Linear and nonlinear spin control of a harmonic qudit hosted in an oscillator

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Spins and oscillators are foundational to much of physics and applied sciences. For quantum information, a spin 1/2 exemplifies the most basic unit, a qubit. High angular momentum spins (HAMSs) and harmonic oscillators provide multi-level manifolds (e.g., qudits) which have the potential for hardware-efficient protected encodings of quantum information and simulation of many-body quantum systems. In this talk, I will describe our recent work on novel protocols and perspectives on quantum control protocol that conceptually merges these disparate hardware platforms [1]. Namely, we show how to modify a harmonic oscillator on-demand to implement a continuous range of generators associated to resonant driving of a harmonic qudit, including both linear (SU(2)) rotations and harmonicity-preserving nonlinear spin rotations. Our scheme allows the first universal control of such a harmonic qudit encoding: we use linear operations to accomplish four logical gates and show that our nonlinear operations complete the logical gate set. Finally, I will discuss how these insights have led us to some new ideas for fault-tolerant gates on qudit encodings [2].

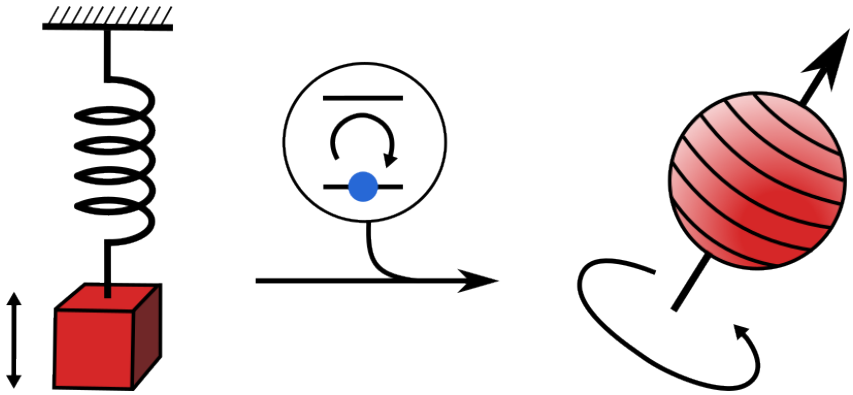

Figure 1, Schematic of our protocol [1].

[1] S. Roy, et al. arXiv:2405.15695 (2024)
[2] O. Wetherbee, et al. [in preparation]