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An open-system quantum simulator with trapped ions JULIO T. BARREIRO, P. SCHINDLER, D. NIGG, T. MONZ, M. CHWALLA, M. HENNRICH, Institute for Experimental Physics, Univ. of Innsbruck, M. MÜLLER, P. ZOLLER, Institute for Theoretical Physics, Univ. of Innsbruck, Institute for Quantum Optics and Information, Austrian Academy of Sciences, C.F. ROOS, R. BLATT, Institute for Experimental Physics, Univ. of Innsbruck, Institute for Quantum Optics and Information, Austrian Academy of Sciences — We present the realization of an experimental toolbox for simulating an open quantum system with up to five qubits by engineering the multi-qubit dynamics through a controlled coupling to an environment. Using a quantum computing architecture with trapped ions, multi-qubit gates are combined with optical pumping to implement coherent operations and dissipative processes. We illustrate this engineering by the dissipative preparation of entangled states, the simulation of coherent many-body spin interactions, and the quantum non-demolition measurement of multi-qubit observables. Our toolbox represents a conceptual step towards the realization of an open quantum system simulator with applications in various fields, including condensed-matter physics and quantum chemistry, possibly in modeling quantum effects in biology, and in quantum computation driven by dissipation.

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