SUMMARY OF Ph.D. DISSERTATION

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Title

Generation and purification of optical coherent state superposition for quantum information processing with continuous variables

Abstract

The development of some fields of modern physics leads to the possibility to control quantum phenomena even better. The transfer of the properties of a quantum state, partially even interaction-free measurements and the computation with quantum state are examples for that. On the other hand, the coherent state of light will keep acting as a communication carrier because of its robustness against the linear loss in communication channels. Therefore, a most realizable novel communication scheme, which can significantly increase the capacity of communication, is a classical-quantum hybrid system where the quantum computation is combined in the node points with conventional optical communication. All this is based on the principles of the state superposition and entanglement of various systems. Coherent state superposition (CSS) is the most basic state to treat continuous variables of optical coherent states, but its generation is difficult. Furthermore, the CSS easily decoheres in a linear dissipative process, which is unavoidable in its generation and propagation.

In this study, to overcome this issue, first, a theoretical analysis is made on the two previously proposed schemes for generating the CSS under taking account of imperfections in experiments to evaluate their feasibilities. A practical protocol for restoring the CSS is proposed and its performance is evaluated. Furthermore, the experiment to generate quadrature squeezed light with higher purity that is required for the CSS generation is performed. These results will contribute to experimental implementation of the CSS, which is a milestone in developing the optical quantum information processing with continuous variables using the coherent states.

Chapter 1 summarizes previous studies on the quantum information processing and addresses the main objective of this study.

Chapter 2 gives preparations for the analytical studies described in chapter 3—4.

Chapter 3 describes the analysis on the schemes for the CSS generation under taking account of experimental imperfections. The first scheme is based on the quadrature squeezing onto the single-photon state. The other scheme is based on subtracting one photon from the quadrature squeezed state. The analysis clarified that the latter scheme is more feasible under practical conditions.

Chapter 4 gives the proposal of the purification protocol based on homodyne detection and event selection. Under specific conditions, the protocol purifies the decohered CSS which has undergone a linear dissipative process.

Chapter 5 describes the experiment of quadrature squeezed light generation at a wavelength of 860 nm using periodically-poled $KTiOPO_4$ crystals. The maximum squeezing level of −7.5 dB and the purity of 0.97 with the squeezing level of −3 dB have been achieved.

Chapter 6 gives the conclusion to summarize the results of this study and gives future prospects.