PROCEEDINGS OF SPIE

[SPIDigitalLibrary.org/conference-proceedings-of-spie](https://spiedigitallibrary.org/conference-proceedings-of-spie)

Front Matter: Volume 8163

, "Front Matter: Volume 8163," Proc. SPIE 8163, Quantum Communications and Quantum Imaging IX, 816301 (4 October 2011); doi: 10.1117/12.913671

SPIE.

Event: SPIE Optical Engineering + Applications, 2011, San Diego, California, United States

PROCEEDINGS OF SPIE

Quantum Communications and Quantum Imaging IX

**Ronald E. Meyers
Yanhua Shih
Keith S. Deacon**
Editors

**24–25 August 2011
San Diego, California, United States**

Sponsored and Published by
SPIE

Volume 8163

Proceedings of SPIE, 0277-786X, v. 8163

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Quantum Communications and Quantum Imaging IX*, edited by Ronald E. Meyers, Yanhua Shih, Keith S. Deacon, Proceedings of SPIE Vol. 8163 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X

ISBN 9780819487735

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2011, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/11/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

vii *Conference Committee*

SESSION 1 QUANTUM IMAGING

- 8163 02 **Exploiting PDC spatial correlations for innovative quantum imaging protocols (Invited Paper)** [8163-01]
M. Genovese, G. Brida, A. Meda, I. Ruo Berchera, Istituto Nazionale di Ricerca Metrologica (Italy)
- 8163 03 **Secrets of subwavelength imaging and lithography (Invited Paper)** [8163-02]
P. R. Hemmer, Texas A&M Univ. (United States)
- 8163 04 **Turbulence-free quantum ghost imaging experiments and results (Invited Paper)** [8163-03]
R. E. Meyers, K. S. Deacon, A. D. Tunick, U.S. Army Research Lab. (United States)
- 8163 05 **Quantum enhancement of a coherent ladar receiver using phase-sensitive amplification (Invited Paper)** [8163-05]
P. A. Wasilousky, K. H. Smith, R. Glasser, G. L. Burdge, L. Burberry, B. Deibner, M. Silver, R. C. Peach, C. Visone, Harris Corp. (United States); P. Kumar, O.-K. Lim, G. Alon, C.-H. Chen, A. R. Bhagwat, P. Manurkar, Northwestern Univ. (United States); M. Vasilyev, M. Annamalai, N. Stelmakh, The Univ. of Texas at Arlington (United States); Z. Dutton, S. Guha, C. Santivañez, J. Chen, M. Silva, W. Kelly, Raytheon BBN Technologies (United States); J. H. Shapiro, R. Nair, B. J. Yen, F. N. C. Wong, Massachusetts Institute of Technology (United States)
- 8163 06 **Enhanced optical resolution in target detection with phase-sensitive versus phase-insensitive pre-amplification (Invited Paper)** [8163-04]
O.-K. Lim, Northwestern Univ. (United States); Z. Dutton, Raytheon BBN Technologies (United States); G. Alon, C.-H. Chen, Northwestern Univ. (United States); M. Vasilyev, The Univ. of Texas at Arlington (United States); P. Kumar, Raytheon BBN Technologies (United States)

SESSION 2 QUANTUM COMMUNICATIONS I

- 8163 07 **Designing quantum repeaters and networks (Invited Paper)** [8163-06]
W. J. Munro, NTT Basic Research Labs. (Japan) and National Institute of Informatics (Japan); S. J. Devitt, K. Nemoto, National Institute of Informatics (Japan)
- 8163 08 **Multiplexing schemes for quantum repeater networks** [8163-07]
L. Aparicio, The Univ. of Tokyo (Japan); R. Van Meter, Keio Univ. (Japan)
- 8163 09 **Intersatellite quantum communication feasibility study** [8163-08]
A. Tomaello, A. Dall'Arche, G. Nalletto, P. Villoresi, Univ. degli Studi di Padova (Italy)

- 8163 0A **Randomization techniques for the intensity modulation-based quantum stream cipher and progress of experiment (Invited Paper)** [8163-09]
K. Kato, O. Hirota, Tamagawa Univ. (Japan)

SESSION 3 QUANTUM COMMUNICATIONS II

- 8163 0B **Multi-client quantum key distribution using wavelength division multiplexing (Invited Paper)** [8163-10]
W. Grice, Oak Ridge National Lab. (United States) and The Univ. of Tennessee (United States); R. Bennink, D. Earl, P. Evans, T. Humble, R. Pooser, Oak Ridge National Lab. (United States); J. Schaafe, B. Williams, Oak Ridge National Lab. (United States) and The Univ. of Tennessee (United States)
- 8163 0D **Improved key rates for quantum key distribution employing soft metrics using Bayesian inference with photon counting detectors (Invited Paper)** [8163-12]
F. Daneshgaran, California State Univ., Los Angeles (United States); M. T. Delgado, M. Mondin, Politecnico di Torino (Italy)

SESSION 4 QUANTUM TECHNOLOGY I

- 8163 0E **Simultaneous quadrature detection of suppressed-carrier weak-coherent-states using a homodyne optical Costas loop receiver** [8163-13]
J. A. López, Ctr. de Investigación Científica y de Educación Superior de Ensenada (Mexico); E. García, Univ. Autónoma de Baja California (Mexico); F. J. Mendieta, A. Arvizu, Ctr. de Investigación Científica y de Educación Superior de Ensenada (Mexico); P. Gallion, Telecom ParisTech (France)

SESSION 5 QUANTUM TECHNOLOGY AND ENTANGLEMENT

- 8163 0J **Parameter dependence of the decoherence of orbital angular momentum entanglement in atmospheric turbulence** [8163-18]
A. Hamadou Ibrahim, Council for Scientific and Industrial Research (South Africa) and Univ. of KwaZulu-Natal (South Africa); F. S. Roux, Council for Scientific and Industrial Research (South Africa); T. Konrad, Univ. of KwaZulu-Natal (South Africa)

SESSION 6 QUANTUM INFORMATION AND QUANTUM TECHNOLOGY I

- 8163 0N **Single photon frequency up-conversion and its applications (Invited Paper)** [8163-22]
L. Ma, O. Slattery, X. Tang, National Institute of Standards and Technology (United States)
- 8163 0Q **Two coupled Jaynes-Cummings cells** [8163-24]
P. Xue, Southeast Univ. (China), and Univ. of Calgary (Canada); Z. Ficek, King Abdulaziz City for Science and Technology (Saudi Arabia); B. C. Sanders, Univ. of Calgary (Canada)
- 8163 0R **The optical quantum computer: how big and how fast? (Invited Paper)** [8163-25]
S. J. Devitt, A. M. Stephens, National Institute of Informatics (Japan); W. J. Munro, NTT Basic Research Labs. (Japan); K. Nemoto, National Institute of Informatics (Japan)

SESSION 7 QUANTUM INFORMATION AND QUANTUM TECHNOLOGY II

- 8163 0U **The Dolinar receiver in an information theoretic framework (Invited Paper)** [8163-27]
B. I. Erkmen, K. M. Birnbaum, B. E. Moision, S. J. Dolinar, Jet Propulsion Lab. (United States)

SESSION 8 QUANTUM TECHNOLOGY II

- 8163 0Y **State discrimination signal nulling receivers (Invited Paper)** [8163-31]
F. E. Becerra, J. Fan, Joint Quantum Institute, National Institute of Standards and Technology and Univ. of Maryland (United States); G. Baumgartner, Lab. for Telecommunications Sciences (United States); S. Polyakov, Joint Quantum Institute, National Institute of Standards and Technology and Univ. of Maryland (United States); J. Goldhar, Univ. of Maryland, College Park (United States); J. T. Kosloski, The Johns Hopkins Univ. (United States); A. Migdall, Joint Quantum Institute, National Institute of Standards and Technology and Univ. of Maryland (United States)
- 8163 0Z **Quantum enhanced lidar resolution with multi-spatial-mode phase sensitive amplification (Invited Paper)** [8163-34]
C. A. Santivanez, S. Guha, Z. Dutton, Raytheon BBN Technologies (United States); M. Annamalai, M. Vasilyev, The Univ. of Texas at Arlington (United States); B. J. Yen, R. Nair, J. H. Shapiro, Massachusetts Institute of Technology (United States)
- 8163 10 **Quantum-enhanced lidar ranging with squeezed-vacuum injection, phase-sensitive amplification, and slow photodetectors (Invited Paper)** [8163-35]
R. Nair, B. J. Yen, J. H. Shapiro, Massachusetts Institute of Technology (United States); J. Chen, Z. Dutton, S. Guha, M. P. da Silva, Raytheon BBN Technologies (United States)
- 8163 11 **Physical implementation of non-physical quantum operations: realization of the universal transpose operation (Invited Paper)** [8163-36]
H.-T. Lim, Y.-S. Ra, Y.-S. Kim, Pohang Univ. of Science and Technology (Korea, Republic of); J. Bae, Korea Institute for Advanced Study (Korea, Republic of); Y.-H. Kim, Pohang Univ. of Science and Technology (Korea, Republic of)

POSTER SESSION

- 8163 12 **Generation of broadband spontaneous parametric fluorescence and its application to quantum optical coherence tomography** [8163-32]
M. Okano, R. Okamoto, A. Tanaka, S. Subashchandran, Osaka Univ. (Japan) and Hokkaido Univ. (Japan); S. Ishida, N. Nishizawa, Nagoya Univ. (Japan); S. Takeuchi, Osaka Univ. (Japan) and Hokkaido Univ. (Japan)
- 8163 13 **Turbulence measurement and characterization for quantum ghost imaging** [8163-33]
R. E. Meyers, K. Deacon, A. Tunick, U.S. Army Research Lab. (United States)

- 8163 14 **Towards interferometric quantum lithography: observation of spatial quantum interference of the three-photon NOON state** [8163-37]
Y.-S. Kim, O. Kwon, Pohang Univ. of Science and Technology (Korea, Republic of); S. M. Lee, Korea Research Institute of Standards and Science (Korea, Republic of); H. Kim, Pohang Univ. of Science and Technology (Korea, Republic of); S.-K. Choi, H. S. Park, Korea Research Institute of Standards and Science (Korea, Republic of); Y.-H. Kim, Pohang Univ. of Science and Technology (Korea, Republic of)
- 8163 15 **Quantum memory for a photonic polarization qubit using hot atomic vapor** [8163-38]
Y.-W. Cho, Y.-H. Kim, Pohang Univ. of Science and Technology (Korea, Republic of)

Author Index

Conference Committee

Program Track Chairs

Stephen M. Hammel, Space and Naval Warfare Systems Command
(United States)

Alexander M. J. van Eijk, TNO Defence, Security and Safety
(Netherlands)

Conference Chairs

Ronald E. Meyers, U.S. Army Research Laboratory (United States)

Yanhua Shih, University of Maryland, Baltimore County (United States)

Keith S. Deacon, U.S. Army Research Laboratory (United States)

Program Committee

Stefania Castelletto, University of Melbourne (Australia)

Milena D'Angelo, Università degli Studi di Bari (Italy)

Mark T. Gruneisen, Air Force Research Laboratory (United States)

Richard J. Hughes, Los Alamos National Laboratory (United States)

Yoon-Ho Kim, Pohang University of Science and Technology (Korea,
Republic of)

Todd B. Pittman, University of Maryland, Baltimore County (United
States)

Barry C. Sanders, University of Calgary (Canada)

Alexander V. Sergienko, Boston University (United States)

Dmitry V. Strekalov, Jet Propulsion Laboratory (United States)

Shigeki Takeuchi, Hokkaido University (Japan)

Xiao Tang, National Institute of Standards and Technology (United
States)

Arnold Tunick, U.S. Army Research Laboratory (United States)

Zhi Zhao, Oak Ridge National Laboratory (United States)

Session Chairs

- 1 Quantum Imaging
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 2 Quantum Communications I
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)

- 3 Quantum Communications II
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 4 Quantum Technology I
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 5 Quantum Technology and Entanglement
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 6 Quantum Information and Quantum Technology I
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 7 Quantum Information and Quantum Technology II
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)
- 8 Quantum Technology II
Ronald E. Meyers, U.S. Army Research Laboratory (United States)
Keith S. Deacon, U.S. Army Research Laboratory (United States)