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Second-Order Asymptotics for the Classical Capacity of Image-Additive Quantum Channels

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We study non-asymptotic fundamental limits for transmitting classical information over memoryless quantum channels, i.e. we investigate the amount of classical information that can be transmitted when a quantum channel is used a finite number of times and a fixed, non-vanishing average error is permissible. Specifically we consider the classical capacity of quantum channels that are image-additive, including all classical to quantum channels, as well as the product state capacity of arbitrary quantum channels. In both cases we show that the non-asymptotic fundamental limit admits a second-order approximation that illustrates the speed at which the rate of optimal codes converges to the Holevo capacity as the blocklength tends to infinity. The behavior is governed by a new channel parameter, called channel dispersion, for which we provide a geometrical interpretation.