

PROCEEDINGS OF SPIE

Laser Beam Shaping XV

Andrew Forbes
Todd E. Lizotte
Editors

17–19 August 2014
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 9194

Proceedings of SPIE 0277-786X, V. 9194

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

Laser Beam Shaping XV, edited by Andrew Forbes, Todd E. Lizotte, Proc. of SPIE Vol. 9194,
919401 © 2014 SPIE · CCC code: 0277-786X/14/\$18 · doi: 10.1117/12.2085351

Proc. of SPIE Vol. 9194 919401-1

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 *Laser Beam Shaping XV*, edited by Andrew Forbes, Todd E. Lizotte, Proceedings of SPIE Vol. 9194 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628412215

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 © 2014, 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/14/\$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 *Authors*
- ix *Conference Committee*
- xi *Radiance and photon noise: imaging in geometrical optics, physical optics, quantum optics and radiology (Plenary Paper) [9193-200]*
- xxix *Optical design for consumer products (Plenary Paper) [9197-201]*

SESSION 1 VECTOR AND VORTEX BEAMS

- 9194 06 **Optical information transfer based on helico-conical laser beams [9194-5]**

SESSION 2 SINGLE-PHOTON BEAM SHAPING

- 9194 08 **Simulating spontaneous parametric down-conversion using classical light [9194-7]**
- 9194 09 **Entangled Bessel beams [9194-8]**
- 9194 0A **Digital bi-photon spiral imaging [9194-9]**

SESSION 3 METHODS

- 9194 0B **Detecting Bessel beams [9194-10]**
- 9194 0C **Wavefront sensing with all-digital Stokes measurements [9194-11]**
- 9194 0D **Coherent radiation enhancement for laser beam shaping applications [9194-12]**
- 9194 0E **Optimal diffraction-limited focusing through static aberrations [9194-13]**

SESSION 4 APPLICATIONS

- 9194 0H **Characterization and application of bubbles during thermal blooming [9194-16]**
- 9194 0J **One Tbps superchannel generated by Optical Flat Comb Source WDM-Nyquist and OFDM system simulative investigation [9194-18]**

SESSION 5 OPTICAL DESIGN I

- 9194 0K **Dynamic beam shaping with freeform optics (Invited Paper)** [9194-19]
- 9194 0L **Laser beam shaping with nano-structured lens** [9194-20]
- 9194 0M **Experimental characterization of variable output refractive beam shapers using freeform elements** [9194-21]
- 9194 0N **Modelling of a reflective waveplate for high-power lasers** [9194-22]

SESSION 6 OPTICAL DESIGN II

- 9194 0Q **Multi-functional diffractive optical elements (Invited Paper)** [9194-23]
- 9194 0R **Building achromatic refractive beam shapers** [9194-24]
- 9194 0T **Designing refractive beam shapers via aberration theory** [9194-26]
- 9194 0U **Monolithical aspherical beam expanding systems** [9194-27]

SESSION 7 LASER BEAMS AND RESONATORS I

- 9194 0V **Propagation of optical vortices with fractional topological charges in free space** [9194-28]
- 9194 0W **Compact optically actuated high-power laser beam delivery system for industrial metal processing applications** [9194-29]
- 9194 0Y **Direct synthesis of the laser beam with pre-determined intensity distribution by means of intracavity beam shaping** [9194-31]
- 9194 0Z **Three-dimensional self-similar fractal light in canonical resonators** [9194-32]

SESSION 8 LASER BEAMS AND RESONATORS II

- 9194 13 **Hysteresis loop and pattern from the dual-wavelength competition in an Nd:YVO₄ laser with an intracavity periodically poled lithium niobate Bragg modulator** [9194-36]
- 9194 14 **Coherent combining of four slab laser amplifiers with high beam quality** [9194-37]
- 9194 15 **Generation and transformation of azimuthal and radial polarization in a typically three-element Nd:GdVO₄ laser** [9194-38]

POSTER SESSION

- 9194 16 **Techniques to measure complex-plane fields** [9194-39]

- 9194 19 **Non-uniformly correlated partially coherent beams and pulses** [9194-42]
- 9194 1A **Laguerre Gaussian beam multiplexing through turbulence** [9194-43]
- 9194 1B **Digital holograms for laser mode multiplexing** [9194-44]
- 9194 1C **Beam propagation in a uniaxial crystal under small angle to the optical axis and arrays of bottle beams** [9194-45]
- 9194 1D **Optical vortex in microscopy imaging** [9194-46]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four 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.

Abeywickrema, Ujitha, 0H
Alfano, Robert R., 0C
Ali, Tamelia, 0V
Baker, Ian, 0W
Banerjee, Neil, 0H
Barrett, Harrison H., xi
Bhattacharya, Shanti, 0Q
Buck, Samuel, 0N
Caucci, Luca, xi
Chang, Ken-Chia, 15
Chen, Li, 14
Chetty, Naven, 16
Clarke, Robert J., 0N
Courtial, Johannes, 0Z
Crouse, David T., 0V
Davies, Matthew A., 0M
Dudley, Angela, 0C, 16, 1A, 1B
Dutterer, Brian S., 0M
Forbes, Andrew, 08, 09, 0A, 0B, 0C, 16, 1A, 1B
Fuchs, U., 0U
Gao, Qingsong, 14
Golovin, Andrii B., 0V
Green, James S., 0N
Gupta, Anurag, xxix
Hay, Nick, 0W
Heathcote, Robert I., 0N
Hong, Kun-Guei, 13
Hong, Liying, 0L
Hraghi, Abir, 0J
Ibrahim, Alpha, 0A
Ismail, Yaseera, 0B
Ivanov, Maksym, 1C
Khoo, Eng Huat, 0L
Kislov, Victor, 0Y
Kiyko, Vadim, 0Y
Kondratyev, Vladimir, 0Y
Konrad, Thomas, 0A
Kreminska, Liubov, 0V
Kusko, C., 06
Kwon, Young, 0W
Lajunen, Hanna, 19
Laskin, Alexander V., 0R, 0T
Li, Guohui, 14
Liao, Yuan, 14
Lin, Shoutai, 13
Liu, Zhengtong, 0L
Lu, Fei, 14
Luo, Jia, 14
Majola, Nombuso, 16
Masajada, Jan, 1D
Matthias, Sabrina, 0U
McLaren, Melanie, 08, 09, 0A, 0B
Menif, Mourad, 0J
Mhlanga, Thandeka, 09, 0A, 0B, 1A, 1B
Mihailescu, M., 06
Milione, Giovanni, 0C
Miller, Steven W., 0Z
Myers, Kyle J., xi
Naidoo, Darryl, 1A, 1B
Nelson, John, 0Z
Ngo, Chun Yong, 0L
Ofitserov, Eugeny, 0Y
Padgett, Miles J., 09
Pan, Xundong, 14
Patlan, Vsevolod, 0E
Popiotek-Masajada, Agnieszka, 1D
Preda, L., 06
Roux, Filippus S., 08, 09, 0B
Saastamoinen, Toni, 19
Shealy, David L., 0R, 0T
Shostka, Natalia, 1C
Shultz, Jason A., 0K, 0M
Smilie, Paul J., 0K, 0M
So, HyeonSeok, 0W
Soloviev, Oleg, 0E
Soskind, M., 0D
Soskind, R., 0D
Soskind, Yakov G., 0D
Suleski, Thomas J., 0K, 0M
Szatkowski, Mateusz, 1D
Teng, Jing Hua, 0L
Tian, Fei, 14
Trichili, Abderrahmen, 0B, 1A, 1B
Vdovin, Gleb V., 0E, 0Y
Vijayakumar, A., 0Q
Wei, Ming-Dar, 13, 15
Wu, Rui Fen, 0L
Yan, Hong, 14
Ye, Yidong, 14
Zghal, Mourad, 0B, 1A, 1B
Zhang, Wei, 14
Zhang, Yingwen, 08
Zhou, Tangjian, 14

Conference Committee

Program Track Chairs

José Sasián, College of Optical Sciences, The University of Arizona
(United States)

R. John Koshel, College of Optical Sciences, The University of Arizona
(United States)

Conference Chairs

Andrew Forbes, CSIR National Laser Center (South Africa) and
University of KwaZulu-Natal (South Africa)

Todd E. Lizotte, Hitachi Via Mechanics (USA), Inc. (United States)

Conference Program Committee

Daniel M. Brown, Optosensors Technology, Inc. (United States)

Fred M. Dickey, FMD Consulting LLC (United States)

Angela Dudley, CSIR National Laser Center (South Africa)

Michael Duparré, Friedrich-Schiller-Universität Jena (Germany)

Julio Cesar Gutiérrez-Vega, Tecnológico de Monterrey (Mexico)

Marc D. Himel, JENOPTIK Optical Systems GmbH (Germany)

Alexis V. Kudryashov, Active Optics Night N Ltd. (Russian Federation)

Alexander V. Laskin, AdlOptica Optical Systems GmbH (Germany)

Carlos López-Mariscal, U.S. Naval Research Laboratory
(United States)

David L. Shealy, The University of Alabama at Birmingham
(United States)

Yakov G. Soskind, DHPC Technologies (United States)

Session Chairs

- 1 Vector and Vortex Beams

Andrew Forbes, CSIR National Laser Center (South Africa)

- 2 Single-Photon Beam Shaping

Giovanni Milione, The City College of New York (United States)

- 3 Methods

Fred M. Dickey, FMD Consulting LLC (United States)

- 4 Applications

Alexander V. Laskin, AdlOptica Optical Systems GmbH (Germany)

- 5 Optical Design I
Todd E. Lizotte, Hitachi Via Mechanics (USA), Inc. (United States)
- 6 Optical Design II
Angela Dudley, CSIR National Laser Center (South Africa)
- 7 Laser Beams and Resonators I
Raul I. Hernandez-Aranda, Tecnológico de Monterrey (Mexico)
- 8 Laser Beams and Resonators II
Yakov G. Soskind, DHPC Technologies (United States)