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Collapse Postulate for Observables with Continuous Spectra

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Abstract. In order to provide a mathematical framework for discussing the statistical correlations between the outcomes, when an arbitrary sequence of observables are measured, it is necessary to generalize the conventional von Neumann–Lüders collapse postulate to observables with a continuous spectrum. It is shown that the standard prescription in conventional quantum theory for the joint probabilities of compatible observables is sufficient to characterize, more or less completely, the appropriate "generalized collapse postulate" which associates with each observable a unique "finitely additive expectation valued measure". An interesting feature of the collapse associated with observables with continuous spectra, which again follows from the basic principles of conventional quantum theory, is that it must be formulated in terms of the so-called non-normal conditional expectations, which implies that the joint probabilities associated with successive observations of such observables are not in general σ-additive. The implications of this non-σ-additivity on the determination of expectation values, correlation functions etc., are also investigated. It is demonstrated that the basic prescriptions introduced in this paper constitute a natural completion of the framework of conventional quantum theory for discussing the statistics of an arbitrary sequence of observations.

I. Introduction

One of the major problems of the quantum theory of measurement, which has eluded a satisfactory solution so far, has been that of extending the collapse postulate to observables with a continuous spectrum. It is well known that the collapse postulate plays a very crucial role in quantum theory in any discussion of the statistics of the outcomes of a sequence of observations performed on a system. However, the collapse postulate as introduced by von Neumann [1] and later

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