

Research Highlight: Moderate deviation analysis for classical communication over quantum channels

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In this joint work [CTT17] with Christopher T. Chubb (University of Sydney) and Marco Tomamichel (University of Technology Sydney), we are interested in characterising the fundamental performance limits of classical communication over classes of quantum channels. Such analyses potentially have immense impact in the study of performance limits of quantum computing and quantum cryptography. Specifically, we analyze families of codes that have both a vanishing probability of error and a code rate approaching capacity as the code length increases (see figure below). To characterise the fundamental tradeoff between decoding error, code rate and code length for such codes we introduce a quantum generalisation of the moderate deviation analysis proposed originally by Altuğ and Wagner [AW14] as well as Polyanskiy and Verdú [PV10]. We derive such a tradeoff for classical-quantum (as well as image-additive) channels in terms of the channel capacity and the channel dispersion, giving further evidence that the latter quantity characterises the necessary backoff from capacity when transmitting finite blocks of classical data. To derive these results we also study asymmetric binary quantum hypothesis testing in the moderate deviations regime. Due to the central importance of the latter task, we expect that our techniques will find further applications in the analysis of other quantum information processing tasks.

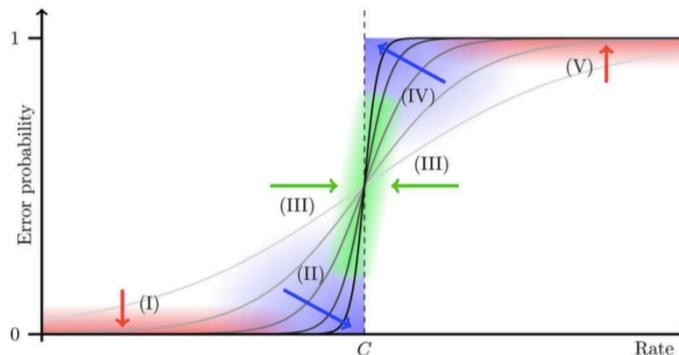


Figure 1: Different regimes of operation. We operate in regimes (II) and (IV) in which the probability of error approaches 0 or 1 and the rate approaches the first-order fundamental limit, i.e., the capacity.

References:

- [AW14] Y. Altuğ and A. B. Wagner “Moderate deviations in channel coding”, *IEEE Trans. Inf. Theory*, 60, 4417–4426 (2014).
- [CTT17] C. T. Chubb, V. Y. F. Tan, and M. Tomamichel, “Moderate Deviations Analysis for Classical Communication over Quantum Channels”, *Communications in Mathematical Physics*, Vol. 355, No. 3, Pages 1283–1315, Nov 2017
- [PV10] Y. Polyanskiy and S. Verdú, “Channel dispersion and moderate deviations limits for memoryless channels”. *48th Annual Allerton Conf. on Communication, Control, and Computing*, pp. 1334–1339, 2010