MILLER INSTITUTE NEWSLETTER

Spring 2004

Miller Fellow Focus: Elena Mantovan

Second year Miller Fellow Elena Mantovan studies arithmetic algebraic geometry. Her research mainly focuses on geometric aspects of the Langlands program. She is hosted by Professor Kenneth Ribet in the Department of Mathematics.

In 1967 Robert Langlands wrote a letter to Andre Weil where he proposed the existence of a relation between seemingly unrelated objects in number theory and harmonic analysis: Galois representations and automorphic forms.

A Galois group is the collection of all symmetries existing among the roots of a given polynomial in one variable; a Galois representation is the realization of such symmetries as matrices.

In the theory of Galois representations a key role is played by L-series. These are power series defined as infinite products, incorporating information from infinitely many primes. In the case of L-series attached to Galois representations, the factors encode information about the matrices corresponding to some distinguished elements of the Galois group (the Frobenius elements), which are indexed by prime numbers.

Deadlines to note:

Wednesday, September 22
Miller Professor applications due

Monday, September 27
Visiting Miller Professor nominations due

Monday, October 4
Miller Fellowship nominations due

L-series carry an enormous amount of information about Galois representations and questions regarding their properties are genuinely hard and among the deepest problems in number theory.

Langlands' new idea was to introduce L-series in the context of automorphic forms. Automorphic forms are analytic functions on the complex upper half-plane (or on higher dimensional analogues of it) with the property that they are essentially invariant under certain transformations of the domain. Before 1967, L-series were regarded as a purely number theoretic notion, and had no counterpart in harmonic analysis.

In his letter to Weil, Langlands attached L-series to automorphic forms, and made the remarkable suggestion that these new automorphic L-series are related to the ones arising from Galois representations. More precisely, he conjectured that every L-series arising from a Galois representation is equal to one arising from an automorphic form.

In contrast to L-series attached to Galois representations, many properties about L-series attached to automorphic forms could be established (for example the fact that they satisfy a simple functional equation) and therefore a proof of Langlands' conjecture would provide answers to many difficult questions in number theory.

In the years to follow, Langlands' ideas took the form of a web of interrelated and increasingly precise conjectures known at first as the Langlands philosophy and, more recently, as the Langlands program. There were precedents to these ideas, one of which

was a to-be-famous conjecture formulated by Taniyama and Shimura in 1955, and later rendered more precisely by Weil, which in 1993 became Andrew Wiles' celebrated work implying Fermat's last theorem. But in Langlands' letter the systematic nature of these relations and the possibility of a grand unified theory were suggested for the first time.

A correspondence between Galois representations and automorphic forms as it is proposed by the Langlands program would be a bridge between the two theories, or in other words a dictionary translating theorems of harmonic analysis into theorems about algebra, and vice versa. This would provide an incredibly powerful math-

ematical tool, and thus it is reasonable to expect that the existence of such a correspondence is not just a formal consequence of definitions, but is explained by some deep mathematics. More precisely, the relation between Galois representations and automorphic forms is to be algebraic geometry (algebraic varieties), which would be explained by the existence of certain objects in the "missing link" between the two. Since Langlands began to formulate his conjectures, many mathematicians contributed in isolating and constructing algebraic varieties whose geometry is supposed to explain the Langlands correspondences. Although the Langlands program is still mostly conjectural, since the late 1960's many of the predictions that it implies have been proven accurate and, more recently, some special but important cases of the Langlands conjectures were proven: in 1998 by Henniart, Harris and Taylor (the latter was a Miller professor and Elena's advisor at the time), and in 1999 by Lafforgue (who shared the 2002 Fields medal for his progress on the Langlands program).

Elena's research focuses on the geometry of these algebraic varieties related to the Langlands program. Algebraic varieties are higher-dimensional analogues of curves in dimension one, or surfaces in dimension two, regarded as the zeros of certain polynomials in possibly many variables. Given any such polynomial, it always admits zeros among the complex numbers (this fact is known as the fundamental theorem of algebra), but the same is not true if we insist that the zeros are real numbers or rational numbers. For example, if the polynomial has integer coefficients, e.g. y^2-x^3+x, one can restricts one's interest to zeros which are integer numbers, e.g. x=1,y=0, or changing the original question a bit, one can focus on integers on which the polynomial assumes values which are divisible by a certain fixed prime, e.g. x=2,y=1 if the prime is 5. These are the kind of questions that concern arithmetic algebraic geometry, and it is surely quite amazing and beautiful that the Langlands correspondences are explained by the existence and the arithmetical properties of certain algebraic varieties.

As the correspondences come in different "flavours," there are many different classes of algebraic objects, which are of interest for the Langlands program. Elena's research is mainly concerned with the study of Shimura varieties and Rapoport-Zink spaces, which are related respectively to the so-called global and local Langlands correspondences. As global and local conjectures are deeply entangled, some of her work is aimed to understanding the relation between the geometry of the Shimura varieties and of the Rapoport-Zink spaces, in a way that explains the compatibility between global and local conjectures. Other interrelations between different aspects of the Langlands conjectures are also expected to be directly explained by precise geometric relations between the corresponding algebraic varieties. Elena's current interest is mostly dedicated to the proof of these predictions.

AWARDS & HONORS

DAN VIRGIL VOICULESCU (MP 1997-98) was selected for a National Academy of Science Award in Mathematics for excellence in published mathematical research. The $5k prize was for work on the theory of free probability.

ARUP CHAKRABORTY (MP Spring 2000) has been elected to the National Academy of Engineering. Election to the NAE is among the highest distinctions awarded to an engineer. He was cited for his application of theoretical chemistry to practical problems, including immune system recognition, polymer interfaces, sensor technology and catalysis.

DALE PERRY (MF 1977-79) was named Fellow of the American Association for the Advancement of Science (AAAS) in 2003.

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Spring 2004

Dear Members, Alumni and Friends of the Miller Institute:

Fiftieth birthdays are milestones in the lives of most people. The Miller Institute's 50th, coming up in the Fall of 2005, is an event worthy of notice also.

I am writing to ask your help, in the preparations for our 50th. We, of the Institute's Advisory Board and Executive Committee, have given some preliminary thought to how to celebrate the Millers' 1955 gift that launched our enterprise. While the official birth date of the Institute is in November of 2005, we could recognize the event any time during the 2005-06 academic year. We have kicked around having a party or some other event at the end of the Fall or late in the Spring terms, with some preference for the winter date, so as not to conflict with the annual Miller Symposium that occurs on the first weekend in June.

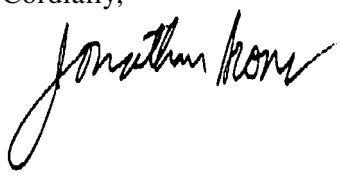
Some of our ideas for activities that could take place during a birthday party include:

- Free time to talk with colleagues
- A panel discussion on pertinent topics
- Updates on science at Berkeley "what's new"
- Talks by Miller alumni or others
- A retrospective panel of Miller Fellows
- A good dinner
- Chamber music; jazz combo; rock band; dancing party
- Discussion on the Miller Institute "the next 50 years"

These thoughts aren't exclusive, or complete. As such, we would much appreciate hearing your ideas for how we can celebrate the Institute's half century of support for science and scientists. Most scientific celebrations take the form of some kind of professional meeting–should we restrict ourselves to such a conventional format? Input now, before we get going with formal planning, would be much appreciated.

You can write to me, either at my e-mail address or the Miller Institute's postal address. All comments and suggestions will be warmly received.

Cordially,



Jonathan Arons,
Executive Director
Miller Institute

MILLER RESEARCH FELLOWSHIP AWARDS 2004-2007

The Miller Institute is pleased to announce the 2004-2007 Miller Research Fellows. Each year, the Miller Institute seeks to discover individuals of outstanding talent and to bring to Berkeley young scholars of great promise. Candidates are nominated for these awards and are selected on the basis of their academic achievement and the potential of their scientific research. They will be working with Berkeley faculty for a three-year term beginning in the 2004 academic year.

Zachary Ball
Ph.D. Stanford University
Berkeley Department: Chemistry
Faculty Sponsor: Jean Frechet

Dr. Ball's research will focus on the design and synthesis of functional organic nanoparticles. During his Miller Fellowship, he will explore the chemistry of structurally defined polyvalent nanoparticles for photochemistry, catalysis, and drug delivery. Improved function through the design of polyfunctional nanoparticles is also an important area of inquiry.

Stacey Combes
Ph.D. University of Washington
Berkeley Department: Integrative Biology
Faculty Sponsor: Robert Dudley

Dr. Combes is interested in evolutionary and ecological aspects of insect flight biomechanics. She previously used comparative, experimental and theoretical techniques to investigate insect wing flexibility and dynamic shape changes during flapping flight. As a Miller Fellow, she plans to perform further comparative analyses to examine the putative trade-off between flight maneuverability and stability, and would like to explore the scaling of maneuverability and its impact on the outcome of aerial predator-prey encounters.

Erin Cunningham
Ph.D. UCSF
Berkeley Dept: Molecular & Cell Biology
Faculty Sponsor: James Berger

The tight spatial and temporal regulation of DNA replication is critical for the faithful duplication of genetic material and the propagation of life. Key "initiator" proteins are responsible for controlling this essential process in all cells at defined replication start sites known as origins. Dr. Cunningham proposes to structurally characterize the assembly of initiation complexes, including local interactions of initiators with origin DNA, to better understand how initiators specifically recognize origin sequences and remodel origin DNA architecture to allow construction of the synthetic replication machinery.

J. Chris Fromme
Ph.D. Harvard University
Berkeley Dept: Molecular & Cell Biology
Faculty Sponsor: Randy Schekman

Dr. Fromme is interested in the mechanisms of protein trafficking within mammalian cells. His research will focus on transport from the endoplasmic reticulum to the golgi, and, in particular, on the proteins involved in vesicle budding and cargo selection.

Jiaxing Huang
Ph.D. UCLA
Berkeley Department: Chemistry
Faculty Sponsor: Peidong Yang

One-dimensional nanostructures of inorganic and organic materials will be the focus of Dr. Huang's research. During his Miller Fellowship he will explore the syntheses and investigate both their individual and collective prroperties.

Sébastien Merkel
Ph.D. École Normale Supérieure de Lyon
Berkeley Dept: Earth & Planetary Science
Faculty Sponsor: Rudolph Wenk

Dr. Merkel plans to investigate the elastic and plastic properties of polycrystals under high pressure and high temperature in order to address the microscopic processes that control the dynamics of the deep Earth. In order to address this issue, he will combine results from high-pressure experimentation and polycrystal plasticity modeling. The aim of this study is to provide the mineral physics basics needed to link the observations from seismic anisotropy and geodynamics modeling.

Matthew Reidenbach
Ph.D. Stanford University
Depts: Civil & Envir Eng / Integrative Bio
Sponsors: Mark Stacey & Mimi Koehl

Dr. Reidenbach's research focuses on the fluid mechanics of how marine organisms interact with the water around them. During his Miller Fellowship he will study how bottom-dwelling animals like lobsters utilize turbulent flow patterns in the environment and intermittent sampling by their olfactory antennules to detect and locate odor sources. This has important ramifications to the larger question of how animals track chemical plumes in the natural environment.

Joshua Shaevitz
Ph.D. Stanford University
Depts: Integrative Bio / Molecular & Cell Bio
Sponsors: Mimi Koehl & George Oster

Bacterial pathogens employ a variety of different strategies to produce directed movement within a hostile host environment. Dr. Shaevitz's research will focus on the physical mechanism by which Spiroplasma, tiny wall-less bacteria only a few microns in length, are able to move through viscous tissue from plants and insects. Measurements from high-resolution video microscopy and optical tweezers will be interpreted through the eyes of theoretical and hydrodynamically-scaled physical models to further the understanding of this fascinating motility.

Yayu Wang
Ph.D. Princeton University
Berkeley Department: Physics
Faculty Sponsor: Michael Crommie

Dr. Wang's field of research is experimental condensed matter physics. His primary interests lie in the investigations of electronic and magnetic properties of low dimensional electron systems. In these materials, strong interactions between the electrons induce many interesting phenomena such as high temperature superconductivity, quantum Hall effect and colossal magneto-resistance. As a Miller Fellow, he will use a special technique called scanning tunneling microscopy (STM) to study the electronics and magnetism of nanoscale materials, such as carbon nanotube and single magnetic molecules.

Rory Waterman
Ph.D. University of Chicago
Berkeley Department: Chemistry
Faculty Sponsor: Don Tilley

Dr. Waterman is an organometallic chemist with interests in metal-ligand multiple bonding of late transition-metals and in group transfer reactions. His research will focus on novel reactivity of transition-metal silylene complexes and the mechanisms of hydrosilation catalysis.

MILLER INSTITUTE ALUMNI JOIN BERKELEY FACULTY

The 2004 Berkeley faculty announcement made in March included three recent Miller Institute alumni. We are very happy to report that the following members have been appointed to Berkeley faculty positions:

Yasunori Nomura, a Miller Research Fellow from 2000–2002, has been named an Assistant Professor in the Department of Physics. His research area is particle physics theory and he is interested in exploring physics beyond the standard model of particle physics.

Peter Bartlett was a Visiting Miller Professor during the Fall of 2001. He has joined the Departments of EECS, Division of Computer Science and Statistics as a Professor. His research interests include machine learning, statistical learning theory, artificial intelligence, and adaptive control.

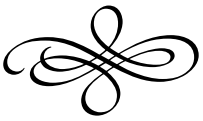
Elchanan Mossel is currently a Miller Research Fellow in the Department of Statistics. Upon completion of his Miller Fellowship term he will assume an Assistant Professorship in the same department. His research focuses on applications of tools from mathematical-physics and probability to the study of algorithms and statistics, in particular, to Markov chain Monte Carlo sampling, to phylogenies and to statistical learning.

Peter Bartlett

Elchanan Mossel

Yasunori Nomura

Visiting Miller Professorship Program Awards – Spring Competition



Each year, the Miller Institute holds two competitions to select Visiting Miller Professors for the following academic year. The following Visiting Miller Professors were selected during the spring competition cycle. The purpose of this program is to bring promising or eminent scientists to the Berkeley campus for collaborative research interactions. The recipients will be on campus for terms during the 2004-05 academic year.

ASTRONOMY	**SANDRA FABER** UNIVERSITY OF CALIFORNIA, SANTA CRUZ SPONSORED BY MARC DAVIS & ALEX FILIPPENKO
CIVIL & ENVIRONMENTAL ENGINEERING	**OLIVIER COUSSY** INSTITUT NAVIER, FRANCE SPONSORED BY PAULO MONTEIRO
EARTH & PLANETARY SCIENCE	**ROGER BILHAM** UNIVERSITY OF COLORADO SPONSORED BY ROLAND BÜRGMANN
ELECTRICAL ENGINEERING & COMPUTER SCIENCE	**HILBERT KAPPEN** UNIVERSITY OF NIJMEGEN, THE NETHERLANDS SPONSORED BY MICHAEL JORDAN
ESPM	**RONALD HOY** CORNELL UNIVERSITY SPONSORED BY MARK TANOUYE
MATHEMATICS	**JOHN LOTT** UNIVERSITY OF MICHIGAN SPONSORED BY MACIEJ ZWORSKI
PHYSICS	**TORD CLAESON** CHALMERS UNIVERSITY OF TECHNOLOGY, SWEDEN SPONSORED BY JOHN CLARKE
PLANT & MICROBIAL BIOLOGY	**RAOUL RANJEVA** UNIVERSITE PAUL SABATIER NO 5546, FRANCE SPONSORED BY RUSSELL JONES AND SHENG LUAN
STATISTICS	**ROBERT KASS** CARNEGIE MELLON UNIVERSITY SPONSORED BY BIN YU

Miller Institute News
Spring 2004
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Recent Publications

Xanthippi Markenscoff (VMP Fall 2003) has submitted a paper entitled, "Conservation laws of linear elasticity in stress formations" to Proceedings of Royal Society of London A. A second paper, "The Inverse Problem of Inclusions of Polynomial Eigenstress" has also been submitted to the Philosophical Magazine.

Benjamin McCall (MF 2001-2004) published twelve papers during his Miller Fellowship term. He has submitted another two and eleven are in preparation. Selected works follow:

A. J. Huneycutt, R. N. Casaes, B. J. McCall, C.-Y. Chung, Y.-P. Lee, and R. J. Saykally
Infrared Cavity Ringdown Spectroscopy of Jet-Cooled Polycyclic Aromatic Hydrocarbons
ChemPhysChem, 5, 321 (2004)

S. Kalhori, R. Thomas, A. Al-Khalili, A. Ehlerding, F. Hellberg, A. Neau, M. Larsson, A. Larson, A. J. Huneycutt, B. J. McCall, N. Djuric, G. H. Dunn, J. Semaniak, O. Novotny, A. Paal, F. Osterdahl, A. E. Orel
Resonant Ion-Pair Formation in Electron Collisions with Rovibrationally Cold H_3+
Physical Review A, 69, 022713 (2004)

M. Adamkovics, G. A. Blake, and B. J. McCall
Observations of Rotationally Resolved C3 in Translucent Sight Lines
Astrophysical Journal, 595, 235 (2003)

B. J. McCall, R. N. Casaes, M. Adamkovics, and R. J. Saykally. *A Re-examination of the 4051 Å Band of C_3 Using Cavity Ringdown Spectroscopy of a Supersonic Plasma* **Chemical Physics Letters**, 374, 583 (2003)

J. L. Gottfried, B. J. McCall, and T. Oka
Near-Infrared Spectroscopy of H_3+ Above the Barrier to Linearity
Journal of Chemical Physics, 118, 10890 (2003)

B. J. McCall, A. J. Huneycutt, R. J. Saykally, T. R. Geballe, N. Djuric, G. H. Dunn, J. Semaniak, O. Novotny, A. Al-Khalili, A. Ehlerding, F. Hellberg, S. Kalhori, A. Neau, R. Thomas, F. Osterdahl, and M. Larsson
Enhanced cosmic-ray flux toward zeta Persei inferred from laboratory study of H_3+-e^- recombination rate
Nature, 422, 500 (2003)