Contribution ID: **2** Type: **not specified**

A Severe Gravitational Constraint on Practical Quantum Computing in Rational Quantum Mechanics

Monday 30 June 2025 09:50 (40 minutes)

A Severe Gravitational Constraint on Practical Quantum
Computing in Rational Quantum Mechanics
By

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It is often argued that the continuum should not play a vital role in fundamental theories of physics; yet it does in quantum mechanics (QM) through QM's dependence on complex Hilbert Space. Here we propose an ansatz for discretising Hilbert Space and provide an explicit information-theoretic representation of the qubit state as a length L bit string. QM is the singular limit of this ansatz at $L = \infty$. With finite L, wavefunction collapse corresponds to a reduction in the information-theoretic content of the quantum state at a rate of at least one bit per unit Planck time t_p.Relating $L \times t_p$ to the collapse timescale in gravitised quantum mechanics, a quantitative estimate $L \approx 10^{193}$ is made for a typical qubit in a quantum computer. It is thus predicted that the quantum speed-up of algorithms with an exponential advantage over their classical counterparts (such as Shor's), will have saturated in quantum computations which utilise more than $\log_2 L \approx 640$ logical entangled qubits. This prediction should be verifiable in the coming 5-10 years. If verified, the practical utility of quantum computers for applications such as decryption will be severely limited by the finite nature of the laws of physics. More positively, it is proposed that quantum computers will provide an important resource for developing and testing future theories which seek to synthesise quantum and gravitational physics within a finite framework.

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