PROCEEDINGS OF SPIE

Quantum Communications and Quantum Imaging XV

Ronald E. Meyers Yanhua Shih Keith S. Deacon Editors

6–7 August 2017 San Diego, California, United States

Sponsored and Published by SPIE

Volume 10409

Proceedings of SPIE 0277-786X, V. 10409

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

Quantum Communications and Quantum Imaging XV, edited by Ronald E. Meyers, Yanhua Shih, Keith S. Deacon, Proc. of SPIE Vol. 10409, 1040901 · © 2017 SPIE CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2296009

Proc. of SPIE Vol. 10409 1040901-1

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in Quantum Communications and Quantum Imaging XV, edited by Ronald E. Meyers, Yanhua Shih, Keith S. Deacon, Proceedings of SPIE Vol. 10409 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X ISSN: 1996-756X (electronic)

ISBN: 9781510612754 ISBN: 9781510612761 (electronic)

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 © 2017, 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/17/\$18.00.

Printed in the United States of America.

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



Paper Numbering: Proceedings of SPIE follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

• The first five 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.

Contents

- v Authors
- vii Conference Committee

SESSION 1 QUANTUM ENTANGLEMENT AND INTERFERENCE

- 10409 03 Coincidence rates and permutation symmetry (Invited Paper) [10409-2]
- 10409 04 Photon number statistics of entanglement generated by multiple single photon sources (Invited Paper) [10409-3]
- 10409 05 Practical schemes of detecting entanglement with a single Hong-Ou-Mandel interferometer via quantum 2-design (Invited Paper) [10409-4]
- 10409 06 **Taking the quantum eraser to the abstract world** [10409-5]

SESSION 2 QUANTUM COMMUNICATIONS, INTERNET I

- 10409 07 Optical hybrid quantum teleportation and its applications (Invited Paper) [10409-6]
- 10409 0A PPLN-waveguide-based polarization entangled QKD simulator [10409-9]

SESSION 3 QUANTUM COMMUNICATIONS, INTERNET II

- 10409 01 Experimental investigation of security parameters of Y-00 quantum stream cipher transceiver with randomization technique: part I (Invited Paper) [10409-17]
- 10409 0J Permutation modulation for quantization and information reconciliation in CV-QKD systems (Invited Paper) [10409-18]
- 10409 OK A unified analysis of optical signal modulation formats for quantum enigma cipher (Invited Paper) [10409-19]

SESSION 4 QUANTUM IMAGING

- 10409 OL The first sub shot noise wide field microscope (Invited Paper) [10409-20]
- 10409 OP Verification of quantum entanglement of two-mode squeezed light source towards quantum radar and imaging [10409-24]

SESSION 5 QUANTUM MECHANICS, PHYSICS

10409 OR	Towards non-classical walks with bright laser pulses (Invited Paper) [10409-26]
10409 OS	Some examples of sum uncertainty relations for compact classical Lie algebra (Invited Paper) [10409-27]
10409 OU	A repository for quantum measurement trajectories (Invited Paper) [10409-29]

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abt, Nikolas, OU Bae, Joonwoo, 05 Daneshgaran, Fred, OJ Dasari, Durga B. Rao, OU de Guise, Hubert, 03, 0S Djordjevic, Ivan B., OA Dudley, A., OR Forbes, A., 06, 0R Furusawa, Akira, 07 Futami, Fumio, Ol Gariano, John, 0A Genovese, M., OL Hirota, Osamu, Ol Hofmann, Holger F., 04 Kato, Kentaro, OI, OK Losero, E., OL Maccone, Lorenzo, OS Masada, Genta, OP Meda, A., OL Mondin, Marina, 0J Nape, I., 06 Ndagano, B., 06 Okada, Masanori, 07 Olia, Khashayar, OJ Ruo-Berchera, I., OL Samantaray, N., OL Sanders, Barry C., 03, 0S Scafirimuto, F., OL Sephton, B., OR Shukla, Namrata, OS Takeda, Shuntaro, 07 Tanizawa, Ken, Ol Wrachtrup, Joerg, OU Wu, Junyi, 04 Yang, Sen, OU

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)

Conference Program Committee

Stefania A. Castelletto, RMIT University (Australia) Milena D'Angelo, Università degli Studi di Bari (Italy) Warren P. Grice, Oak Ridge National Laboratory (United States) 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)

Session Chairs

- 1 Quantum Entanglement and Interference **Ronald E. Meyers**, U.S. Army Research Laboratory (United States)
- 2 Quantum Communications, Internet I **Keith S. Deacon**, U.S. Army Research Laboratory (United States)
- 3 Quantum Communications, Internet II **Ronald E. Meyers**, U.S. Army Research Laboratory (United States)

- 4 Quantum Imaging Ronald E. Meyers, U.S. Army Research Laboratory (United States)
- 5 Quantum Mechanics, Physics **Keith S. Deacon**, U.S. Army Research Laboratory (United States)