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# QUANTUM INFORMATION AND THE PROBLEM OF TIME

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**Abstract.** In many cases tensor universality implies that multi-partite quantum-state processing is determined by what happens in totally disentangled cases. In independent systems relative time direction for the parts is arbitrary. This hints that time may be linked to entanglement and measurements and that there may be a measurement-only version of quantum mechanics. One-way quantum computation suggests that this may be possible.

## 1. Introduction

We have recently proved a theorem implying that under certain conditions quantum state processing in entangled systems is uniquely determined by processing in totally disentangles systems [3]. In totally disentangles systems time direction is arbitrary in the independent parts so one can ask: does time arise from entanglement and measurements? In particular, can unitary time evolution be reduced to entanglement and measurement? This is the reverse side of the quantum-mechanical measurement problem. Instead of "How do measurements happen?" we ask "How does unitary time evolution happen?". In other words: is there a measurement-only model of quantum mechanics? We argue that "yes" is a plausible answer.

We begin by illustrating the theorem in simple cases, including teleportation.

## 2. Tensor Universality and Quantum-state Processing

Consider subjecting a multipartite Heisenberg quantum state $\Phi \in \mathcal{H}_1 \otimes \cdots \otimes \mathcal{H}_n$ to $m$ successive observations, described by self-adjoint opertors $A_1, \dots, A_m$. Each $A_j$ acts in a subproduct of $\mathcal{H} = \mathcal{H}_1 \otimes \cdots \otimes \mathcal{H}_n$ where we assume it is non-degenerate. Assume for simplicity that each $A_i$ is a bipartite operator.