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Relational quantum dynamics: Quantum time dilation and temporal nonlocality[1] ALEXANDER R. H. SMITH, Dartmouth College, PHILIPP A. HOEHN, University College London, MAXIMILIAN P. E. LOCK, University of Vienna, MEHDI AHMADI, Santa Clara University — The lesson of general relativity is background independence, which results in a Hamiltonian constraint. This presents a challenge for quantum gravity because the quantization of this constraint demands that physical states of geometry and matter are frozen, leading to the problem of time. We must then explain how the conventional notion of time evolution emerges, which motivates the need for relational quantum dynamics. Using covariant time observables, I will demonstrate the equivalence of two previously thought to be distinct approaches to relational quantum dynamics: the evolving constants of motion program and the Page-Wootters formalism. The equivalence between these approaches yields a temporal frame change map that transforms between the dynamics seen by different clocks. This map will be used to illustrate a temporal nonlocality effect that results in a superposition of time evolutions from the perspective of a clock indicating a superposition of different times. I will then demonstrate a novel quantum time dilation effect that occurs between two clocks when one moves in a superposition of different relativistic momenta. I will argue that this time dilation effect is observable with present-day technology and offers a new test of relativistic quantum mechanics.

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Alexander Smith
Dartmouth College

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