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The operational foundations of PT-symmetric and quasi-Hermitian quantum theory

PT-symmetric quantum theory was originally proposed with the aim of extending standard quantum theory by relaxing the Hermiticity constraint on Hamiltonians. However, no such extension has been formulated that consistently describes states, transformations, measurements and composition, which is a requirement for any theory. We aim to answer the question of whether a consistent theory with PT-symmetric observables extends standard quantum theory. We work within the framework of general probabilistic theories, which is the most general framework for physical theories. We construct the set of states of a system with PT-symmetric observables, and show that the resulting theory allows only one trivial state. We then analyze one of the most popular fixes to the issues of PT-symmetric quantum theory, which is the requirement of quasi-Hermiticity on observables. After showing that quasi-Hermitian systems are equivalent to standard quantum systems, we prove that if PT-symmetry is added on top of quasi-Hermiticity, then the system is equivalent to a real quantum system. Thus our results show that neither PT-symmetry nor quasi-Hermiticity constraints are sufficient to extend standard quantum theory consistently.