DAMOP19-2019-020072

Abstract for an Invited Paper
for the DAMOP19 Meeting of
the American Physical Society

Large-Scale Quantum Simulators and Quantum Computers over Continuous Variables: Theory and Experiment[1]

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Continuous-variable (CV) quantum computing [1,2] is based on harmonic-oscillator qumodes such as position and momentum, or the two quadrature amplitudes of the quantized electromagnetic field, rather than on qubit- or qudit-based discrete encodings. It is a viable approach for which error correction [3] and fault tolerance [4] have been elucidated. It is particularly well suited to electromagnetic qumodes, which scale up very well as the resonant modes of a single optical cavity, such as that of an optical parametric oscillator, analogously to the classical optical frequency comb of a femtosecond laser. This allows cluster entangled states, which are quantum-computing "substrates" [5] in a sense, to be implemented over CV [6] on very large scales [7] as was experimentally demonstrated in the quantum optical frequency comb of a single OPO (60 entangled qumodes, simultaneously accessible) [8]. Note that sequential time-bin implementations are also possible (one million entangled qumodes, accessible two at a time) [9]. This paves the way to realizing interesting testbeds for bosonic, and possibly more general, quantum simulation [10]. In this talk, I will present the fundamentals of scalable CV cluster state generation in quantum optics, experimental realizations on five different continents, and applications to quantum simulation.
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[1] This work was supported by the U.S. National Science Foundation.