PROCEEDINGS OF SPIE

Optical and Infrared Interferometry and Imaging IX

Jens Kammerer Stephanie Sallum Joel Sanchez-Bermudez Editors

17–22 June 2024 Yokohama, Japan

Sponsored by SPIE

Cosponsored by NAOJ—National Astronomical Observatory of Japan (Japan) NICT—National Institute of Information and Communications Technology (Japan) JNTO—Japan National Tourism Organization (Japan) City of Yokohama (Japan)

Cooperating Organization Optronics Co., Ltd. (Japan)

Published by SPIE

Volume 13095

Proceedings of SPIE 0277-786X, V. 13095

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

Optical and Infrared Interferometry and Imaging IX, edited by Jens Kammerer, Stephanie Sallum, Joel Sanchez-Bermudez, Proc. of SPIE Vol. 13095, 1309501 © 2024 SPIE · 0277-786X · doi: 10.1117/12.3049539 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 and Infrared Interferometry and Imaging IX*, edited by Jens Kammerer, Stephanie Sallum, Joel Sanchez-Bermudez, Proc. of SPIE 13095, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510675131 ISBN: 9781510675148 (electronic)

Published by **SPIE** P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone +1 360 676 3290 (Pacific Time) SPIE.org Copyright © 2024 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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.



Paper Numbering: A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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

xi Conference Committee

CURRENT AND PLANNED FACILITIES I

- 13095 02 Recent technical and scientific highlights from the CHARA Array (Invited Paper) [13095-1]
- 13095 03 CHARA/SPICA: the new 6T visible combiner for the CHARA Array [13095-2]
- 13095 04 Integrating a mobile telescope into the CHARA Array [13095-3]
- 13095 05 Silmaril: final design and on-sky performance [13095-4]

CURRENT AND PLANNED FACILITIES II

- 13095 06 The LBTI: pioneering the ELT era (Invited Paper) [13095-5]
- 13095 07 The GLINT nulling interferometer: improving nulls for high-contrast imaging [13095-6]

CURRENT AND PLANNED FACILITIES III

- 13095 OB GRAVITY+ Wide: towards hundreds of z ~ 2 AGN, larger throughput and improved vibrational control [13095-10]
- 13095 OC MATISSE, the VLTI mid-infrared spectro-interferometric imager: achievements and perspectives [13095-11]
- 13095 0D Pushing high angular resolution and high contrast observations on the VLTI from Y to L band with the Asgard instrumental suite: integration status and plans [13095-12]

CURRENT AND PLANNED FACILITIES IV

13095 OF	L-band nulling interferometry at the VLTI with Asgard/NOTT: status and plans [13095-14]
13095 0G	Recent progress with the Magdalena Ridge Observatory Interferometer project (Invited Paper) [13095-15]
13095 OH	Performance verification results for the Magdalena Ridge Observatory Interferometer (MROI) [13095-16]

13095 01 Stellar intensity interferometery: from Narrabri to CTA (Invited Paper) [13095-17]

CURRENT AND PLANNED FACILITIES V

- 13095 0J A new version of the stellar intensity interferometry instrument for the ASTRI Mini-Array telescopes [13095-18]
- 13095 OK Planet Formation Imager (PFI): project update and future directions (Invited Paper) [13095-19]

CRITICAL SUBSYSTEMS I

- 13095 OL **GRAVITY for MATISSE** [13095-20]
- 13095 0M VLTI Unit Telescope coudé train vibration control upgrade for GRAVITY+ [13095-21]

CRITICAL SUBSYSTEMS II

13095 OP Asgard/NOTT: first lab assembly and experimental results [13095-25]

TECHNOLOGIES I

- 13095 OR Astrophotonic technologies (Invited Paper) [13095-27]
- 13095 08 Wavefront sensing and control for a photonic lantern nuller for exoplanet characterization [13095-28]
- 13095 0T Spectral characterization of 3-port photonic lantern for spectroastrometry [13095-29]
- 13095 0U Kernel nulling at VLTI with photonic lanterns for optimal fibre injection [13095-30]

APERTURE MASKING INTERFEROMETRY I

13095 0Z Jewel masks: non-redundant Fizeau beam combination without the guilt [13095-34]

APERTURE MASKING INTERFEROMETRY II

- 13095 10 Polarimetric, non-redundant aperture masking with next generation VAMPIRES: new instrumental capabilities, scientific outcomes, and image reconstruction techniques (Best Thesis Presentation Prize) [13095-35]
- 13095 11 The search for protoplanets with aperture masking (SPAM) survey: progress update and close-in small grain protoplanetary disk features [13095-36]
- 13095 13 Differentiable modelling and data analysis for the JWST aperture masking interferometer [13095-38]

DATA PROCESSING, ANALYSIS, ACCESS, AND DISCOVERY I

- 13095 14 I2C@2024: an interferometric imaging contest in 2024 (Invited Paper) [13095-39]
- 13095 16 Precision interferometry with MIRC-X/MYSTIC for exoplanets [13095-41]
- 13095 17 Pushing the limits of kernel phase interferometry for protoplanet discovery [13095-42]

DATA PROCESSING, ANALYSIS, ACCESS, AND DISCOVERY II

- 13095 19 Machine learning for interferometric image reconstruction with sparse arrays [13095-44]
- 13095 1A Generic data reduction for nulling interferometry package: the grip of a single data reduction package on all the nulling interferometers [13095-45]
- 13095 1B CHARA/Silmaril instrument software and data reduction pipeline: characterization of the instrument in the lab and on-sky [13095-46]
- 13095 1C GRAVITY data curation: opening science-ready data products to the community [13095-47]

SPACE INTERFEROMETRY TECHNOLOGY I

- 13095 1D The Large Interferometer For Exoplanets (LIFE): a space mission for mid-infrared nulling interferometry (Invited Paper) [13095-48]
- 13095 1E Spatial filtering for the Large Interferometer For Exoplanets (LIFE) mission [13095-49]
- 13095 1F Analytical and numerical instrumental noise simulations for the Large Interferometer For Exoplanets (LIFE) [13095-50]

SPACE INTERFEROMETRY TECHNOLOGY II

- 13095 1G The Pyxis Interferometer: updates and future plans [13095-51]
- 13095 1H The Nulling Interferometer Cryogenic Experiment: the warm phase [13095-52]
- 13095 11 Fringe tracking controller modeling for a stellar imaging CubeSat optical interferometer [13095-53]

SPACE INTERFEROMETRY TECHNOLOGY III

- 13095 1J Artemis-enabled Stellar Imager (AeSI): a Lunar long-baseline UV/optical imaging interferometer (Invited Paper) [13095-54]
- 13095 1K Mid-IR (L-band) electro-optic photonics for nulling interferometry (Best Thesis Presentation Prize) [13095-55]
- 13095 1L Toward laboratory demonstration of terahertz intensity interferometry [13095-56]

FUTURE OF INTERFEROMETRY I

13095 1N Towards quantum-enhanced long-baseline optical/near-IR interferometry [13095-58]

FUTURE OF INTERFEROMETRY II

- 13095 10 Demonstrating table-top interferometric imaging using a path-entangled single photon towards quantum telescopy [13095-59]
- 13095 1P Towards stellar temporal intensity interferometry [13095-60]
- 13095 1Q Providing user support and community development (Invited Paper) [13095-61]
- 13095 1R The Big Fringe Telescope [13095-64]

FUTURE OF INTERFEROMETRY III

13095 11 Considerations for a next-generation Great Observatory class space-based interferometer for far-infrared astronomy [13095-63]

POSTERS SESSION: CURRENT AND PLANNED FACILITIES

13095 1U	CMAP: a mobile 7th telescope at the CHARA Array [13095-65]
13095 1V	CHARA Array integrated optics testbench (CHARIOT) for on-sky experiments [13095-66]
13095 1W	Recent and upcoming upgrades for MIRC-X and MYSTIC on the CHARA Array [13095-68]
13095 1Y	Real-time control for the GLINT photonic nulling interferometer [13095-70]
13095 1Z	A new photonic integrated circuit for the FIRST instrument: towards high throughput with a compact photonic chip [13095-71]
13095 20	GRAVITY+ adaptive optics (GPAO) tests in Europe [13095-72]
13095 21	The Asgard/BIFROST pre-injection optics and fiber injection module: optomechanical design and lab results [13095-73]
13095 22	Vanaheim: a dual-field calibration unit for the integration and testing of the BIFROST instrument [13095-74]
13095 23	Software framework for the Asgard/BIFROST 4-telescope interferometer, a VLTI visitor instrument [13095-75]
13095 24	Progress of the 100m-baseline optical interferometer in China [13095-76]
13095 26	The on- and off-axis light injection module for Asgard/BIFROST at VLTI [13095-85]

POSTER SESSION: CURRENT AND PLANNED FACILITIES II

13095 27 Performance of MAGIC stellar intensity interferometer and expansion to MAGIC + CTAO-LST1 stellar intensity interferometer [13095-78]

POSTERS SESSION: CRITICAL SUBSYSTEMS

- 13095 29 Portable in-vacuum computerized beam-relay subsystem for the Magdalena Ridge Observatory Interferometer [13095-80]
- 13095 2A Designing an automated alignment system in fluctuating thermal environments for optomechanical components at MROI [13095-81]
- 13095 2B Integration and site acceptance testing of light sources and sensors for automated beam train alignment at the MROI [13095-82]

- 13095 2C Asgard/NOTT: water vapor and CO₂ atmospheric dispersion compensation system [13095-83]
- 13095 2D Spectrographs for the Asgard/BIFROST beam combiner for the VLTI: optical and optomechanical design and first lab results [13095-84]
- 13095 2E Opto-mechanical design of GRAVITY+ wavefront sensor [13095-86]
- 13095 2H Hierarchical fringe tracking [13095-89]
- 13095 21 End-to-end simulation of hierarchical fringe tracking [13095-90]

POSTER SESSION: TECHNOLOGIES

- 13095 2J **Dual-aperture fiber nulling for high spatial and spectral resolution studies of exoplanets** [13095-91]
- 13095 2K Dual channel imaging system in Ha and Hel 1083nm lines using a universal tunable filter [13095-92]
- 13095 2M Identifying embedded accreting protoplanets at and within the diffraction limit using photonic lantern spectro-astrometry [13095-94]
- 13095 2N Laboratory demonstration of an all-fiber-based focal plane nulling interferometer [13095-95]
- 13095 20 Study on a co-phasing sensing technology based on integrated photonic chip merging arrayed waveguide grating with multi-axial combining [13095-96]
- 13095 2P Toward deep single-mode cross-aperture nulling [13095-97]
- 13095 2Q Precision speckle interferometry with CMOS detector [13095-98]

POSTERS SESSION: APERTURE MASKING INTERFEROMETRY

- 13095 2R Commissioning and calibration of the JWST aperture masking interferometry mode [13095-100]
- 13095 2T Simultaneous sub-aperture wavefront sensing with holographic aperture masking improves calibration [13095-102]
- 13095 2U On-sky tests of an upgraded holographic mask in the OSIRIS imager [13095-142]

- 13095 2V Planet search around seven white dwarfs in the Hyades cluster using kernel phase interferometry [13095-103]
- 13095 2W Oimodeler: a modular modelling software for optical interferometry [13095-104]
- 13095 2X Designing the data reduction pipeline for FOURIER: the first light near-IR science beam combiner at the Magdalena Ridge Observatory Interferometer [13095-105]
- 13095 30 Piston error detection and closed-loop control based on fringe contrast measurement applied to a kind of interferometric imaging telescope with four apertures [13095-108]

POSTERS SESSION: SPACE INTERFEROMETRY TECHNOLOGY

- 13095 33 Spectroscopic imaging method for next-generation space infrared interferometers [13095-110]
- 13095 34 Prospects for using drones to test formation-flying CubeSat concepts, and other astronomical applications [13095-111]
- 13095 36 Single spacecraft nulling interferometer for exoplanets: preliminary concepts [13095-113]
- 13095 37 Demonstrating complex visibility measurements and image reconstruction using a double-Fourier interferometer testbed [13095-114]
- 13095 38 Beam metrology and control for the Nulling Interferometry Cryogenic Experiment [13095-115]

POSTERS SESSION: FUTURE OF INTERFEROMETRY

13095 39 SPINER: spectro-interferometry with echelle grating at high resolution [13095-116]

Conference Committee

Symposium Chairs

 Sarah Kendrew, European Space Agency (United States)
Satoshi Miyazaki, National Astronomical Observatory of Japan (Japan)

Symposium Co-chairs

Desirée Della Monica Ferreira, DTU Space (Denmark) Anna Moore, The Australian National University (Australia)

Conference Chairs

Jens Kammerer, European Southern Observatory (Germany)
Stephanie Sallum, University of California, Irvine (United States)
Joel Sanchez-Bermudez, Universidad Nacional Autónoma de México (Mexico)

Conference Program Committee

Fabien R. Baron, Georgia State University (United States) David S. Doelman, Leiden Observatory (Netherlands) Xavier Haubois, European Southern Observatory (Chile) Sebastian F. Hönig, University of Southampton (United Kingdom) Elsa Huby, Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique (France) Lucas Labadie, Universität zu Köln (Germany) Antoine Mérand, European Southern Observatory (Chile) Keiichi Ohnaka, Universidad Andres Bello (Chile) Claudia Paladini, European Southern Observatory (Chile) Sylvie Robbe-Dubois, Observatoire de la Côte d'Azur (France) Rachael M. Roettenbacher, University of Michigan (United States) Stephen A. Rinehart, NASA (United States) Gail H. Schaefer, CHARA (United States) Gerard T. van Belle, Lowell Observatory (United States) Felix Widmann, Max-Planck-Institut für extraterrestrische Physik (Germany) Rebeca García-López, University College Dublin (Ireland)