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Quantum groups and quantum information theory

Let $\mathbb{G} = (\mathcal{M}, \Gamma, \varphi, \psi)$ be a co-amenable locally compact quantum group. In recent work with M. Junge and Z.-J. Ruan, we have constructed and studied a completely isometric representation of the algebra of completely bounded (right) multipliers of $L_1(\mathbb{G})$ on $\mathcal{B}\big(L_2(\mathbb{G})\big)$. This extends and unifies earlier work by F. Ghahramani, E. Størmer and myself in the case $\mathcal{M} = L_\infty(G)$, and by Z.-J. Ruan, N. Spronk and myself for $\mathcal{M} = VN(G)$, where G is a locally compact group. We have shown that the multiplier algebra can in fact be identified with the algebra of completely bounded, normal $\widehat{\mathcal{M}}$-bimodule maps on $\mathcal{B}\big(L_2(\mathbb{G})\big)$ leaving $\mathcal{M}$ invariant. The part of the latter algebra consisting of completely positive maps provides a natural class of quantum channels which, from the viewpoint of quantum computing, are of particular interest in the case of finite-dimensional quantum groups.

In this talk, we shall discuss various applications of the above representation to quantum information theory. Indeed, several properties of our channels are highly desirable with regard to quantum error correction: the bimodule property means precisely that the channels are noiseless for $\widehat{\mathcal{M}}$; moreover, every such channel has a symbol which is easy to retrieve, and the completely bounded minimal entropy (*cb-entropy*) can be calculated explicitly. Note that the cb-entropy has recently be shown to be additive (I. Devetak, M. Junge, C. King, and M. B. Ruskai); proving additivity of the bounded minimal entropy is a major open problem in quantum information theory.

This is joint work with Marius Junge, David Kribs and Zhong-Jin Ruan.