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Time emerging from quantum entanglement: an experimental illustration

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Time as an emergent property deriving from quantum correlations remains an open and controversial question among physicists. In fact, the ?problem of time? in essence stems from the fact that a canonical quantization of general
relativity yields the Wheeler-DeWitt equation predicting a static state of the universe, contrary to obvious everyday evidence. Page and Wootters speculated that by means of quantum entanglement, a static system may describe an
evolving ?universe? from the point of view of the internal observers. In particular, the entanglement between a ?clock? system and the rest of the universe can yield a stationary state for an (hypothetical) external observer that is able to test
the entanglement vs. abstract coordinate time. The same state will be, instead, evolving for internal observers that test the correlations between the clock and the rest. Thus, time would be an emergent property of subsystems of the universe deriving from their entangled nature. We present an experiment that illustrates Page and Wootters' mechanism of "static" time, and Gambini et al. subsequent refinements, describing how this idea can be naturally embedded into (small) subsystems of the universe, where Page and Wootters? mechanism can be easily studied.
We show how a static, entangled state of two photons can be seen as evolving by an observer that uses one of the two photons as a clock to gauge the time-evolution of the other photon. However, an external observer can show that
the global entangled state does not evolve.

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