Purifications of multipartite states: limitations and constructive methods

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We analyze the description of quantum many-body mixed states using matrix product states and operators. We consider two such descriptions: (i) as a matrix product density operator of bond dimension D, and (ii) as a purification that is written as a matrix product state of bond dimension D'. We show that these descriptions are inequivalent in the sense that D' cannot be upper bounded by D only. Then we provide two constructive methods to obtain (ii) out of (i). The sum of squares (sos) polynomial method scales exponentially in the number of different eigenvalues, and its approximate version is formulated as a Semidefinite Program, which gives efficient approximate purifications whose D' only depends on D. 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 which is both efficient and locally positive semidefinite does not exist, but that good approximations do.

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- SIQS [4]
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- 03.90.+m (Other) mathematical aspects of composite quantum systems [6]

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