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Departamentos de Física Teórica I y II
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TITULO: Preparing topological states on a quantum computer

(joint work with Martin Schwarz, Kristan Temme, Frank Verstraete, and David Perez-Garcia)

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ABSTRACT

Projected Entangled Pair States (PEPS) are often presented as the natural class of states for modelling ground states of non-critical many-body quantum systems. On the other hand, we know that an oracle which can generate an arbitrary PEPS, given its classical description, is an unreasonably powerful computational resource (PP-complete).

So which PEPS are "physical"? In other words, which of them can be prepared efficiently on a quantum computer?

This question was raised by Verstraete, Wolf, Perez-Garcia, and Cirac in 2006. Schwarz, Temme and Verstraete recently gave a solution for the sub-class known as "injective" PEPS (which are always unique ground states of local Hamiltonians), in the form of a new quantum algorithm for constructing these states using a quantum computer. The algorithm is efficient as long as the injective PEPS is well-conditioned. This class of states includes many physically interesting ones, such as the ground state of the 2D AKLT model.

However, the "injectivity" property rules out all topological quantum states (which by definition cannot be unique ground states of local Hamiltonians). The more general class of G-injective PEPS are defined over a discrete symmetry group G. This more general class of PEPS includes many important topological quantum states: familiar examples such as Kitaev's toric code, and more exotic examples such as resonating valence bond states. By generalising the PEPS preparation algorithm to the larger class of G-injective PEPS, we show how to prepare these more exotic topological quantum states using a quantum computer. The algorithm is again efficient as long as the G-injective PEPS is well-conditioned.

References: arXiv:1104.1410, arXiv:1211.4050