PROCEEDINGS OF SPIE

Adaptive X-Ray Optics II

Ali M. Khounsary
Stephen L. O'Dell
Thomas G. Bifano
Editors

14 August 2012
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 8503

Proceedings of SPIE 0277-786X, V. 8503

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

Adaptive X-Ray Optics II, edited by Ali M. Khounsary, Stephen L. O'Dell, Thomas G. Bifano,
Proc. of SPIE Vol. 8503, 850301 · © 2012 SPIE · CCC code: 0277-786/12/$18
doi: 10.1117/12.2012086

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 *Adaptive X-Ray Optics II*, edited by Ali M. Khounsary, Stephen L. O'Dell, Thomas G. Bifano, Proceedings of SPIE Vol. 8503 (SPIE, Bellingham, WA, 2012) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819492203

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

Printed in the United States of America.

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

SPIE Digital Library
SPIEDigitalLibrary.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

Conference Committee

Program Track Chair

Carolyn A. MacDonald, University at Albany (United States)

Conference Chairs

Ali M. Khounsary, Argonne National Laboratory (United States)
Stephen L. O'Dell, NASA Marshall Space Flight Center (United States)
Thomas G. Bifano, Boston University (United States) and Boston Micromachines Corporation (United States)

Conference CoChairs

Sergio R. Restaino, U.S. Naval Research Laboratory (United States)
Stuart B. Shaklan, Jet Propulsion Laboratory (United States)
Kazuto Yamauchi, Osaka University (Japan)

Conference Program Committee

Klaus Attenkofer, Brookhaven National Laboratory (United States)
Kevin L. Baker, Lawrence Livermore National Laboratory (United States)
Raymond Barrett, European Synchrotron Radiation Facility (France)
Daniele Cocco, SLAC National Accelerator Laboratory (United States)
Michael Hart, Hart Scientific Consulting International L.L.C. (United States)
Michael A. Helmbrecht, Iris AO, Inc. (United States)
Mourad Idir, Brookhaven National Laboratory (United States)
Daniel Lopez, Argonne National Laboratory (United States)
Carolyn A. MacDonald, University at Albany (United States)
Derrick C. Mancini, Argonne National Laboratory (United States)
Michael J. Pivovaroff, Lawrence Livermore National Laboratory (United States)
Michael C. Roggemann, Michigan Technological University (United States)
Kawal J. Sawhney, Diamond Light Source Ltd. (United Kingdom)
Daniel A. Schwartz, Harvard-Smithsonian Center for Astrophysics (United States)
Riccardo Signorato, Bruker ASC GmbH (Germany)
Robert K. Tyson, The University of North Carolina at Charlotte (United States)

Melville P. Ulmer, Northwestern University (United States)
Richard Willingale, University of Leicester (United Kingdom)

Session Chairs

1 Light-Source Applications
Ali Khounsary, Argonne National Laboratory (United States)

2 Astronomical Applications
Daniel A. Schwartz, Harvard-Smithsonian Center for Astrophysics (United States)
Michael Hart, Hart Scientific Consulting International L.L.C. (United States)

3 Device Development
Thomas G. Bifano, Boston University (United States) and Boston Micromachines Corporation (United States)
Kevin L. Baker, Lawrence Livermore National Laboratory (United States)

4 Simulation and Characterization
Melville P. Ulmer, Northwestern University (United States)

Introduction

Adaptive or active optics (AO) has become indispensable for applications in which aberrations would otherwise limit performance—including ground-based astronomy, retinal imaging, free-space laser communication, and synchrotron x-ray optics. The emergence of economical wavefront sensing and control hardware has leveraged technical advances in this field. The resulting scientific achievements—especially in infrared/visible ground-based astronomy and retinal ophthalmology—have inspired the exploration of AO technologies for x-ray applications.

X-ray beam control and imaging systems are rarely diffraction limited, and thus provide a promising new frontier for active optics. A significant challenge involves development of wavefront sensing and correcting hardware and algorithms that provide suitable control of surface figure to improve x-ray system performance, both in grazing-incidence and near-normal-incidence systems, at wavelengths ranging from extreme ultraviolet (with applications in lithography) through soft and hard x-rays (with applications in space-based astronomy, medicine, and microscopy).

This volume comprises the papers presented at the second biennial conference series on Adaptive X-ray Optics within SPIE Optics + Photonics. The conference serves as a forum for reviewing recent advancements in "traditional" adaptive optics, for examining extension of that technology to active or adjustable x-ray optics, and for reporting progress in what we loosely term "Adaptive X-ray Optics".

The Conference comprised four sessions. The first session focused on deformable mirror systems developed for grazing-incidence control of synchrotron x-ray sources. The second session focused on astronomical applications, from a ground-based infrared AO system for imaging exoplanets against the light of the host star, to studies of prospective next-generation x-ray space telescopes. The third session reported on deformable mirror devices and actuation technologies. The final session addressed simulation and characterization of x-ray AO technologies and systems.

We thank the speakers and session chairs for their contributions. We are grateful to Conference Co-Chairs Sergio R. Restaino, Stuart B. Shaklan, and Kazuto Yamauchi for their advice and support. Finally, we appreciate the invaluable help of the SPIE staff in hosting this Conference and in publishing these Proceedings.

Ali M. Khounsary
Stephen L. O'Dell
Thomas G. Bifano