2015 CONFERENCE ON LABORATORY INSTRUCTION BEYOND THE FIRST YEAR

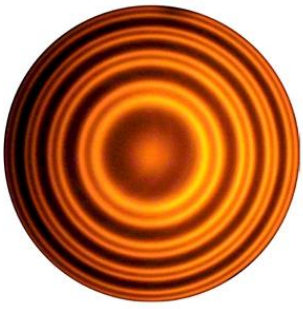
COLLEGE PARK, MD, USA JULY 22-24, 2015

EDITORS

MELISSA EBLEN-ZAYAS

ERNEST BEHRINGER

JOSEPH KOZMINSKI



ALPhA

Advanced Laboratories

Editor

Melissa Eblen-Zayas
Carleton College
Department of Physics and Astronomy
1 North College St
Northfield, MN 55057
USA

Email: meblenza@carleton.edu

Co-editors

Ernest Behringer
Eastern Michigan University
Department of Physics and Astronomy
303 Strong Hall
Ypsilanti, MI 48197
USA

Email: ebehringe@emich.edu

Joseph Kozminski
Lewis University
Department of Physics
1 University Pkwy
Romeoville, IL 60446
USA

Email: kozminjo@lewisu.edu

Published under the terms of a Creative Commons Attribution 3.0 license:
https://creativecommons.org/licenses/by/3.0/

You are free to:
- Share, copy, and redistribute the material in any medium or format
- Adapt, remix, transform, and build upon the material for any purpose, even commercially.

Provided you give attribution (include the original article's title, author(s), proceedings citation, and DOI), provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

TABLE OF CONTENTS

Acknowledgements 1

Conference Overview 2

Peer reviewed papers

Integrating Commercial Solar Panels in the Physics Curriculum 4
Nicole L. Ackerman, Amy J. Lovell, Meghan Franklin, Rebecca Cupp, Yijun (Emma) Wan, Victoria Wood, Connor Day, and Eli Whisnant

A Spectral Analysis of Laser Induced Fluorescence of Iodine 8
S. B. Bayram and M. V. Freamat

Witnessing Entanglement 12
Marisol N. Beck and M. Beck

Screening Electric Fields Using a Tube of Water: The Transition From Conductive To Dielectric Screening 16
Jake S. Bobowski and Jaklyn De Vos

Using Split-ring Resonators to Measure the Electromagnetic Properties of Materials: An Experiment for Senior Physics Undergraduates 20
Jake S. Bobowski

An Intensive Short Course on Atomic-Force Microscropy 24
Nancy A. Burnham, Andrea Arcifa, Mohammad Divandari, Christian Mathis, Shivaprakash N. Ramakrishna, Nicholas D. Spencer

Comparing Electronic and Traditional Lab Notebooks in the Advanced Lab 28
Melissa Eblen-Zayas

From a Low-Cost Spectrograph to a High Resolution Spectrograph 32
T.T. Grove

A Differential Thermal Analysis Apparatus for Exploring the Glass Transition 36
William R. Heffner

Micro-ESR as a Laboratory Teaching Tool 40
Christine Hofstetter and James R. White

Assessing Modeling in the Lab: Uncertainty and Measurement 44
N.G. Holmes and Carl Wieman

Nonlinear Dynamics on the Cheap in the Junior Laboratory 48
Richard Krantz, Nick Hoen, Julie Zimmerman, Randall Tagg, and John Carlson

A Peer Review of Writing Workshop in the Advanced Lab 52
Melanie B. Lott

Low-cost Coincidence Counting Apparatus for Single Photon Optics Investigations 56
Mark F. Masters, Tanner Heral, and Kakathi Tummala

Investigation of the Bragg-Snell Law in Photonic Crystals 60
Gina Mayonado, Shabbir M. Mian, Valentina Robbiano, and Franco Cacialli

Introducing Students to Single Photon Detection with a Reverse-Biased LED in Avalanche Mode 64
Lowell I. McCann

The Thermographic Phospor Labkit 68
Mark M. McKeever, Michael R. Cates, Stephen W. Allison, David L. Beshears, Alfred Akerman, Matthew B. Scudiere, and James E. Parks

***LCphysX*: Teaching Undergraduate Physics Majors Multi-Media Science Communication Skills for Public Outreach** 72
Shannon O'Leary and Parvaneh Abbaspour

Compton Scattering of Cs-137 Gamma Rays 76
James E. Parks and Christine P. Cheney

Exploring the Rotating Reference Frame in Off-Resonance Pulsed NMR 80
David B. Pengra

An Optics Laboratory Module on Image Formation, Aberrations and Lens Design 84
Robert D. Polak and Nicholas M. Pflederer

Sequential Introduction of Data Analysis Methods in the Modern Lab 88
Timothy Roach

Effectiveness of Flipped Classroom Techniques in an Advanced Laboratory Physics Course 92
Sean P. Robinson, Gunther Roland, Charles Bosse, and Evan Zayas

Undergraduate Advanced Laboratory Studies on Supersonic Nozzle Flow 96
Keith R. Stein, Connor D. Fredrick, and Richard W. Peterson

Technical Competencies - A Versatile Framework for Learning Practical Knowledge 100
Randall Tagg

Using Digilent's Basys3 FPGA Board with LabVIEW for Single Photon Counting 104
Matthew T. Vonk

An Arduino-Based Alternative to the Traditional Electronics Laboratory 107
Rodney Yoder

Author Index 111

ACKNOWLEDGMENTS

At the 2015 Conference on Laboratory Instruction Beyond the First Year of College (BFY II), sponsored by the Advanced Laboratory Physics Association (ALPhA), 150 members of the advanced lab community gathered to share effective lab curricula, teaching methods, and experiments. In addition, with the release of the *AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum* in November 2014, the BFY II conference provided the opportunity for discussion of the recommendations and opportunities and challenges for implementation. These Proceedings provide documentation of some of the 52 posters and 55 workshops that were presented as part of the conference.

This year marks the first time that the Conference on Laboratory Instruction Beyond the First Year of College has published a peer-reviewed Proceedings. This volume is the result of an idea that originally arose from the Documentation Subcommittee, which included Ernie Behringer, Melissa Eblen-Zayas, Erin Flater, Joe Kozminski, and Randy Peterson. The support of Elizabeth George, Conference Chair, and other members of the organizing committee was also important in making this volume possible. The Proceedings' on-line submission and review process were supported by Lyle Barbato and Bruce Mason, who provided significant support in ensuring that the submission, review, and publication process ran smoothly. We thank both Lyle and Bruce for their effort and the excellent work. In addition, this volume would not be possible without all of the referees who volunteered their time and expertise to review the papers submitted for publication in the Proceedings.

The Editors thank:

Nicole Ackerman, Stephen Allison, Eric Ayars, Burcin Bayram, Mark Beck, Ernest Behringer, Jake Bobowski, Charles Bosse, Nancy Burnham, Christine Cheney, Nathaniel Cunningham, Robert DeSerio, Melissa Eblen-Zayas, John Essick, Nathan Frank, Mario Freamat, Elizabeth George, Elena Gregg, Timothy Grove, William Heffner, Christine Hofstetter, Natasha Holmes, Joss Ives, Joseph Kozminski, Richard Krantz, Shawn Langan, Melanie Lott, Jenny Magnes, Mark Masters, Lowell McCann, Shabbir Mian, Shannon O'Leary, James Parks, David Pengra, Randolph Peterson, Robert Polak, Timothy Roach, Sean Robinson, Gabriel Spalding, Keith Stein, Randall Tagg, Matt Vonk, Jeremiah Williams, Rodney Yoder.

We hope that these Proceedings provide useful documentation for advanced lab instructors in physics and are another means to support this growing community.

Melissa Eblen-Zayas
Ernest Behringer
Joe Kozminski

CONFERENCE OVERVIEW

2015 Conference on Laboratory Instruction Beyond the First Year (BFY II)

The conference theme, "Constructing Great Instructional Lab Experiences," was inspired by the recent *AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum*. These recommendations underscore the essential role of laboratory instruction in developing students' physics knowledge and experimental abilities in addition to many transferable skills such as modeling, design, troubleshooting, innovation, and communication. Implementing the recommendations requires attention to the overall spiral/scaffolded nature of the curriculum as well as to the specific experiments and techniques to be taught.

At the conference, invited talks, workshops, breakout sessions, and posters provided opportunities for participants to share their ideas and expertise regarding specific experiments, assessment practices, developing an effective BFY laboratory curriculum, and approaches to cultivating broadly transferable skills in our students. The conference also provided time and space to discuss community-building initiatives to support laboratory instructors and staff in a time of diminishing resources and increasing pressures on hands-on laboratory instruction. The 2015 BFY conference was an opportunity for those who share a vision for effective laboratory instruction to come together to share ideas and knowledge, learn new techniques, ask questions, and plan for the future, so that we can continue to construct positive instructional laboratory experiences for our students and for ourselves. We thank all those who participated and contributed toward the success of the conference.

Organizers:
Elizabeth George (chair), *Wittenberg University*
Gabe Spalding (co-chair), *Illinois Wesleyan University*
Randolph Peterson (co-chair), *University of the South*
Ernie Behringer, *Eastern Michigan University*
Andy Dawes, *Pacific University*
Paul Dolan, *Northeastern Illinois University*
Bob DeSerio, *University of Florida*
Melissa Eblen-Zayas, *Carleton College*
Emily Edwards, *University of Maryland - College Park*
John Essick, *Reed College*
Erin Flater, *Luther College*
Nathan Frank, *Augustana College*
Joss Ives, *University of British Columbia*
Joseph Kozminski, *Lewis University*
Yongkang Le, *Fudan University*
Mark Masters, *Indiana University - Purdue University Fort Wayne*
Lowell McCann, *University of Wisconsin - River Falls*
Shannon O'Leary, *Lewis and Clark College*
Jeremiah Williams, *Wittenberg University*
Benjamin Zwickl, *Rochester Institute of Technology*

The organizing committee of BFY II thanks the following people for their indispensable assistance in making this conference a reality:

Lyle Barbato and Bruce Mason (ComPADRE); Tiffany Hayes, Bob Hilborn, and Beth Cunningham (AAPT); and the Proceedings Editor, Melissa Eblen-Zayas, and Co-Editors Ernie Behringer and Joseph Kozminski. We especially thank our hosts, the Physics Frontier Center at the Joint Quantum Institute, and the University of Maryland Physics Department. We are also grateful for financial support from the National Science Foundation TUES Type II DUE Award 1122993, the Advanced Labs Physics Association (ALPhA), the APS Forum on Education, and our participating vendors: Keysight Technologies, Active Spectrum, Cold Quanta, Quantum Design, PASCO Scientific, Spectrum Techniques, TeachSpin, MathWorks, Klinger Educational Products, Keithley Instruments, Star Cryoelectronics, and Edmund Optics.