

JOHN TEMPLETON FOUNDATION

SUPPORTING SCIENCE - INVESTING IN THE BIG QUESTIONS

Project approved for the period 1 October 2013 to 30 June 2016

Project Leader:

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Project Title:

Steps to a Natural Interpretation of Quantum Mechanics – deriving quantum mechanics from new axioms with clear physical meaning

Executive Summary:

Quantum mechanics has several plausible interpretations, but no single agreed interpretation. I aim at an interpretation so natural as to win consensus. Specifically, I propose four parallel and closely related projects. The first project is to analyze novel types of measurement (including “weak” and “protective” measurements, and measurements of “modular” variables) for a fuller account of the measurable content of quantum mechanics, and to exhibit new quantum effects. These novel measurements were found through a careful analysis, by Y. Aharonov and coworkers, of what quantum mechanics allows us, in principle, to measure. The second project is to design laboratory experiments to demonstrate that “weak values” are both apt (intuitively appealing) and useful. The third project is to apply two convergent analyses of time symmetry in microphysics – one from physics and one from philosophy – to derive a causal-retrocausal or “two-state” quantum formalism. Such a formalism could avoid measurement paradoxes, place quantum mechanics in a broad context of theories, and offer a new approach to free will and determinism. In physics, a causal-retrocausal formalism has already been defined (by Aharonov and coworkers), but it takes quantum mechanics as its starting point. The work of philosopher H. Price suggests that a more general starting point, not assuming quantum mechanics, is possible. In turn, the fourth project is to develop alternative axioms, each with a clear physical meaning, for deriving all or part of quantum mechanics. This work, including a novel derivation of Tsirelson's bound, will appear in papers submitted to peer-refereed journals and in a new edition of the book *Quantum Paradoxes: Quantum Theory for the Perplexed* by Y. Aharonov and D. Rohrlich. Progress in any of these projects could produce, via a paradigm change, consensus on how to interpret quantum mechanics, a consensus that has eluded physicists and philosophers for over a century.