論文 / 著書情報
Article / Book Information

題目(和文)	弱値増幅における最適プローブと統計的検定
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	基礎物理学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　理学　）
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要旨（英文 800 語程度）
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Recently, the weak-value amplification (WVA) has been extensively investigated as a promising quantum technique for improving an accuracy of a precision measurement. The basic idea of the WVA comes from the weak measurement introduced by Aharonov, Albert, and Vaidman in 1988. The weak measurement is the indirect quantum measurement with the weak interaction and postselection of the final state of the measured system. The attention point is that we can measure the quantity called the weak value with the weak measurement, which appears in the shift of the measuring probe induced by the interaction between the measured system and the measuring probe. Because the weak value can be outside the range of the eigenvalues, the shift of the measuring probe obtained by the weak measurement becomes larger than the one given by the measurement without postselection. This shift amplification effect by the weak value is the WVA, which has been studied for precisely measuring the small interaction strength.

In this thesis, we consider the ways to make the WVA advantageous. Especially, we concentrate on the two applications of the WVA from the different viewpoints, a probe engineering to give a large amplification and a task of the statistical hypothesis testing for the interaction detection problem.

First, we analytically obtain the optimal probe wave function for a given weak value by the variational method. It is shown that the amplification factor obtained by the optimal probe has no-upper bound while the one in the Gaussian probe already reported by some researchers has the upper bound. Furthermore, the variance of the optimal probe after the measurement can be zero for a certain weak value. We can derive the optimal probe by the Lagrange multiplier method for maximizing the shift of the probe position or minimizing the variance of the final distribution. Through the discussion of the optimal probe wave function, we find that the preparing initial probe other than Gaussian would be significant for developing the WVA.

Second, we have developed the way which has a technical advantage of the WVA from the viewpoint of statistics. It is often argued that the WVA is not helpful for the parameter estimation. Therefore, we consider the statistical inferences that the WVA will be advantageous. We propose a method to determine whether the interaction is present or not and evaluate the capability of the WVA for this interaction detection problem by using the hypothesis testing in statistics. As the main result, it is shown that the merit of the WVA is the reduction of the possibility to miss the presence of the interaction more than the conventional measurement while keeping the probability of a misdetection, when the absolute value of the weak value is outside the range of the eigenvalues. In this discussion, we assume that the number of the obtained data is infinitely large and we neglect the data loss by the failure of the postseleciton. Furthermore, we apply our proposed testing method to the famous weak measurement experiment to understand the physical intuition of the proposed testing method. This experiment uses the two polarizers and the single birefringent crystal, which is originally designed for measurement of a weak value. In this framework, we consider the testing problem to determine whether a crystal used is birefringent or not. We show that the case of the almost orthogonal angles of the two polarizers, which does not satisfy the weak coupling approximation, make the WVA notable powerful in terms of the testing power. This result will support the experimental usefulness of the proposed testing method with the WVA.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).