Foreword

Quantum optics, in a sense, is precisely as old as the quantum theory, that is to say 100 years old this year. The very first quanta, after all, and for a long time the only ones, were the indivisible units of radiation energy discovered by Planck. Those oddly constrained light waves were indeed quanta, and our coming to grips with their baffling particle-like behavior consumed another 27 years. That understanding was not, in fact, fully achieved until well after all the particles of matter were understood to have the same dual nature. The quantum mechanical theory of the atom, based on that duality, brought many dramatic successes, but it was only in 1927, after many of these, that Dirac was able to extend the theory to include light itself – and thus lay the true groundwork for quantum optics.

The decades that followed provided many verifications of Dirac's fundamental theory. Most of them involved the particle-like behavior of high-energy quanta in processes that never involved more than one or two quanta at a time. The calculations could be carried out by the standard method of perturbation theory, which turned out to work quite well.

Although light quanta are normally present in vast abundance, our interest in multi-quanta phenomena was slow in developing. The first hint of the need for a more comprehensive theory came from the photon correlation measurements of Hanbury Brown and Twiss in 1956. But it was not long before the brilliant and monochromatic beams of the laser began to change the optical landscape completely, revealing new worlds of experimental wonders. It was only in that context that we began to develop a range of mathematical tools sufficiently versatile to deal quantum mechanically with light of all intensities. And only then did we begin seriously to apply the name "quantum optics" to such studies.

The ensuing years have seen the introduction of a vast range of new experimental techniques. These have been guided by ever more sophisticated theory, exploring in the most intimate detail the ways in which light interacts with matter. Isolated atoms, suspended in vacuum, can be made to perform many of the stunts that were hardly even imaginable as "thought experiments" a few years ago.

And now it has become possible, partly by quantum optical means, to reduce the temperature of atomic gases to so low a level that the wave-like properties of the atoms dominate their particle-like properties. We are witnessing in this work

the development of a remarkable new field of wave optics that we call for the moment "atom optics". As the offspring of quantum optics, it possesses many resemblances to its parent field. It can be approached and understood by using many of the same mathematical tools.

It is the most recent advances in the related fields of quantum and atom optics that concern us here, and their description in one form or another has occupied most of this conference. But there is another development that is worth pointing out at this meeting. The gospel of quantum mechanics, which was in its earliest days localized to three or four countries of Europe, has spread gradually over the globe in the last century, eliciting contributions from the United States and many countries of the Northern Hemisphere. Within the last several years we have seen significant research in quantum optics appear from the southern countries as well, and we can now point to contributions from groups in Argentina, Brazil, Chile, Colombia, Peru and Uruguay, not to mention Australia and New Zealand. Those groups are now advancing the gospel as well as spreading it.

Cambridge, March 2001 *Roy J. Glauber*

Preface

QUANTUM OPTICS I was the 1st International Meeting in Quantum Optics held in Santiago, Chile, in 23-26 August, 2000 at the Pontificia Universidad Catolica de Chile.

Just under 60 participants gathered together in Santiago, to discuss problems in Non-Linear Optics, Quantum Information, Trapped Ions, Matter Waves and Fundamentals of Quantum Mechanics.

There was a strong participation by Latin-American Scientists and students, in particular from Brazil, Chile, Argentina, Peru, Uruguay and Colombia, as well as by Scientists from USA, Europe and Asia.

New experimental and theoretical results were presented at the Conference.

Prof. Walther talked about quantum phenomena of single trapped atoms and the experimental demonstration of pure Fock states in the micromaser. Prof. Eberly talked about quantum entanglement(not included here) and determination of the localization of a single photon in a space time volume. Professor Meystre referred to matter-wave amplification, Prof. Glauber talked about the Polarium Model(not included here) and coherent trapping. Prof. Kenkre talked about oscillations between coupled Bose-Einstein condensates and also did some beautiful sketches of several participants (included in this volume), Prof. Becker addressed the topic of above- threshold ionization and harmonic generation, Prof. Marangos gave us an interesting talk on Electromagnetically Induced Transparency, Prof. Swain referred to the quantum interference effects in fluorescence and Prof. Kaige talked about QND measurements in trapped ions.

From the Southern Hemisphere there were talks about dwell time and tunneling, quite relevant for several recent experiments on " superluminal effects" (Prof. M.Nussezweig), quantum error correction (Aldo Delgado et. al.), manipulation of motional states (Prof. Zagury et. al.),ion-trapped lasers and squeezing(Prof. Orszag et. al.), decoherence and state protection (Prof. Davidovich), radiation pressure and decoherence(Professor Maia Neto et al.),and many more exciting results.

The Conference took place during the Chilean Winter, in a relaxing atmosphere with a beautiful background of the snow covered Andes Cordillera.

It was a good opportunity to establish new collaborations and contacts.

The editors would like to thank the participants for providing their papers promptly after the Conference and also the following organizations who provided financial or other forms of support: Pontificia Universidad Catolica de Chile(PUC), Universidad de Santiagode Chile (USACH), Conicyt(Fondecyt), Consortium of the Americas for Interdisciplinary Science(UNM), Centro Latinoamericano de Fisica(CLAF), The Abdus Salam International Centre for Theoretical Physics(Trieste), Fundacion Andes, United Airlines.

Finally, Ms. Carolina Leon was a great help in the local organization and also we would like to thank Ms. Marta Montoya for her support in all the local events as well as the general organization of this Conference.

Santiago,
February 2001

Miguel Orszag
Juan Carlos Retamal

List of Contributors

M. Anscombe
Laser Optics and Spectroscopy Group,Blackett Laboratory
Imperial College of Science, Technology and Medicine,
London, SW7 2BW UNited Kingdom

V. Ahufinger
Departamento de Física,
Universitat Autònoma de Barcelona,
E-08193, Bellaterra, Spain

Wilhelm Becker
Max-Born-Institut,
Max-Born-Str. 2a,12489
Berlin, Germany

Jean Bellissard
Université Paul Sabatier,
Institut de Recherche sur les Systèmes Atomiques ou Moléculaires Complexes,
F-31062 Toulouse cedex 4, France,

A.R.R. Carvalho
Instituto de Física, Universidade Federal do Rio de Janeiro,
Caixa Postal 68528, 21945-970
Rio de Janeiro, RJ, Brazil

R. Corbalán
Departamento de Física,
Universitat Autònoma de Barcelona,
E-08193, Bellaterra, Spain

D.A.R. Dalvit
T-6, Theoretical Division,
MS B288, Los Alamos National Laboratory
Los Alamos, NM 87545, USA

L. Davidovich
Instituto de Física, Universidade Federal do Rio de Janeiro,
Caixa Postal 68528,21945-970
Rio de Janeiro, RJ, Brazil

Aldo Delgado
Abteilung für Quantenphysick,
Universität Ulm, D-89069 Ulm,
Germany

Sergio M. Dutra
Huygens Laboratory,
Leiden University
P.O. Box 9504, 2300 RA Leiden,
The Netherlands

Marcelo França Santos
Instituto de Física,Universidade Federal do Rio de Janeiro,

Caixa Postal 68528, 21945-970
Rio de Janeiro, RJ, Brazil

Z. Ficek
Department of Physics,
The University of Queensland,
Brisbane, QLD 4072, Australia

Victo S. Filho
Instituto de Física Teórica
Universidade Estadual Paulista,
Rua Pamplona, 145, 01405-900,
São Paulo, SP, Brazil.

Tobias Frederico
Departamento de Física,
Instituto Tecnológico da Aeronáutica,
Centro Técnico Aeroespacial,
12228-900, São José dos Campos,
SP, Brazil

Arnaldo Gammal
Departamento de Física,
Instituto Tecnológico da Aeronáutica,
Centro Técnico Aeroespacial,
12228-900, São José dos Campos,
SP, Brazil

K. M. Gheri
Institut für Theoretische Physik,
Universität Innsbruck,
Technikerstrasse 25/2, A-6020
Innsbruck, Austria

Angela Guzmán
Depto. de Física,
Universidad Nacional de Colombia,
Bogotá, Colombia

Wang Kaige
CCAST (World Lab.),
P. O. Box, 8730,Beijing 100080;
and Department of Physics,
Beijing Normal University,
Beijing 100875, China

J. I. Kim
Instituto de Física,
Universidade de São Paulo,
Caixa Postal 66318, CEP 05315-970,
São Paulo, SP, Brazil

Richard Kopold
Max-Born-Institut,
Max-Born-Str. 2a, 12489
Berlin, Germany

I. Kuçukkara
Laser Optics and Spectroscopy
Group, Blackett Laboratory
Imperial College of Science,
Technology and Medicine,
London, SW7 2BW United Kingdom

M. L. Ladrón de Guevara
Departamento de Física,
Facultad de Ciencias,
Universidad de Chile,
Casilla 653, Santiago, Chile

P.A. Maia Neto
Instituto de Física, UFRJ,
Caixa Postal 68528 21945-970
Rio de Janeiro, Brazil

J.P. Marangos,
Laser Optics and Spectroscopy
Group, Blackett Laboratory
Imperial College of Science,

Technology and Medicine,
London, SW7 2BW

R.L. de Matos Filho
Instituto de Física, Universidade
Federal do Rio de Janeiro,
Caixa Postal 68528, 21945-970
Rio de Janeiro, RJ, Brazil

Han Pu
Optical Sciences Center,
University of Arizona,
Tucson, AZ 85721, USA

S. Maniscalco
INFM, MURST and
Dipartimento di Scienze
Fisiche ed Astronomiche
dell'Università di Palermo,
Palermo 90123, Italy

Eduardo Massoni
Facultad de Física, Pontificia
Universidad Católica de Chile,
Casilla 306, Santiago, Chile

Dejan B. Milošević
Faculty of Science,
University of Sarajevo,
Zmaja od Bosne 35, 71000 Sarajevo,
Bosnia-Hercegovina

P. Milman
Instituto de Física, Universidade
Federal do Rio de Janeiro,
Caixa Postal 68528, 21945-970
Rio de Janeiro, RJ, Brazil

Pierre Meystre
Optical Sciences Center,
University of Arizona,
Tucson, AZ 85721, USA

A. Messina
INFM, MURST and
Dipartimento di Scienze
Fisiche ed Astronomiche
dell'Università di Palermo,
Palermo 90123, Italy

Michael G. Moore
ITAMP, Harvard-Smithonian
Institute for Astrophysics,
Cambridge, MA, USA

J. Mompart
Departament de Física,
Universitat Autònoma de Barcelona,
E-08193, Bellaterra, Spain

A. Napoli
INFM, MURST and
Dipartimento di Scienze
Fisiche ed Astronomiche
dell'Università di Palermo,
Palermo 90123, Italy

Gerard Nienhuis
Huygens Laboratory,
Leiden University
P.O. Box 9504, 2300 RA Leiden,
The Netherlands

H.M. Nussenzweig
Instituto de Fisica da UFRJ
C.P. 68528, Rio de Janeiro,
R.J., Brazil

P. Nussenzveig
Instituto de Física,
Universidade de São Paulo,
Caixa Postal 66318, CEP 05315-970,
São Paulo, SP, Brazil

Miguel Orszag
Facultad de Física, Pontificia
Universidad Católica de Chile,
Casilla 306, Santiago, Chile

J. C. Retamal
Departamento de Física
Universidad de Santiago de Chile,
Avda. Ecuador 3493, casilla 3493
correo 2 Santiago, Chile
jretamal@lauca.usach.cl

Luis Roa
Departamento de Física,
Universidad de Concepción,
Casilla 160-C, Concepción

Carlos Saavedra
Departamento de Física,
Universidad de Concepción,
Casilla 160-C, Concepción

R.B.B. Santos
Instituto de Física,
Universidade de São Paulo,
Caixa Postal 66318, CEP 05315-970,
São Paulo, SP, Brazil

F. Silva
Departament d'Òptica,
Universitat de València,
E-46100 Burjassot, Spain

E. Solano
Sección Física,
Departamento de Ciencias, Pontificia
Universidad Católica del Perú,
Apartado 1761, Lima, Peru

Dominique Spehner
Facultad de Física, Pontificia
Universidad Católica de Chile,
Casilla 306, Santiago 22, Chile
dspehner@alfven.fis.puc.cl

S. Swain
School of Mathematics and Physics,
The Queen's University of Belfast,
Belfast BT7 1NN, The United
Kingdom

Lauro Tomio
Instituto de Física Teórica -
Universidade Estadual Paulista,
Rua Pamplona, 145, 01405-900,
São Paulo, SP, Brazil

Wilhelm von Waldenfels
Institut für Angewandte Mathematik
der Universität Heidelberg,
Im Neuenheimer Feld 294 69120
Heidelberg Germany

Herbert Walther
Sektion Physik der Universität
München and Max-Planck-Institut
für Quantenoptik
85748 Garching,
Fed. Rep. of Germany

Nicim Zagury
Instituto de Física, Universidade
Federal do Rio de Janeiro,
Caixa Postal 68528, 21945-970
Rio de Janeiro, RJ, Brazil

Jesús Zapata
Depto. de Física,
Universidad Nacional de Colombia,
Bogotá, Colombia

F. De Zela
Sección Física,
Departamento de Ciencias, Pontificia
Universidad Católica del Perú,
Apartado 1761, Lima, Peru