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A monomial matrix formalism to describe quantum many-body states

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We propose a framework to describe and simulate a class of many-body quantum states. We do so by considering joint eigenspaces of sets of monomial unitary matrices, called here "M-spaces"; a unitary matrix is monomial if precisely one entry per row and column is nonzero. We show that M-spaces encompass various important state families, such as all Pauli stabilizer states and codes, the AKLT model, Kitaev's (abelian and non-abelian) anyon models, group coset states, W states and the locally maximally entanglable states. We furthermore show how basic properties of M-spaces can transparently be understood by manipulating their monomial stabilizer groups. In particular we derive a unified procedure to construct an eigenbasis of any M-space, yielding an explicit formula for each of the eigenstates. We also discuss the computational complexity of M-spaces and show that basic problems, such as estimating local expectation values, are NP-hard. Finally we prove that a large subclass of M-spaces—containing in particular most of the aforementioned examples—can be simulated efficiently classically with a unified method.

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