In this dissertation we investigate the capabilities of a generalized version of the displacement receiver (DR) in the context of classical communication with coherent states over noisy channels. The receiver itself consists of a displacement operation followed by a photon-number resolving detector and enables flexible strategies to cope with different communication tasks at hand, e.g. different types of noise or encodings. The physical channel over which the states are transferred is modelled as a quantum channel and all scenarios are analyzed on the basis of the error probability as well as mutual information.

When communication takes place over a lossless and noiseless channel with information encoded in a binary alphabet of coherent states, the optimal measurement is known to be the Dolinar receiver and the displacement receiver provides the same scaling of the error probability with the average energy of the alphabet.

Assuming an infinite photon-number resolution (PNR) the DR can interpolate between operating as a photon counter and a homodyne detector by controlling the displacement. Also, the Dolinar receiver can be understood as a series of DRs using the information provided by its predecessors. Therefore, we can use the theoretical concept of the DR as a basic model to understand advantages and disadvantages of the various receivers.

Imperfections in different parts of a DR have to be taken into account for a realistic theoretical model. We analyze the effects of non-unit visibility, dark counts, afterpulsing and limited detection efficiency on the DR. Non-unit visibility imposes the most severe restriction, but all of them can be mitigated by PNR and optimization of the communication strategy. Already current or near term technology allows for sub-shot noise detection and the DR is therefore an interesting candidate for optical communication.

Apart from standard classical communication the DR can also be employed to show superadditivity of accessible information. In the limit of vanishing average energy the DR approaches the optimal individual measurement. Based on previous proposals we show that there exist several setups for achieving a superadditive advantage of accessible information with the DR in the low power limit.

All of the applications rely on a near-optimal performance of the receiver. However, displacement receivers in particular are susceptible to noise in the channel that may render them useless. The particular impact depends highly on the type of noise in question.

First, we analyze a scenario where thermal noise is present in the communication channel. Here, the DR can be made more robust by increasing the PNR of the detector. Only for large amounts of thermal background photons the DR gets overwhelmed and conventional detection provides better results. In the photon-starved regime pulse-position modulation is a commonly employed type of encoding and also in this scenario the DR can offer an improvement in performance when thermal noise is present.

Another type of noise is phase noise which directly affects the phase variable of the state. As a physical motivation, we develop a full quantum model of lossy state transmission through a nonlinear medium and show that quantum effects are indeed present. Due to the interplay between distributed losses and the nonlinearity a fundamental type of nonlinear phase noise arises where the strength of the phase noise is closely tied to the energy of the state. We analyze the effects of communication over such a nonlinear channel and the impact on the generation of squeezed states in a nonlinear Kerr medium.

Furthermore we study how both linear and nonlinear phase noise impact binary alphabets and possible receivers. Conventionally implemented DRs are especially vulnerable to phase noise and loose their advantage over conventional receivers rather quickly with rising strength of the noise. However, the DR is able to retain its superior performance by optimizing its displacement at the same time as the alphabet. The particular strategy depends on the constraint placed on the energy of the alphabet and we consider a constraint on the average and maximum energy. Notably, the DR approaches the Helstrom bound for very strong phase noise.