Self-testing of quantum state ensembles and extreme POVMs in the prepare-and-measure scenario

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1. Abstract

Think of a communication scenario where one party, Alice, prepares D-dimensional states that another party, Bob, probes. In such a prepare-and-measure scenario, we prove that any set of pure states {\psi_i}_{i=1}^M and any set of extreme POVMs {Q_j}_{j=1}^N can be jointly and robustly self-tested. That is: there exists a linear function f, acting on the vector P of measurement probabilities, such that f(P) is close to its maximum value iff the underlying quantum states and measurements generating P are close in trace (resp., operator) norm to the reference states and POVMs, modulo a unitary or an anti-unitary transformation. The proof requires a generalization of Wigner's theorem, a fundamental result in particle physics that characterizes the structure of physical symmetries. The robustness analysis combines ideas from quantum state discrimination and exactly solvable models.