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TITULO: Purifications of multipartite states: limitations and constructive methods

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ABSTRACT:

Matrix product forms are an efficient way of representing quantum many-body systems. For mixed states, there are two such forms: (i) as matrix product density operators, or (ii) as a purification that is itself written as a matrix product state, which allows to check positivity locally, and is thus well-behaved and stable under local truncations. Here we show that form (ii) can be arbitrarily more costly than form (i), thus revealing a tradeoff between efficiency and local positivity. Our proof uses very recent results in convex polytopes, which have also been used to prove separations in communication complexity. In addition, we provide two constructive methods to obtain form (ii) out of (i). The sum of squares polynomial method scales exponentially in the number of different eigenvalues, and its approximate version is formulated as a Semidefinite Program, which works efficiently and robustly for the tested eigenvalue distributions. The eigenbasis method scales quadratically in the number of eigenvalues, and its approximate version is very efficient for rapidly decaying distributions. Our results imply that a description of mixed states that is both efficient and locally positive semidefinite does not exist, but that good approximations do.

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