Quantum Information Theory and the Foundations of Quantum Mechanics

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Abstract

This thesis is a contribution to the debate on the implications of quantum information theory for the foundations of quantum mechanics.
In Part 1, the logical and conceptual status of various notions of information is assessed. It is emphasized that the everyday notion of information is to be firmly distinguished from the technical notions arising in information theory; however it is maintained that in both settings `information' functions as an abstract noun, hence does not refer to a particular or substance (the worth of this point is illustrated in application to quantum teleportation). The claim that `Information is Physical' is assessed and argued to face a destructive dilemma. Accordingly, the slogan may not be understood as an ontological claim, but at best, as a methodological one. The reflections of Bruckner and Zeilinger (2001) and Deutsch and Hayden (2000) on the nature of information in quantum mechanics are critically assessed and some results presented on the characterization of entanglement in the Deutsch-Hayden formalism. Some philosophical aspects of quantum computation are discussed and general morals drawn concerning the nature of quantum information theory.
In Part II, following some preliminary remarks, two particular information-theoretic approaches to the foundations of quantum mechanics are assessed in detail. It is argued that Zeilinger's (1999) Foundational Principle is unsuccessful as a foundational principle for quantum mechanics. The information-theoretic characterization theorem of Clifton, Bub and Halvorson (2003) is assessed more favourably, but the generality of the approach is questioned and it is argued that the implications of the theorem for the traditional foundational problems in quantum mechanics remains obscure.

Keywords:	quantum information, Shannon information, entanglement, teleportation, Dretske, Deutsch-Hayden representation, Turing Principle, Zeilinger's foundational principle, Clifton-Bub-Halvorson theorem
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