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Noiseless quantum circuits for measuring entanglement

The non-local properties of a density matrix are often defined in terms of the effects of unphysical maps, such as the Partial Transpose on the spectrum of the density matrix (PT-spectrum). Is it possible to measure these functions efficiently, or must we use full state tomography?

Previously proposed methods for measuring these quantities directly relied on the Structural Physical Approximation, which typically produce output states with visibilities that scale poorly with the system size. The moments of the resulting modified density operator must then be measured in a separate procedure, which can be done using a set of generalized Mach-Zehnder interferometers. The spectrum can then be obtained using a little algebra.

I will show how to construct a family of simple quantum circuits that can determine the PT-spectrum for any bipartite state, without incurring any loss of visibility. These circuits measure the minimum amount of information required to determine the PT-spectrum completely. They depend only on the dimension of the state and they will be exact up to the statistical uncertainties inherent in any experimental data. The analysis of the output of these circuits for general bipartite states also raises an interesting eigenspectrum reconstruction problem.