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Distinct Quantum States Can Be Compatible with a Single State of Reality[1] PETER LEWIS, DAVID JENNINGS, Imperial College, London, JONATHAN BARRETT, University of Oxford, TERRY RUDOLPH, Imperial College, London — Perhaps the quantum state represents information available to some agent or experimenter about reality, and not reality directly. This view is attractive because if quantum states represent only information, then wave function collapse is possibly no more mysterious than a Bayesian update of a probability distribution given new data. Several other "puzzling" features of quantum theory also follow naturally given this view. In order to explore this idea rigorously, we consider models for quantum systems with probabilities for measurement outcomes determined by some underlying physical state of the system, where the underlying state is not necessarily described by quantum theory. In our model, quantum states correspond to probability distributions over the underlying states so that the Born rule is recovered. More specifically, we consider models for quantum systems where several quantum states are consistent with a single underlying state–i.e., probability distributions for distinct quantum states overlap. Recent work shows that such a model is impossible (e.g. the PBR theorem (Nat. Phys. 8, p.474)). Significantly, our example demonstrates that non-trivial assumptions (beyond those required for a well-defined realistic model) are necessary for the PBR theorem and those like it.

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