

Decoherence-Resistant Elastic Bits: A Novel Approach to Quantum Analogue Computing Using Coherent Superpositions of States

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Abstract

In quantum information science and technology (QIST), the superposition of states is pivotal. Current qubits, formed by superposing two pure states, are foundational in QIST but are susceptible to decoherence, causing loss of superposed states. Addressing this, we introduced an "elastic bit" using the Hertz-type nonlinearity of elastic beads under external driving. These beads exhibit phase-dependent nonlinear vibrations, leading to coherent superpositions of energy states in linear vibration modes. The resulting amplitudes span a two-dimensional Hilbert space, with time allowing parametric spanning. We showcased the Hadamard gate, translating one state superposition to another through a unitary transformation. Remarkably, these elastic bits operate at room temperature and resist decoherence, making them apt for intermediate-scale quantum analogue computing. They offer solutions for challenges in supercomputing for artificial intelligence and autonomous vehicle data processing.

Biographies

Kazi Tahsin Mahmood is a graduate student in the Department of Mechanical Engineering at Wayne State University. He earned his B.Sc. in Mechanical Engineering from Bangladesh University of Engineering and Technology. His undergraduate research field is on Mechanics of Materials. He is currently working on the topological characteristics of nonlinear granular beads and studying the classical analogous superposition of states. His research spans both the theoretical and experimental aspects, particularly focusing on the harmonic oscillations exhibited by these beads in nonlinear systems.

M. Arif Hasan is an assistant professor in the Department of Mechanical Engineering at Wayne State University. He received his Ph.D. from the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign. Throughout his academic journey, Dr. Hasan has demonstrated a strong commitment to excellence in research and has a particular passion for research-based mentoring. His dedication to this aspect of his profession is highlighted by the funding he has received from the National Science Foundation (NSF) to support and cultivate the next generation of engineers and researchers.