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Optimization of quantum states for signaling across an arbitrary qubit noise channel with minimum-error detection

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Résumé en anglais	For discrimination between two signaling states of a qubit, the optimal detector minimizing the probability of error is applied to the situation where detection has to be performed from a noisy qubit affected by an arbitrary quantum noise separately characterized. With no noise, any pair of orthogonal pure quantum states is optimal for signaling as it enables error-free detection. In the presence of noise, detection errors are in general inevitable, and the pairs of signaling states best resistant to such noise are investigated. With an arbitrary quantum noise, modeled as a channel affecting the qubit, and when minimum-error detection is performed from the output, a characterization of the optimal input signaling pairs and of their best detection performance is obtained through a simple maximization of a quadratic scalar criterion in three constrained real variables. This general characterization enables to establish that such optimal signaling pairs are always made of two orthogonal pure quantum states, but that they must be specifically selected to match the noise properties and prior probabilities. The maximization is explicitly solved for several generic quantum noise processes relevant to the qubit, such as the squeezed generalized amplitude damping noise which describes interaction with a thermal bath representing a decohering environment and which includes as special cases both the generalized and the regular amplitude damping noise processes, and such as general Pauli noise processes which include for instance the bit-flip noise and the depolarizing noise. Also, examined is the situation of one imposed (pure or mixed) signaling state, for which the other associated signaling state optimal for noisy detection is determined as a pure state, yet not necessarily orthogonal.
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