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Nonnegative subtheories of qubits: stabilizer states and more STEPHEN BARTLETT, JOEL WALLMAN, The University of Sydney — Negativity in a quasi-probability representation is typically interpreted as an indication of nonclassical behavior. However, this does not preclude bases that are nonnegative from having interesting applications—the single-qubit stabilizer states have nonnegative Wigner functions and yet play a fundamental role in many quantum information tasks. We determine what other sets of quantum states and measurements of a qubit can be nonnegative in a quasi-probability distribution, and identify nontrivial groups of unitary transformations that permute such states. These sets of states and measurements are analogous to the single-qubit stabilizer states. We show that no quasi-probability representation of a qubit can be nonnegative for more than 2 bases in any plane of the Bloch sphere. Furthermore, there is a unique set of 4 bases that can be nonnegative in an arbitrary quasi-probability representation of a qubit. We provide an exhaustive list of the sets of single-qubit bases that are nonnegative in some quasi-probability distribution and are also closed under a group of unitary transformations, revealing two families of such sets of 3 bases with quasi-probability distributions defined on a space of 8 ontic states. We extend several of these results to higher dimensions.

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