SOCIETÀ ITALIANA DI FISICA

PROCEEDINGS
OF THE
INTERNATIONAL SCHOOL OF PHYSICS
«ENRICO FERMI»

COURSE CLXII

Quantum Computers, Algorithms and Chaos

SOCIETÀ ITALIANA DI FISICA BOLOGNA-ITALY

ITALIAN PHYSICAL SOCIETY

PROCEEDINGS

OF THE

INTERNATIONAL SCHOOL OF PHYSICS

"ENRICO FERMI"

COURSE CLXII

edited by G. CASATI, D. L. SHEPELYANSKY and P. ZOLLER

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and

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VARENNA ON LAKE COMO

VILLA MONASTERO

5 – 15 July 2005

Quantum Computers, Algorithms and Chaos

2006

IOS Press

AMSTERDAM, OXFORD, TOKIO, WASHINGTON DC

ISBN 1-58603-660-2 (IOS)
ISBN 88-7438-033-X (SIF)
Library of Congress Control Number: 2006931142

Production Manager
A. OLEANDRI

Copy Editor
M. MISSIROLI

jointly published and distributed by:

IOS PRESS
Nieuwe Hemweg 6B
1013 BG Amsterdam
The Netherlands
fax: +31 20 620 34 19
order@iopress.nl

SOCIETÀ ITALIANA DI FISICA
Via Saragozza 12
40123 Bologna
Italy
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Distributor in the UK and Ireland
Gazelle Books Services Ltd.
White Cross Mills
Hightown
Lancaster LA1 4XS
United Kingdom
fax: +44 1524 63232
sales@gazellebooks.co.uk

Distributor in the USA and Canada
IOS Press, Inc.
4502 Rachael Manor Drive
Fairfax, VA 22032
USA
fax: +1 703 323 3668
iosbooks@iospress.com

Supported by UNESCO-ROSTE, Contract No.: 875.767.5

Supported by Consiglio Nazionale delle Ricerche (CNR)

Supported by Istituto Nazionale di Fisica Nucleare (INFN)

Supported by Università degli Studi dell'Insubria

Supported by U.S. Army International Technology Center-Atlantic, European Research Office

Supported by the FET-QIPC programme of European Union

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Preface

During the last ten years Quantum Information Processing and Communication (QIPC) has established itself as one of the new hot topic fields in physics, with the potential to revolutionize many areas of science and technology. QIPC replaces the laws of classical physics applied to computation and communication with the more fundamental laws of quantum mechanics. This becomes increasingly important due to technological progress reaching smaller and smaller scales where quantum effects start to be dominant. In addition to its fundamental nature, QIPC promises to advance computing power beyond the capabilities of any classical computer, to guarantee secure communication and establish direct links to emerging quantum technologies, such as, for example, quantum-based sensors and clocks.

One of the outstanding features of QIPC is its interdisciplinary character: it brings together researchers from physics, mathematics and computer science. In particular, within physics we have seen the emergence of a new QIPC community, which ranges from theoretical to experimental physics, and crosses boundaries of traditionally separated disciplines such as atomic physics, quantum optics, statistical mechanics and solid-state physics, all working on different and complementary aspects of QIPC.

In the spirit of the interdisciplinary character of QIPC, the purpose of the School was to bring together world leading experts to give lectures on the foundations of QIPC, and on theoretical and experimental questions of QIPC implementations with different physical devices. The School covered the following topics:

- Introduction to quantum computing.
- Quantum logic, information and entanglement.
- Quantum algorithms.
- Error-correcting codes for quantum computations.
- Quantum measurements and control.
- Quantum communication.

- Quantum optics and cold atoms for quantum information.
- Quantum computing with solid-state devices.
- Theory and experiments for superconducting qubits.
- Interactions in many-body systems: quantum chaos, disorder and random matrices.
- Decoherence effects for quantum computing.
- Future prospects of quantum information processing.

The School attracted a large number of applications from all over the world and attained its maximum capacities of nearly a hundred participants. This clearly shows the great interest of young researchers in the field of QIPC. To a good extent this is due to the recent impressive experimental progress achieved with various physical implementations of quantum information processors, highlighted in the lecture courses given during the School. They include ion-trap–based quantum computers, Josephson junction qubits, semiconductor quantum dots, cold atoms and optical lattices, linear optics quantum computation and entangled photons. The School also highlighted the deepening in our understanding of theoretical aspects of quantum computation and quantum communication, including topics like quantum error-correcting codes, quantum algorithms for complex dynamics, quantum measurements and feedback control, decoherence and imperfections effects for the accuracy of computation, applications of quantum chaos to systems with many qubits, entanglement in mesoscopic structures, critical phenomena and one-way quantum computation.

With the rapid development of QIPC we are witnessing the emergence of a new field in physics, mathematics and computer science. The enthusiasm, which is generated by this new field in the physics community, was clearly visible at the School, with young promising people entering this new field, for whom QIPC will be a major part in their future scientific careers.

We acknowledge financial support provided to the School and students by Università degli Studi dell'Insubria, the FET-QIPC programme of European Union, UNESCO-ROSTE and U.S. Army European Research Office. The School benefited from the nice environment and general atmosphere and from the support of the staff of the Italian Physical Society, which we gratefully acknowledge.

G. CASATI, D. L. SHEPELYANSKY, P. ZOLLER and G. BENENTI