Quantum Martingale Theory and Entropy Production

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We develop a martingale theory to describe fluctuations of entropy production for open quantum systems in nonequilbrium steady states. Using the formalism of quantum jump trajectories, we identify a decomposition of entropy production into an exponential martingale and a purely quantum term, both obeying integral fluctuation theorems. Moreover, employing martingale theory, we obtain genuine universal results for stopping-time and infimum statistics of stochastic entropy production. We demonstrate our results with numerical simulations of a qubit system.