PROTECTIVE MEASUREMENT AND QUANTUM REALITY

Protective measurements offer an intriguing method for measuring the wave function of a single quantum system. With contributions from leading physicists and philosophers of physics – including two of the original discoverers of this important method – this book explores the concept of protective measurement, investigating its broad applications and deep implications.

Addressing both physical and philosophical aspects, it covers a diverse range of topics, including the experimental possibility of protective measurements, connections with the PBR theorem, and the implications of protective measurement for understanding the nature of quantum reality. Including a clear and concise introduction to standard quantum mechanics, conventional measurement, and the fundamentals of protective measurement, this is a valuable resource for graduate students and researchers interested in the conceptual foundations of quantum mechanics.

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PROTECTIVE MEASUREMENT AND QUANTUM REALITY

Towards a New Understanding of Quantum Mechanics

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To my parents

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Preface

In 1993, Yakir Aharonov, Lev Vaidman and Jeeva Anandan discovered an important new method of measurement in quantum mechanics, the so-called protective measurement. Distinct from conventional measurements, protective measurement is a method for measuring the expectation value of an observable on a single quantum system. By a series of protective measurements, one can even measure the wave function of a single quantum system. In this way, theoretical analysis of protective measurement may lead to a new and deeper understanding of quantum mechanics. Moreover, its experimental realization may also be useful for quantum information technology.

This book is an anthology celebrating the 20th anniversary of the discovery of protective measurement. It begins with a clear and concise introduction to standard quantum mechanics, conventional measurement and protective measurement, and contains fourteen original essays written by physicists and philosophers of physics, including Yakir Aharonov and Lev Vaidman, the two discoverers. The topics include the fundamentals of protective measurement, its meaning and applications, and current views on the importance and implications of protective measurement. The book is accessible to graduate students in physics and chemistry. It will be of value to students and researchers with an interest in the meaning of quantum theory and especially to physicists and philosophers working on the foundations of quantum mechanics.

When I contacted potential contributors to this anthology, one of them replied, "Protective measurements are something I know nothing about." Indeed, as one referee of this book also admitted, although protective measurement has attracted attention over the last 20 years and has raised many interesting questions, it is still an under-studied aspect of quantum mechanics. In recent years the associated field of weak measurement has seen significant increased activity, and the latest Pusey–Barrett–Rudolph theorem has also caused many people to revisit the question of the reality of the wave function. Can protective measurement, like weak measurement,

be performed in laboratories in the near future? Do protective measurements anticipate the Pusey–Barrett–Rudolph theorem? What, if any, are the implications of protective measurements for the ontological meaning of the wave function and the nature of quantum reality? I hope this anthology will arouse more researchers' interest in protective measurement and its implications, and further open up a new line of research in the foundations of quantum mechanics.

I wish to express my warm thanks to Baichun Zhang, Yidong Liu and Miao Tian for helpful discussions, which inspired me to take up the project of editing an anthology about protective measurement and relevant topics. I am grateful to Yakir Aharonov and Lev Vaidman for their support for the project. I thank all contributors for taking the time to write these new essays in the anthology. I also thank Simon Capelin of Cambridge University Press for his kind support as I worked on this project, and the three referees who gave helpful suggestions on how the work could best serve its targeted audience. Finally, I am deeply indebted to my wife Huixia and my daughter Ruiqi for their unflagging love and support.

Shan Gao
Beijing, 2013

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