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Quantum Foundations of Quantum Information[1]

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The main foundational issue for quantum information is: What is quantum information about? What does it refer to? Classical information typically refers to physical properties, and since classical is a subset of quantum information (assuming the world is quantum mechanical), quantum information should–and, it will be argued, does–refer to quantum physical properties represented by projectors on appropriate subspaces of a quantum Hilbert space. All sorts of microscopic and macroscopic properties, not just measurement outcomes, can be represented in this way, and are thus a proper subject of quantum information. The Stern-Gerlach experiment illustrates this. When properties are compatible, which is to say their projectors commute, Shannon's classical information theory based on statistical correlations extends without difficulty or change to the quantum case. When projectors do not commute, giving rise to characteristic quantum effects, a foundation for the subject can still be constructed by replacing the "measurement and wave-function collapse" found in textbooks–an efficient calculational tool, but one giving rise to numerous conceptual difficulties–with a fully consistent and paradox free stochastic formulation of standard quantum mechanics. This formulation is particularly helpful in that it contains no nonlocal superluminal influences; the reason the latter carry no information is that they do not exist.

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