AGPhil 2: Quantum-Classical Divide I

Time: Wednesday 16:30–18:45 Location: SPA SR22

AGPhil 2.1 Wed 16:30 SPA SR22

Convergence in theories of quantum gravity? — •Johannes Thürigen — Albert Einstein Institute, Potsdam, Germany

Theories in (empirical) science can be considered epistemically justified not only by empirical content but also by systematization power and uniformity. In the light of these concepts we present an analysis of the basic structure and intertheoretic relations of some approaches to quantum gravity each starting from quite different assumptions. These are Loop quantum gravity, Spin foams, Causal dynamical triangulations, Regge calculus and Group field theory. The aim of this analysis is to critically discuss an argument of physicists working on quantum gravity, stating that there is some kind of convergence of the mentioned approaches which (at least partially) justifies them.

Such an argument would be of high relevance since neither the precise relation to the established theories (and thus the phenomena described by those) nor the derivation of original phenomena might be achievable in the foreseeable future, leaving uniformity as the only epistemological criterion in favor for them.

We find that intertheoretic relations can be found mainly at the level of the conceptual framework of the theories, rather than regarding the actual dynamical laws. Therefore a weaker notion of theory relation is needed. The recent concept of theory crystallization is a good candidate and we analyze to what extent the approaches to quantum gravity meet its conditions.

AGPhil 2.2 Wed 17:00 SPA SR22

On the Significance of the Gottesman-Knill Theorem — •Michael Cuffaro — Ludwig-Maximilians-Universität München, Munich Center for Mathematical Philosophy, München, Deutschland

This paper addresses the question of the quantum-classical divide from the perspective of quantum computation, as well as the relevance of this for our understanding of the limitations of local hidden variables theories, and thus for our understanding of the quantum-classical divide more generally. According to the Gottesman-Knill theorem, quantum algorithms utilising operations chosen from a particular restricted set are efficiently simulable classically. Since some of these algorithms involve entangled states, it is commonly concluded that entanglement is not sufficient to enable quantum computers to outperform classical computers. It is argued in this paper, however, that what the Gottesman-Knill theorem shows us is only that if we limit ourselves to the Gottesman-Knill operations, we will not have used the entanglement with which we have been provided to its full potential, for all of the Gottesman-Knill operations are such that their associated statistics (even when they involve entangled states) are reproducible in a local hidden variables theory. It is further argued that considering the Gottesman-Knill theorem is illuminating, not only for our understanding of quantum computation, but also for our understanding of what we take to be a plausible local hidden variables theory, as well as for our understanding of the relationship between all-or-nothing inequalities such as GHZ, and statistical inequalities such as CHSH.

AGPhil 2.3 Wed 17:30 SPA SR22

Quantum and Classical Computation: Foundational Issues besides the Speed-up — •Filippo Annovi — Department of Philosophy, University of Bologna, Italy

The divide between quantum and classical computation does not concern which tasks can be performed, but the amount of resources necessary to achieve them. Does this entail that the computational divide is only relevant from a practical point of view, but not from a foundational one? No, because both the formal structure of quantum computers (based on the properties of Hilbert spaces) and the physical tools used by them (e.g. entangled states) are not classically available, thus the differences between quantum and classical computation go beyond complexity questions: the divide would remain in place even in the extremely unlikely case that the discovery of new classical algorithms were to nullify the quantum speed-up.

Moreover, there exist alternative equivalent models of quantum computation, some of which, like the cluster-state model, make an essential use of classical resources. Then, while the "where does the quantum speed-up come from?" question can satisfyingly receive a different answer for each model, the "where does the quantum-classical computational divide lie?" question requires an unified answer. This could be the first step towards a "representation theorem" for quantum computation, which would turn out to be very fruitful for the debate over the foundations of quantum mechanics.

Invited Talk AGPhil 2.4 Wed 18:00 SPA SR22

Properties Are ... — •Antigone Nounou[1] and Harris Anastopoulos[2] — [1]University of Athens, Athens, Greece — [2]University of Patras, Patras, Greece

The object of this paper is the notion of property and its objective is to study the different nuances that manifest as we transition from the classical to the quantum. Of the many questions that might -in our view need- be addressed, only one has been discussed thus far, namely whether properties in non-relativistic QM can be viewed as categorical or dispositional but the answers have been given in the context of particular interpretations only. The dispositional-categorical distinction constitutes the backdrop of the present discourse also as it bears on a more comprehensive discussion of the metaphysics of quantum physics and the question whether QM is amenable to a Humean construal or not. Given the nature of quantum probabilities and the possibility of entangled states, we acknowledge that in order to be able to talk about properties of microscopic systems (presumed determinate and single-valued) additional elements are required, such as the Copenhagen inspired mechanisms for wavefunction collapse, Bohmian pilot waves or GRW spontaneous localizations. Committing to any one of them implicates the adoption of a certain interpretation or rendition of the QM formalism and this has an effect on how properties can be understood. But by offering as exhaustive an analysis as we possibly can, we attempt to propose a satisfactory general account of how quantum properties may be understood in the context of non-relativistic QM.