Elements of Quantum Information

Edited by
Wolfgang P. Schleich and Herbert Walther

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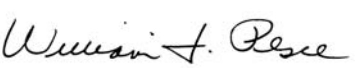

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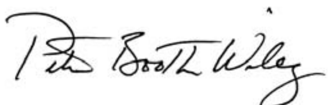

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Cover Image

Segmented linear Paul trap, University of Ulm, Germany (2006) by S. Schulz and F. Schmidt-Kaler.
The trap is fabricated from gold coated ceramic wafers which are structured by fs-laser pulses. The large number of 12 segments in the 500 µm wide loading zone – at the right hand side of the slit – and 19 segments in the 250 µm wide processor zone of this trapping device allow to scale-up quantum computing with trapped ions.
The article *Optimization of Segmented Linear Paul Traps and Transport of Stored Particles* by S. Schulz, U. Poschinger, K. Singer, and F. Schmidt-Kaler explains how to transport ions in this device fast but without any heating effects.

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Preface to the Book Edition

Elements of Quantum Information is based on a collection of articles previously published in a special issue of *Fortschritte der Physik/Progress of Physics.* It summarizes the results obtained in a collaboration of scientists from Bavaria and Baden-Württemberg working in the field of quantum information processing. This research effort was coordinated by H. Walther and W.P. Schleich. Despite his illness H. Walther was part of the project until his un-timely death on July 22, 2006, at which time all manuscripts were already in press. Unfortunately, he never saw the special issue nor the present book in their final forms.

Ulm, November 2006 W.P. Schleich

Preface to the Journal Edition

Quantum information processing has come a long way – from the early ideas of a quantum computer, put forward by Richard Feynman and David Deutsch in the early eighties, via the factorization algorithm of Peter Shor, to the present day quantum optical realisations of quantum gates. This newly emerging branch of quantum physics has united many disciplines by encompassing computer science, physics, mathematics as well as engineering. The potential gain in using the resources of quantum mechanics is enormous.

The governments of Baden-Württemberg and Bavaria have recognized the importance of quantum information and have dedicated substantial support to its development. Four years ago 12 groups from Baden-Württemberg and 6 groups from Bavaria joined forces to collaborate on this topic. Since all groups were located (more or less) along the highway A8 the descriptive title *Quantum Information Highway A8* was chosen for this project. We are also very proud that our colleague and collaborator in the *Quantum Information Highway A8*, Prof. Dr. Theodor Hänsch, Munich, was awarded the Nobel Prize 2005.

The present special issue represents a state of the art summary of the various projects of the *Quantum Information Highway A8*. The contribution by Reichle et al. is a slight exception to this program. It summarizes the approach taken by the Wineland group in Boulder (Colorado) and, therefore, lies outside of the *Quantum Information Highway A8*. Since the theme of this work complements that of the article by Schulz et al. and the paper was prepared in Ulm with the assistance of the *Quantum Information Highway A8* we have decided to include it in this issue. Moreover, it demonstrates clearly one of the many international connections of this collaboration.

We take this opportunity to express our sincere thanks to our sponsors and the enthusiastic support of Dr. Heribert Knorr from the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg and the late Dr. Christian Schuberth and his successor Felix Köhl from the Bayerisches Staatsministerium für Wissenschaft, Forschung und Kunst, without them the idea of a quantum information highway would have never materialized. We are most grateful for the financial support provided by the Landesstiftung Baden-

Württemberg as well as from the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg and the Bayerisches Staatsministerium für Wissenschaft, Forschung und Kunst. Moreover, the continuously kind assistance of Clemens Benz and Irene Purschke from the Landesstiftung made it an enjoyable working environment.

Thomas Beth, a strong proponent of quantum computing from its infant days, deserves a lot of credit for establishing quantum information processing in Germany; the community rightfully considers him a true pioneer of this field. For example, Thomas Beth was one of the initiators of the Schwerpunkt-Programm of the Deutsche Forschungsgemeinschaft in this area. Likewise, in the *Quantum Information Highway A8* he was a major player. The world of science has suffered a tragic loss when Thomas passed away August 2005. In memory of his achievements and prominent role in the A8 the present special issue of *Fortschritte der Physik* becomes a living testimony to his drive in pushing new ideas to their limits. We were all privileged to have his company in this enterprise of quantum information and dedicate this special issue to his memory.

Wolfgang P. Schleich and Herbert Walther

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