Quantum clock precision studied with a superconducting circuit

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We theoretically and experimentally study the precision of a quantum clock near zero temperature, explicitly accounting for the effect of continuous measurement. The clock is created by a superconducting transmon qubit dispersively coupled to an open co-planar resonator. The cavity and qubit are driven by coherent fields, and the cavity output is monitored with a quantum noise-limited amplifier. When the continuous measurement is weak, it induces persistent coherent oscillations (with fluctuating periods) in the conditional moments of the qubit, which are manifest in the output of the resonator. On the other hand, strong continuous measurement leads to an incoherent cycle of quantum jumps. We theoretically find the precision of the clock in each regime which reveals that in the coherent regime reveals that the precision can in principle be arbitrarily large in spite of the presence of measurement backaction. We also derive a kinetic uncertainty relation for the precision, and experimentally verify that this quantum clock obeys the kinetic uncertainty relation for the precision, thus making an explicit link between the (kinetic) thermodynamic behaviour of the clock and its precision, thus achieving the first experimental test of a kinetic uncertainty relation in the quantum domain.

References

[1] Xin He, Prasanna Pakkiam, Adil A. Gangat, Michael J. Kewming, Gerard J. Milburn, Arkady Fedorov, Quantum clock precision studied with a superconducting circuit, arXiv: 2207.11043