PROCEEDINGS OF SPIE

Optical System Alignment, Tolerancing, and Verification X

José Sasián
Richard N. Youngworth
Editors

28–29 August 2016
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 9951

Proceedings of SPIE 0277-786X, V. 9951

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 *Optical System Alignment, Tolerancing, and Verification X*, edited by José Sasián, Richard N. Youngworth, Proceedings of SPIE Vol. 9951 (SPIE, Bellingham, WA, 2016) Six-digit Article CID Number.

ISSN: 0277-786X
ISSN: 9781510602946 (electronic)
ISBN: 9781510602939
ISBN: 9781510602946 (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

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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. 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 six-digit CID article numbering system structured as follows:

- 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.

Contents

v *Authors*

vii *Conference Committee*

ix *Introduction*

xi *The advanced LIGO detectors in the era of first discoveries (Plenary Paper)* [9960-200]

SESSION 1 SPACE SYSTEMS AND JWST ALIGNMENT AND INTEGRATION I

9951 02 **Multispectral optical telescope alignment testing for a cryogenic space environment** [9951-1]

9951 03 **Tolerancing, alignment and test of the Transiting Exoplanet Survey Satellite (TESS) optical assembly** [9951-2]

9951 04 **Data veracity checks for the alignment of the JWST optical telescope element** [9951-3]

9951 05 **Optical testing and verification methods for the James Webb Space Telescope Integrated Science Instrument Module element** [9951-4]

9951 06 **Critical science instrument alignment of the James Webb Space Telescope (JWST) Integrated Science Instrument Module (ISIM)** [9951-5]

SESSION 2 ALIGNMENT METHODS AND ALGORITHMS

9951 07 **High precision optomechanical assembly using threads as mechanical reference** [9951-6]

9951 08 **A toolbox of metrology-based techniques for optical system alignment (Invited Paper)** [9951-7]

9951 09 **Design and performance of a new compact adaptable autostigmatic alignment tool** [9951-8]

9951 0A **Array imaging system for lithography** [9951-9]

SESSION 3 SPACE SYSTEMS AND JWST ALIGNMENT AND INTEGRATION II

9951 0C **Alignment of the James Webb Space Telescope Integrated Science Instrument Module Element** [9951-11]

9951 0D **JWST science instrument pupil alignment measurements** [9951-12]

9951 0E **JWST's optical telescope simulator for verification of the Integrated Science Instrument Module** [9951-13]

9951 0F **How to align a new detector and micro shutter inside JWST's Near Infrared Spectrograph (NIRSpec)** [9951-14]

9951 0G **Mechanical blind gap measurement tool for alignment of the JWST Optical Telescope Element** [9951-15]

SESSION 4 ASPHERES, TOLERANCING, AND VERIFICATION

9951 0H **Precision spacers as compensators** [9951-16]

9951 0I **Asphere wedge and decenter: What you see is not always what you get** [9951-17]

9951 0J **The structure function as a metric for roughness and figure** [9951-18]

9951 0K **Measurement of the alignment of the surfaces and the edges of aspheric lenses** [9951-19]

9951 0L **Method for quick thermal tolerancing of optical systems** [9951-20]

9951 0M **Sensitivity analysis in the test of a parabolic trough solar collector (PTSC) with flat null-screens** [9951-21]

MONDAY POSTER SESSION

9951 0N **Cryogenic optical test planning using the Optical Telescope Element Simulator with the James Webb Space Telescope Integrated Science Instrument Module** [9951-23]

9951 0O **Toward image registration process: Using different interpolation methods in case of subpixel displacement** [9951-24]

9951 0P **Analysis of the influence of the aperture size on the differences of *L *a *b* chromatic coordinates in a spectrocolorimeter** [9951-25]

WEDNESDAY POSTER SESSION

9951 0Q **Using short helically wrapped single-mode fibers as illuminated fiducials** [9951-22]

This paper describes the tolerancing, assembly and alignment methods developed during the build of the TESS Risk Reduction Unit optical system. Lens assembly tolerances were derived from a sensitivity analysis using an image quality metric customized for mission performance. The optomechanical design consists of a two-stage lens housing that provides access for active alignment of each lens using a Trioptics OptiCentric measurement system. The topics of tolerancing, alignment, and verification are crucial in the development of successful optical systems. The assembly of actual optical systems requires alignment of different system components. The precision level of the alignment depends on the assigned tolerance error budget, and so alignment and tolerances are interrelated. Verification involves validating optical system performance, including assurance of performance under a variety of operating conditions. This conference seeks to further the state-of-the-art in alignment and tolerancing, including verification of subsystems PROCEEDINGS VOLUME 9951. Optical System Alignment, Tolerancing, and Verification X. Editor(s): JosÃ© SasiÃ¡n; Richard N. Youngworth. For the purchase of this volume in printed format, please visit Proceedings.com.Â Measured alignment error and mirror figure error test results are reported with a discussion of their impact on system optical performance. Tolerancing, alignment and test of the Transiting Exoplanet Survey Satellite (TESS) optical assembly Author(s): Brian Primeau; Gregory Balonek; Robert MacDonald; Michael Chrisp; Christian Chesbrough; James Andre; Kristin Clark. Show Abstract. The Transiting Exoplanet Survey Satellite (TESS) will carry four visible waveband seven-element refractive f/1.4 lenses, each with a 34 degree diagonal field of view.