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A Cryogenic Linear Paul Trap for Quantum Simulation[1]

PAUL HESS, HARVEY KAPLAN, AARON LEE, BRIAN NEYENHUIS, LEXI PARSAGIAN, PHIL RICHERME, JAKE SMITH, CHRISTOPHER MONROE, Joint Quantum Institute, University of Maryland Department of Physics and National Institute of Standards and Technology, College Park, Maryland 20742 — Ions confined in radio frequency Paul traps are a useful tool for quantum simulation of long-range spin-spin interaction models. As the system size increases, classical simulations cannot fully compute the properties of the exponentially growing Hilbert space, necessitating quantum simulation for accurate predictions. Current experiments are limited to less than 20 qubits due to the fragile nature of linear ion chains. Even at UHV pressures, collisions with background gas particles are sufficient to melt the ion crystal and frequent enough to disrupt the accumulation of statistics. We present progress towards the construction of a cryogenic ion trap apparatus, designed to cryopump background gas within the 4K chamber. The resulting reduction in pressure will allow robust trapping of up to 100 ions in a single chain. Cooling is provided by a closed cycle cryostat with a gas mediated thermal linkage which mechanically decouples the ion trap from the vibrating cold head. A spherical octagon surrounding the ion trap allows optical access for global and individual addressing beams and high numerical aperture fluorescence collection.

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