Abstract

Quantum Information

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Beyond Noether's theorem: on robustness of conservation laws

Joint with Kamil Korzekwa and David Jennings

Symmetries of closed systems lead to conservation laws. Under a unitary symmetric dynamics, expectation values of Noether's conserved charges remain constant. However, for open quantum systems this is usually no longer the case. *How robust are conservation laws under a dynamics described by a symmetric (covariant) quantum channel?* We quantify the trade-off relations between decoherence and violations of conservation laws for systems that undergo a symmetric general quantum process. The analysis leads to bounds on unitarity in terms of the average deviation from the conservation laws. We show that if a symmetric quantum channel approximates a symmetric unitary dynamics then the corresponding conservation law holds approximately. The converse holds only for particular cases such as spin systems carrying an irreducible representation of $SU(2)$, and more generally whenever the input and output operator spaces have a multiplicity-free decomposition into irreducible components. Therefore for these particular types of symmetries we show robustness of conservation laws under symmetric interaction with an environment. We also investigate *what are the maximal expected deviations from a conservation law*? These give fundamental limits imposed by quantum mechanics and for spin j systems the question is directly related to the maximal allowed spin inversion which in the particular case of 1/2-spin system is achieved by the Universal-NOT operation.