Probing thermodynamics and entanglement with bosonic quantum simulators

Jens Eisert

FU Berlin, Arnimallee 14, Berlin 14195, Germany

Quantum simulators based on bosonic systems–particularly cold atoms on atom chips, but also superconducting devices–allow us to probe thermodynamic features and protocols under precisely controlled conditions. This talk will elaborate on this theme along several lines of thought. We will explore how Landauer's principle can be experimentally tested, relating the erasure of information to the dissipation of heat in the quantum many-body regime [1]. We will also highlight the considerable challenge of detecting entanglement in such cold-atom quantum simulators [2], and examine how compactness can curb entanglement growth in bosonic systems [3]. Furthermore, we will argue that analog quantum simulators are presumably more robust to noise than their digital counterparts [4]. Finally, we will discuss in what ways quantum advantages may emerge in bosonic quantum simulators [5], and how notions of Hamiltonian learning are expected to support this endeavor [6].

[1] Nature Physics 21, 1326 (2025)

[2] In preparation (2026)

[3] arXiv:2603.16775 (2026)

[4] arXiv:2510.08467 (2025)

[5] In preparation (2026)

[6] Nature Comm. 15, 9595 (2024)