions; or, How Unified Field Theory Was Employed in the Quest for Realism in Quantum Mechanics — •Bernadette Lessel[1] and Alessio Rocci[2] — [1]Philosophisches Institut, Universität Bonn — [2]Vrije Universiteit Brussel

Louis de Broglie is most prominently known for his doctoral thesis from 1924 in which he introduced the notion of material waves. He is also known for belonging to the camp opposing the Copenhagen point of view on quantum mechanics, denying state space formalism and advocating a realist interpretation of the wave function until he gave it up in the year 1928. This talk explores de Broglie's use of ideas from classical field theories, particularly general relativity and unified field theory, in his quest for a causal interpretation of quantum mechanics. In this regard, two distinct phases of de Broglie's work are identified: 1. The academic year 1926/27 - collaborating with young Léon Rosenfeld, de Broglie experimented with a five-dimensional formalism, similar to Kaluza and Klein's approach, to counter Schrödinger's notion of configuration space. 2. A later development starting in 1952 - utilizing the property of gravitational field singularities following geodesics, de Broglie incorporated concepts from general relativity into his 1927 theory of double solution. In this phase, de Broglie is assisted by French relativist Vigier. Central to their reasoning was the duality of particle and wave which they viewed as analogous to the particle-field duality in classical field theory.

AGPhil 6.2 Wed 17:15 HS XVII

Simulating spin measurement as unitary time evolution — •Thomas Dittrich, Oscar Rodríguez, and Carlos Viviescas — Departamento de Física, Universidad Nacional de Colombia, Bogotá D.C., Colombia

Quantum measurement is studied as a unitary time evolution of the measurement object, coupled to an environment representing the meter and the apparatus. Modelling the environment as a heat bath comprising a large but finite number of boson modes, it can be fully included in the time evolution of the total system. As a prototype of quantum measurement, we perform numerical simulations of projective measurements of the polarization of spin-1/2 particles. Their spin is prepared in an unpolarized pure state, the environment as a product of coherent states with a thermal distribution of centroids. Initially, the spin gets entangled with the heat bath and loses coherence, reproducing the collapse of the wave packet. For most of the initial states of the environment, we see a definite outcome of the measurement as the spin returning asymptotically to a pure state, either spin up or spin down with equal probability. Unitarity allows us to run the simulations backwards, undoing the measurement and recovering the initial state of the apparatus that led to the specific final spin state, relating it to the respective initial conditions of the heat bath, i.e., the observed randomness to quantum and thermal noise of the macroscopic environment. Extending our approach to a complete EPR setup with two arms remains as a challenge for future work.

AGPhil 6.3 Wed 17:30 HS XVII

History and Metaphysics of Shape Dynamics — •Paula Reichert — Mathematisches Institut, LMU München, Theresienstr. 39, 80333 München

This talk will discuss the history and metaphysics of shape dynamics. Shape dynamics is a relationalist theory of gravity in the spirit of Leibniz and Mach. It has been introduced by Barbour and Bertotti in the 1980s. In shape dynamics, space and time are relational. This makes it a rival theory both to Newtonian gravity and to Einstein's general relativity. In this talk, I will distinguish three ontologies of space and time: 1) Newtonian absolute space and absolute time, 2) Leibnizian relational space and relational time, and 3) Einsteinian relativistic spacetime. I will show how the standard route from Newtonian absolute space and time has led via Galiliean spacetime and Minkowski spacetime to curved spacetime. Relationalists, however, followed a different path. They developed a theory of 3d conformal space + 1d relational time instead of 4d relativistic spacetime. Still, shape dynamics and general relativity agree on the relevant set of solutions. One reason for this to work is that time, in shape dynamics, is essentially given by the expansion rate of the universe (the dilational momentum or York time) and enters the time-dependent Hamiltonian, taking up the role of (relative) scale. After having outlined the different historical routes and the metaphysical and physical differences between shape dynamics and general relativity, I will shortly compare future prospects of the two theories.

AGPhil 6.4 Wed 17:45 HS XVII

Bohr's hidden variables — •Moritz Epple — Center for Science and Thought, University of Bonn, Konrad-Zuse-Platz 1-3, 53227 Bonn

In 1927, Einstein and Bohr discussed the foundations of quantum mechanics. While Bohr held the view that the quantum formalism was complete and best understood in terms of complementary quantum phenomena, Einstein was skeptical und unleashed an unparalleled, decade-long effort of ingenuity aimed at showing that quantum mechanics offered only an incomplete description of physical reality. According to the standard narrative, Bohr not only persevered, but also won the intellectual competition between the two friends. However, looking back at these thrilling discussions from the distance of almost a century, new perspective can emerge. In this talk, I will present a non-deterministic hidden variable interpretation of quantum mechanics, which can be seen as a mathematically precise (re)formulation of Bohr's interpretation. I will thus argue that (contrary to Bohr's own claims) Bohr's interpretation of quantum mechanics actually goes beyond the standard (von Neumann-Dirac) quantum formalism und thus agrees with Einstein's criticism at least in so far as it affirms the incompleteness of the standard formalism. I will also discuss the relation of our proposal to quantum nonlocality and Bell's theorem.

AGPhil 6.5 Wed 18:00 HS XVII

On the prospects of a grounding-based account of entanglement swapping — •Jørn Kløvfjell Mjelva — Department of Philosophy, Classics, History of Art and Ideas, University of Oslo, Norway

Quantum mechanics predicts that measurements on entangled systems will display correlations that defy a causal explanation in terms of a common cause, apparently indicating "spooky action-at-a-distance". Ismael and Schaffer (2020) have proposed that the modal connections between entangled systems may instead be explained by the correlated events being the results of a common ground. Rather than attributing the connection to action-at-a-distance, the common ground explanation attributes it to an ontological dependence of the parts on the entangled whole they compose. But what if the state of the whole itself depends on distant events? In particular, what if the state of a composite system could be either entangled or non-entangled depending on operations performed on a distant system? These questions become pertinent as we consider the case of entanglement swapping; a process in which entanglement is "transferred" from on pair of particles to another, without any direct interactions facilitating the transfer. In this paper, I discuss the issues entanglement swapping raises for the common ground-strategy, and present a way they may be resolved.