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Quantum systems under gravitational time dilation

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ABSTRACT:

Despite continuous development, modern physics still rests on two separate frameworks, quantum mechanics and general relativity. The notion of time is central to understanding the regime where both theories have to be jointly applied. This thesis develops an operational approach to the notion of time and temporal order in quantum theory by studying composed quantum systems – quantum “clocks” – subject to general relativistic time dilation. The approach can address scenarios in which proper time displays quantum properties, e.g. when a “clock” runs according to different proper times in superposition, and the resulting new effects are promising for near future experiments. The tools developed further enable treating scenarios in which causal relations between events cannot be described classically. A Gedankenexperiment is presented, that involves a massive body prepared in a specific quantum state, in which the order between time-like separated events effectively becomes “entangled”.