CONTEMPORARY MATHEMATICS

606

Centre de Recherches Mathématiques Proceedings

Women in Numbers 2: Research Directions in Number Theory

BIRS Workshop
WIN2—Women in Numbers 2
November 6–11, 2011
Banff International Research Station
Banff, Alberta, Canada

Chantal David
Matilde Lalín
Michelle Manes
Editors

American Mathematical Society
Providence, Rhode Island

Centre de Recherches Mathématiques
Montréal, Québec, Canada

Women in Numbers 2: Research Directions in Number Theory

CONTEMPORARY MATHEMATICS

606

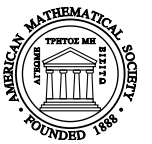
Centre de Recherches Mathématiques Proceedings

CRM

Women in Numbers 2: Research Directions in Number Theory

BIRS Workshop
WIN2—Women in Numbers 2
November 6–11, 2011
Banff International Research Station
Banff, Alberta, Canada

Chantal David
Matilde Lalín
Michelle Manes
Editors



American Mathematical Society
Providence, Rhode Island

Centre de Recherches Mathématiques
Montréal, Québec, Canada

Editorial Board of Contemporary Mathematics

Dennis DeTurck, managing editor

Michael Loss Kailash Misra Martin J. Strauss

Editorial Committee of the CRM Proceedings and Lecture Notes

Jerry L. Bona	Peter Glynn
Galia Dafni	Andrew Granville
Chantal David	Victor Guillemin
Donald Dawson	François Lalonde
Luc Devroye	Noriko Yui

2010 *Mathematics Subject Classification.* Primary 11G05, 11G40, 11N37, 11R06, 11R11, 11T24, 11Y16, 14J28, 33C20, 94A60.

Library of Congress Cataloging-in-Publication Data

WIN (Conference) (2nd : 2011 : Banff, Alta.)

Women in Numbers 2 : research directions in number theory : BIRS Workshop, WIN2—Women in Numbers 2, November 6–11, 2011, Banff International Research Station, Banff, Alberta, Canada / Chantal David, Matilde Lalín, Michelle Manes, editors.

pages cm. – (Contemporary mathematics ; volume 606) (Centre de recherches mathématiques proceedings)

Includes bibliographical references.

ISBN 978-1-4704-1022-3 (alk. paper)

1. Curves, Elliptic–Congresses. 2. Arithmetical algebraic geometry–Congresses. 3. Number theory–Congresses. I. David, Chantal, 1964- II. Lalín, Matilde, 1977- III. Manes, Michelle, 1970- IV. Title.

QA567.2.E44W56 2011

512.7–dc23 2013027435

Contemporary Mathematics ISSN: 0271-4132 (print); ISSN: 1098-3627 (online)

DOI: http://dx.doi.org/10.1090/conm/606

Copying and reprinting. Material in this book may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Acquisitions Department, American Mathematical Society, 201 Charles Street, Providence, Rhode Island 02904-2294, USA. Requests can also be made by e-mail to reprint-permission@ams.org.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

© 2013 by the American Mathematical Society. All rights reserved.
The American Mathematical Society retains all rights
except those granted to the United States Government.
Copyright of individual articles may revert to the public domain 28 years
after publication. Contact the AMS for copyright status of individual articles.
Printed in the United States of America.

⊗ The paper used in this book is acid-free and falls within the guidelines
established to ensure permanence and durability.
Visit the AMS home page at http://www.ams.org/

10 9 8 7 6 5 4 3 2 1 13 12 11 10 09 08

Contents

Preface vii

Workshop Participants and Affiliations at the Time of the Workshop ix

The Local Equivariant Tamagawa Number Conjecture for Almost Abelian Extensions
Jennifer Johnson-Leung 1

Images of Metabelian Galois Representations Associated to Elliptic Curves
Rachel Davis 29

Newton Polygons for a Variant of the Kloosterman Family
Rebecca Bellovin, Sharon Anne Garthwaite, Ekin Ozman, Rachel Pries, Cassandra Williams, and Hui June Zhu 47

Comparing Arithmetic Intersection Formulas for Denominators of Igusa Class Polynomials
Jacqueline Anderson, Jennifer S. Balakrishnan, Kristin Lauter, Jennifer Park, and Bianca Viray 65

An Algorithmic Approach to the Dwork Family
Adriana Salerno 83

Ranks "Cheat Sheet"
Alice Silverberg 101

Fully Homomorphic Encryption for Mathematicians
Alice Silverberg 111

Mahler Measure of Multivariable Polynomials
Marie-José Bertin and Matilde Lalín 125

Mahler Measure of Some Singular $K3$-Surfaces
Marie-José Bertin, Amy Feaver, Jenny Fuselier, Matilde Lalín, and Michelle Manes 149

Distribution of Squarefree Values of Sequences Associated with Elliptic Curves
Shabnam Akhtari, Chantal David, Heekyoung Hahn, and Lola Thompson 171

Recent Advances for Ramanujan Type Supercongruences
Sarah Chisholm, Alyson Deines, and Holly Swisher 189

Preface

The second Women In Numbers workshop (WIN2) was held November 6–11, 2011, at the Banff International Research Station (BIRS) in Banff, Alberta, Canada. The workshop was one of several Research Collaboration Conferences for Women (`http://research.microsoft.com/en-us/projects/rccw/`) held in recent years. These conferences bring together senior women in a particular mathematical research area—in this case number theory—to lead research projects during a weeklong workshop. The participants in the project groups are women graduate students, postdocs, and junior faculty. The benefit of these workshops is in both directions: senior women meet, mentor, and collaborate with young researchers; junior women encounter important new research problems and develop a network of colleagues, supporters, and mentors.

Forty-one mathematicians attended the WIN2 workshop, which was organized by the three editors of this volume. The organizers first invited senior researchers to lead the projects, and then assigned the other participants to projects according to their expertise and interests. The result was eight working groups of four to six members each, including two leaders per group.

This volume contains survey articles written by leaders of the WIN2 working groups, reports on new research conducted by the working groups at the conference, and additional articles submitted by researchers who are part of the Women in Numbers Network (`http://womeninnumbertheory.org/`).

Workshop project titles and lectures

WIN2 was a working conference, with several hours each day devoted to research in project groups. In addition, there were a few talks each day. During the first three days, group leaders introduced their general areas of research and proposed their projects. On the final two days, group members described their progress and shared their plans to complete the work.

- Elliptic surfaces and Mahler measure
  - Lectures: Marie-José Bertin, Matilde Lalín
  - Group members: Amy Feaver, Jenny Fuselier, Michelle Manes
- Analytic number theory
  - Lectures: Chantal David, Heekyoung Hahn
  - Group members: Shabnam Akhtari, Min Lee, Lola Thompson
- Number theory in functions fields and algebraic geometry over finite fields
  - Lectures: Alina Bucur, Melanie Matchett Wood
  - Group members: Jing Hoelscher, Renate Scheidler
- Arithmetic algebraic geometry
  - Lectures: Alina Cojocaru, Alice Silverberg

  - Group members: Rachel Davis, Antonella Perucca, Katherine Stange, Diane Yap
- K-theory and algebraic number theory
  - Lectures: Wieslawa Niziol, Sujatha Ramdorai
  - Group members: Veronica Ertl, Bregje Pauwels, Ila Varma
- Arithmetic geometry
  - Lectures: Rachel Pries, June Zhu
  - Group members: Rebecca Bellovin, Sharon Garthwaite, Ekin Ozman, Cassie Williams
- Modular forms
  - Lectures: Ling Long, Gabriele Nebe
  - Group members: Sarah Chisholm, Alyson Deines, Holly Swisher
- Arithmetic intersection theory
  - Lectures: Kristin Lauter, Bianca Viray
  - Group members: Jackie Anderson, Jennifer Balakrishnan, Jennifer Park

Contributions to this volume

The editors requested one or two contributions from each working group at the WIN2 workshop. In addition, we solicited articles through the Women in Numbers Network (mailing list and web site). All submissions to this volume were sent to anonymous referees, who assessed them as correct and worthwhile contributions to these proceedings.

Workshop website

`https://www.birs.ca/events/2011/5-day-workshops/11w5075`

Acknowledgements

We are grateful to the following sponsoring organizations for their support of the workshop and this volume:

- Banff International Research Station
- Microsoft Research
- Pacific Institute for the Mathematical Sciences
- The Number Theory Foundation

We would like to thank the referees whose careful and dedicated work have been crucial in assuring the quality of this publication.

July 2013
Chantal David, Concordia University, Canada
Matilde Lalín, Université de Montréal, Canada
Michelle Manes, University of Hawai‘i at Mānoa, USA

Workshop Participants and Affiliations at the Time of the Workshop

Shabnam Akhtari
Centre de recherches mathématiques, Canada

Jackie Anderson
Brown University, USA

Jennifer Balakrishnan
Harvard University, USA

Rebecca Bellovin
Stanford University, USA

Marie-José Bertin
Université Paris 6, France

Alina Bucur
University of California San Diego, USA

Sarah Chisholm
University of Calgary, Canada

Alina Cojocaru
University of Illinois at Chicago, USA

Chantal David
Concordia University, Canada

Rachel Davis
University of Wisconsin–Madison, USA

Alyson Deines
University of Washington, USA

Veronika Ertl
University of Utah, USA

Amy Feaver
University of Colorado Boulder, USA

Jenny Fuselier
High Point University, USA

Sharon Garthwaite
Bucknell University, USA

Heekyoung Hahn
McGill University, Canada

Jing Hoelscher
University of Illinois at Chicago, USA

Matilde Lalín
Université de Montréal, Canada

Kristin Lauter
Microsoft Research, USA

Min Lee
Columbia University, USA

Ling Long
Iowa State University, USA

Michelle Manes
University of Hawai‘i at Mānoa, USA

Gabriele Nebe
RWTH Aachen University, Germany

Wieslawa Niziol
University of Utah, USA

Ekin Ozman
University of Texas at Austin, USA

Jennifer Park
Massachusetts Institute of Technology, USA

Bregje Pauwels
University of California Los Angeles, USA

Antonella Perucca
University of Leuven, Belgium

Rachel Pries
Colorado State University, USA

Sujatha Ramdorai
University of British Columbia, Canada

Renate Scheidler
University of Calgary, Canada

Alice Silverberg
University of California at Irvine, USA

Katherine Stange
University of Colorado Boulder, USA

Holly Swisher
Oregon State University, USA

Lola Thompson
Dartmouth College, USA

Ila Varma
Princeton University, USA

Bianca Viray
Brown University, USA

Cassie Williams
Colorado State University, USA

Melanie Matchett Wood
American Institute of Mathematics and
University of Wisconsin–Madison, USA

Diane Yap
University of Hawai‘i at Mānoa, USA

Hui June Zhu
SUNY at Buffalo, USA

The Centre de Recherches Mathématiques (CRM) was created in 1968 to promote research in pure and applied mathematics and related disciplines. Among its activities are special theme years, summer schools, workshops, postdoctoral programs, and publishing. The CRM receives funding from the Natural Sciences and Engineering Research Council (Canada), the FRQNT (Québec), the NSF (USA), and its partner universities (Université de Montréal, McGill, UQAM, Concordia, Université Laval, Université de Sherbrooke and University of Ottawa).

CONM 606

Women in Numbers 2 • David et al., Editors

The second Women in Numbers workshop (WIN2) was held November 6–11, 2011, at the Banff International Research Station (BIRS) in Banff, Alberta, Canada. During the workshop, group leaders presented open problems in various areas of number theory, and working groups tackled those problems in collaborations begun at the workshop and continuing long after.

This volume collects articles written by participants of WIN2. Survey papers written by project leaders are designed to introduce areas of active research in number theory to advanced graduate students and recent PhDs. Original research articles by the project groups detail their work on the open problems tackled during and after WIN2. Other articles in this volume contain new research on related topics by women number theorists.

The articles collected here encompass a wide range of topics in number theory including Galois representations, the Tamagawa number conjecture, arithmetic intersection formulas, Mahler measures, Newton polygons, the Dwork family, elliptic curves, cryptography, and supercongruences.

WIN2 and this Proceedings volume are part of the Women in Numbers network, aimed at increasing the visibility of women researchers' contributions to number theory and at increasing the participation of women mathematicians in number theory and related fields.

American Mathematical Society
www.ams.org

Centre de Recherches Mathématiques
www.crm.math.ca

ISBN 978-1-4704-1022-3

9 781470 410223

CONM/606

AMS/CRM