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Robust quantum receivers for coherent state discrimination

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Quantum state discrimination is a central task for quantum information and is a fundamental problem in quantum mechanics. Nonorthogonal states, such as coherent states which have intrinsic quantum noise, cannot be discriminated with total certainty because of their intrinsic overlap. This nonorthogonality is at the heart of quantum key distribution for ensuring absolute secure communications between a transmitter and a receiver, and can enable many quantum information protocols based on coherent states. At the same time, while coherent states are used for communications because of their robustness to loss and simplicity of generation and detection, their nonorthogonality inherently produces errors in the process of decoding the information. The minimum error probability in the discrimination of nonorthogonal coherent states measured by an ideal lossless and noiseless conventional receiver is given by the standard quantum limit (SQL). This limit sets strict bounds on the ultimate performance of coherent communications and many coherent-state-based quantum information protocols. However, measurement strategies based on the quantum properties of these states can allow for better measurements that surpass the SQL and approach the ultimate measurement limits allowed by quantum mechanics. These measurement strategies can allow for optimally extracting information encoded in these states for coherent and quantum communications. We present the demonstration of a receiver based on adaptive measurements and single-photon counting that unconditionally discriminates multiple nonorthogonal coherent states below the SQL. We also discuss the potential of photon-number-resolving detection to provide robustness and high sensitivity under realistic conditions for an adaptive coherent receiver with detectors with finite photon-number resolution.