

## Miller Fellow Focus: Isamu Matsuyama

Isamu Matsuyama is a second year Miller Fellow in the Department of Earth & Planetary Science. He obtained his Ph.D. in Astronomy and Astrophysics at the University of Toronto. He has a broad interest in the formation and evolution of solar system objects. His current work focuses on rotational dynamics of planets and satellites and its effect on gravity, shape, and tectonic patterns. This provides insights into their structure, formation and internal evolution. Changes in rotation explain large-scale features such as the deformation of ancient shorelines on Mars, circular depressions on Jupiter's moon Europa, and the gravity field of Mercury. On Earth, changes in rotation are associated with issues of great societal impact such as ice melting and sea level rise.

Any major mass redistribution

on a planet could cause a re-orientation of the rotation axis because the minimum energy state for a spinning body corresponds to principal axis rotation, with most of the mass farthest from the spin axis. This type of reorientation is commonly referred to as true polar wander. Mass redistribution may arise as a result of internal mechanisms such as convection, or external mechanisms such as impacts. In addition to rotation axis reorientation, mass redistribution can also lead to changes in rotation rate to conserve angular momentum.

Isamu developed several new theoretical treatments for the analysis of rotational dynamics, and is using these formalisms to analyze the rotational stability of planets and moons in the solar system. Assumptions made in previous analy-



ses led to the surprising conclusion that the equilibrium rotation axis orientation is independent of the thickness of the elastic lithosphere, the outer shell sufficiently rigid to support elastic stresses over geological time scales. Isamu's new generalized analysis of the rotational stability problem demonstrates that the equilibrium pole position is in fact a function of the elastic lithospheric thickness. The

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### Announcement: Call for Nominations

Miller Fellow nominations are due on  
**Thursday, September 10, 2009**

Miller Professor applications are due on  
**Thursday, September 17, 2009**

Visiting Miller Professor Departmental nominations are due on  
**Monday, September 21, 2009**

**More competition information on Page 3.**

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elastic lithosphere forms a remnant rotational bulge that retains a memory for prior rotational states, stabilizing the rotation axis. The equilibrium rotation axis orientation is governed by a balance between reorientation induced by mass redistribution and stabilization by this remnant rotational bulge. Isamu also illustrated that the minimum total energy state may not correspond to principal axis rotation for planets with elastic lithospheres because reorientation of the rotation axis generates elastic energy, increasing the total energy as the rotation axis approaches principal axis rotation. In this case, a competition between decreasing rotational energy and increasing elastic energy also governs the equilibrium rotation axis orientation.

The largest mass anomaly on the surface of Mars is the Tharsis volcanic region, a ~10 km high, ~4000 km wide bulge that covers roughly a quarter of the surface (Figure 1). Tharsis is near the equator, as expected for a positive mass anomaly. However, it could have formed at its present location, or it could have formed elsewhere and migrated to its current location via true polar wander. Isamu found that the equations governing the rotational stability permit higher excursions of the Martian rotation pole than has previously been appreciated, including reorientations approaching 90°.

Isamu used the new rotational theory in a study that found new evidence to support the presence of large oceans on Mars. Ancient features resembling shorelines had been identified on the surface (Figure 1); however, the Mars Global Surveyor (MGS) spacecraft mapped the Martian topography and found that these ancient features vary in elevation by up to several kilometers. Since shorelines are expected to follow an equipotential surface at constant height, the MGS height measurements had been used to argue against their connection to past oceans on Mars. The study found that these variations in elevation can be explained by surface deformation from true polar wander. Isamu illustrated that the paleopole positions inferred from the shoreline deformation corresponds to the most stable ro-

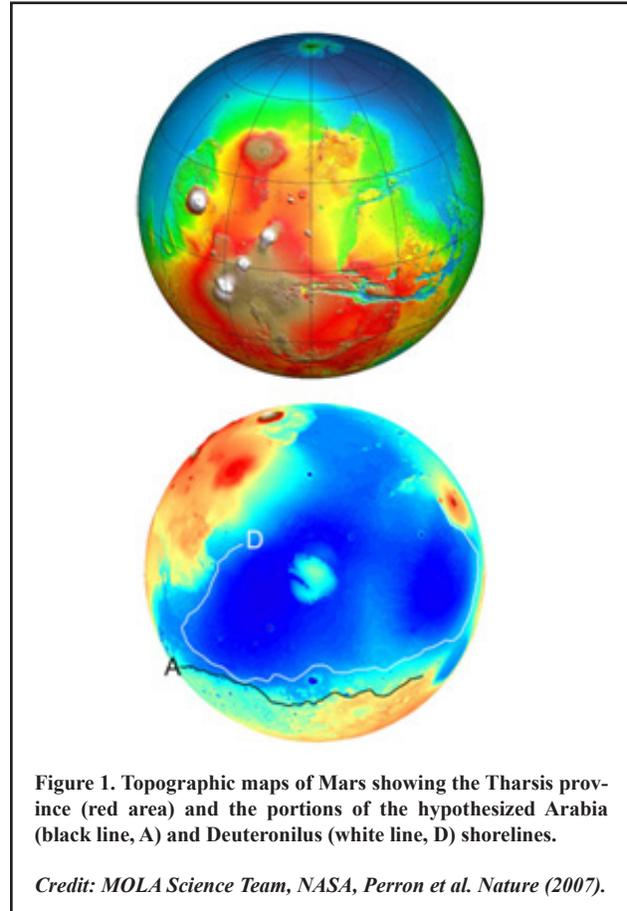


Figure 1. Topographic maps of Mars showing the Tharsis province (red area) and the portions of the hypothesized Arabia (black line, A) and Deuteronilus (white line, D) shorelines.

Credit: MOLA Science Team, NASA, Perron et al. *Nature* (2007).

tational configurations. Reorientation generates large-scale perturbations to the gravity field and Isamu is currently using gravity data to constrain possible reorientation geometries on Mars.

The satellites of the outer solar system exhibit a large diversity, and are natural laboratories for studying planetary evolution. Satellites experience rotational deformation due to their own spin as well as tidal deformation due to tides raised by the parent body. The surface of satellites and planets may show signs of rotational and tidal changes since these can generate stresses that are large enough to produce faults and cracks. Isamu extended his work to include the effect of tidal deformation, and derived analytic solutions for the stresses generated by rotational and tidal changes. In application to Jupiter's moon Europa, he compared the pattern of observed arc-shaped depressions with fractures that would result from stresses caused by reorientation to conclude that the rotation axis had shifted by approximately

# Miller Research Competitions

*Forms and information are available on our website at <http://millerinstitute.berkeley.edu>  
Direct questions to Kathryn Day at the Miller Institute office at 642-4088 or at [millerinstitute@berkeley.edu](mailto:millerinstitute@berkeley.edu)*

**Miller Research Fellowships for 2010-2013**  
**Deadline for RECEIPT of nominations is 4 p.m.**  
**Thursday, September 10, 2009.**

The Miller Institute seeks to discover and encourage individuals of outstanding talent and to provide them with the opportunity to pursue their research in the sciences. The Fellowships are intended to bring to the Berkeley campus brilliant young women and men of great promise who have recently been awarded or who are about to be awarded the doctoral degree.

Early nominations are encouraged to allow the candidate more time to prepare and submit their application materials and request references by deadline. Nominations can be submitted by e-mail, fax or mail to arrive on or before deadline. Nominations may be submitted by UC faculty, faculty from other universities, current and former Miller Institute members and other distinguished scientists worldwide. A Nomination Form is available on our website. Nominations can also be a letter that must include the nominee's: **1) Full and Legal Name** **2) Current, complete E-mail address, Mailing address, Phone & Fax numbers** **3) Date (Expected) of Ph.D. & Ph.D. Institution and 4) Recommendation and judgment of the candidate's promise by the nominator.** To ensure that nominees receive our correspondence, the nomination letter *must* provide an active and accurate e-mail address for the nominee. Incomplete nominations cannot be processed. Suitable nominees will be invited to submit documentation supporting their nomination. Such material will be accepted only following invitation from the Institute. Direct applications are not accepted. *Please note that persons in positions on the Berkeley campus are not eligible for nomination or receipt of an award. This means that an individual cannot be on campus at the time of nomination or throughout the competition cycle.*

The Institute provides Miller Fellows with an annual stipend of \$60,000 and a research fund of \$12,000 per annum. Each Miller Fellow is sponsored by an academic department of the Berkeley campus and performs his or her research in the facilities provided by the host UC Berkeley academic department. The Miller Institute also provides benefits including medical, dental, vision and life insurance. Fellowships will be awarded for three years, generally beginning August 1. Miller Fellows are selected on the basis of their academic achievement and the promise of their scientific research. Approximately eight to ten Fellowships are awarded each year. Eligibility for non-US citizens is contingent upon their ability to obtain J-1 Scholar visa status for the duration of the Miller Fellowship. The Miller Institute cannot support H1B status. Candidates will be notified of the results of the competition in January and a general announcement of the awards will be made in the spring.

**Miller Research Professorship Program**  
**Deadline for RECEIPT of applications is 4 p.m.**  
**Thursday, September 17, 2009.**

This program is open only to faculty of the University of California. Applications received will be considered for either the full academic year, beginning July 1, 2010, or one semester of Academic Year 2010-2011, the semester to be determined by the applicant in consultation with the department. Professorial salary and benefits for a regular 9/12 academic year or semester will be paid by the Miller Institute; other UC campus faculty must seek sponsorship of a Berkeley campus academic department before making an application and need to submit endorsement letters from the Berkeley campus Department Chair as well as their home campus Department Chair. The Miller bequest requires that the research be conducted on the Berkeley campus, so no extended absences from the campus should be planned for the term of the Miller appointment. Candidates will be notified of decisions in December.

**Visiting Miller Professorship Program**  
**Deadline for RECEIPT of nominations is 4 p.m.**  
**Monday, September 21, 2009**

The purpose of the Visiting Miller Professorship is to bring promising or eminent scientists to the Berkeley campus on a short-term basis for collaborative research interactions. It is required that awardees be hosted by UC Berkeley academic departments and that their research be conducted on the Berkeley campus. Awardees are expected to be in residence at Berkeley during their entire Miller Institute appointment terms and the visit should run in consecutive weeks. Travel during appointment is not allowed and will result in adjusted stipend and living expense payments.

The Miller Institute invites Berkeley faculty by way of their academic Department Chair to make departmental nominations for Visiting Miller Professorships. Each complete nomination packet should be submitted separately by email or personally delivered to the Institute. The Department Chair and Faculty Sponsor will receive an email reply of receipt of nomination. Incomplete nominations cannot be processed and the Chair will be notified. If a receipt email is not received, please contact us to ensure the nomination was received for processing. Please note that nominations are to be submitted by Berkeley faculty by way of their Department Chair. Direct applications are not accepted. Terms for Visiting Professorships range from two weeks to one full semester (120 days) and must take place during Fall 2010 or Spring 2011. It is not appropriate to request a starting date between semesters or during the summer. Please note that nominees who are non-US citizens are contingent upon eligibility for obtaining J-1 Scholar visa status for the duration of the Visiting Miller Professor appointment. H1B visa status is not supported. Awards will be announced in December.

## Miller Fellow Focus (continued)

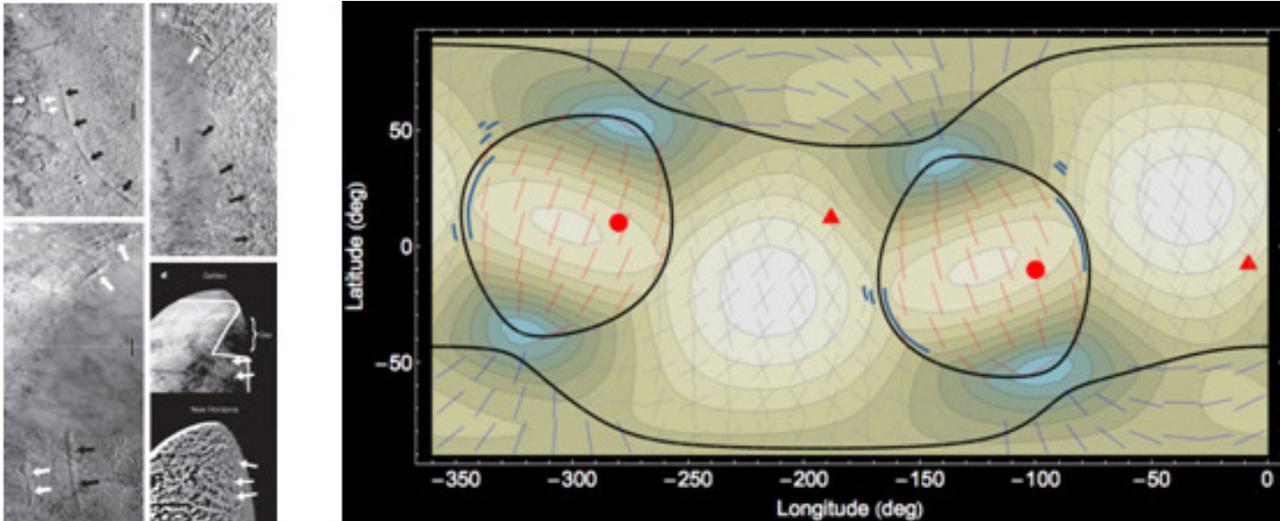


Figure 2. Left: Combined Voyager, Galileo, and New Horizons data showing several arc segments of circular depressions. Right: Expected tectonic pattern for a large reorientation. Red circles indicate the location of the north and south rotation poles prior to reorientation. The arcs of the circular depressions are shown in blue.

Credit: Schenk et al. *Nature* (2008).

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80° (Figure 2). Thickness variations of Europa's outer shell can explain the mass redistribution required for the large reorientation. Such a large reorientation may require decoupling the outer icy shell from the interior, suggesting the existence of an internal liquid ocean beneath the icy shell. However, even with an internal liquid ocean, the outer shell and the interior may be coupled through gravitational, pressure, and viscous torques. Isamu plans to extend his analysis by considering the effect of these torques.

In the future, Isamu plans to make predictions for gravity, shape, and tectonic patterns of planets and icy satellites that will be testable with upcoming space missions. This will provide useful constraints for their internal structure, and rotational and orbital evolution. In application to Earth, current models assume a biaxial shape, and Isamu is extending the theoretical treatments to consider more realistic triaxial shapes.

In his free time, Isamu enjoys playing volleyball, training for triathlons, riding his bike around the hills of Berkeley, and salsa dancing.

## Spring 2009 Newsletter Correction

The printed edition of our Spring 2009 newsletter included incorrect information about incoming Miller Fellow Chang Liu. The correct information appears on the right and in the PDF version of the newsletter available at:

[http://millerinstitute.berkeley.edu/docs/spring\\_2009.pdf](http://millerinstitute.berkeley.edu/docs/spring_2009.pdf)

**Chang Liu**  
**Ph.D. - The Scripps Research Institute**  
**Berkeley Department: Bioengineering**  
**Faculty Host: Adam Arkin**



Much of nature's complexity emerges from evolution in the context of interacting organisms. Dr. Liu is interested in modeling and enforcing various forms of interaction among bacteria in order to understand the dynamics of the resulting ecologies. He will also conduct directed evolution experiments within the constraints of these interdependencies with the aim of finding new dynamical properties.

## Awards & Honors

June 23, 2009: **Stephen Leone** (Visiting Miller Professor Fall 1990, Miller Professor 2010) has been awarded the Royal Society of Chemistry's Polanyi Medal.

June 5, 2009: **Sung-Hou Kim** (Miller Professor 1983 - 1984, Fall 1996) was awarded a two-year research grant from the National Institute of Health's National Institute of Allergy & Infectious Diseases as part of federal stimulus funds through the American Recovery and Reinvestment Act (ARRA).

June 1, 2009: **Rory Waterman** (Miller Fellow 2004 - 2007) has been named a Cottrell Scholar.

May 31, 2009: **Mimi Koehl** (Miller Professor 2000 - 2001, Executive Director 2008-2010) has been awarded an Honorary Degree from Bates College in Lewiston, ME.

May 19, 2009: **Axel Meyer** (Visiting Miller Professor Spring 1996) was elected to the German Academy of Sciences Leopoldina.

May 13, 2009: **Adrian Bejan** (Miller Fellow 1976-1978) received the title of Doctor Honoris Causa from the University of Rome I, La Sapienza.

May 1, 2009: **Ray Jayawardhana** (Miller Fellow 2000 - 2002) has been named one of Canada's Top 40 Under 40.

May 1, 2009: **Robert Bergman** (Miller Professor 1982 - 1983, Fall 1993, Spring 2000) was the winner of a Chancellor's Public Service Award for his work on Chemistry in the Classroom.

April 28, 2009: **Donald DePaolo** (Miller Professor 1997 - 1998) and **Thomas Russell** (Visiting Miller Professor Spring 2009) have both received federal funding as part of the American Recovery and Reinvestment Act of 2009 for the establishment of new Energy Frontier Research Centers.

April 28, 2009: The Miller Institute is pleased to announce the following new National Academy of Sciences appointees:

- Alex Filippenko** (Miller Fellow 1984 - 1986, Miller Professor Spring 1996, Spring 2005)
- Michael Klein** (Visiting Miller Professor Spring 1997)
- Christos Papadimitriou** (Miller Fellow 1978 - 1979, Miller Professor Fall 2005)
- Adam Riess** (Miller Fellow 1996 - 1998)

April 20, 2009: The Miller Institute is pleased to announce the following newly elected members of the American Academy of Arts and Sciences:

- Mehran Kardar** (Visiting Miller Professor Spring 2002), Physics
- Steven Louie** (Miller Professor 1986 - 1987, Fall 1995), Physics
- Richard Eisenberg** (Visiting Miller Professor Spring 2005), Chemistry
- William Michael Gelbart** (Miller Fellow 1971 - 1973), Chemistry
- James Haber** (Visiting Miller Professor Spring 2005), Cellular and Developmental Biology, Microbiology and Immunology
- Guinevere Kauffmann** (Miller Fellow 1993 - 1994), Astronomy and Earth Sciences
- Stevan Arnold** (Miller Fellow 1971 - 1973), Evolutionary and Population Biology and Ecology
- Neil Shubin** (Miller Fellow 1987 - 1989), Evolutionary and Population Biology and Ecology

## Next Steps

The Miller Institute congratulates the following Miller Fellows on their next endeavors.

### **Reimundo Heluani**

Post-doctoral Research Fellow  
Mathematics  
UC Berkeley

### **Jason Stajich**

Assistant Professor  
Plant Pathology and Microbiology  
UC Riverside

### **Dustin Rubenstein**

Assistant Professor  
Ecology, Evolution, and Environmental  
Biology  
Columbia University

### **Jesse Thaler (as of January 2010)**

Assistant Professor  
Physics  
MIT

### **Jonathon Shlens**

Research Associate  
Center for Neural Science  
New York University / Howard Hughes  
Medical Institute

### **Yue Wu**

Assistant Professor  
Chemical Engineering  
Purdue University

### **Yuanbo Zhang**

Professor  
Physics  
Fudan University  
Shanghai, China

## Publications

The following Miller Institute members have recently published works resulting from research during their Miller Institute terms. For more information about these publications, please visit the Miller Institute's website at: [millerinstitute.berkeley.edu/publications.htm](http://millerinstitute.berkeley.edu/publications.htm).

### **Sergio Ferrara**

Visiting Miller Professor Fall 2008

### **Dustin Rubenstein**

Miller Fellow 2006 - 2009

### **Michael Manga**

Miller Fellow 1994 - 1996  
Miller Professor 2008 - 2009

### **Jason Stajich**

Miller Fellow 2006 - 2009

### **Nicholas Mathevon**

Visiting Miller Professor Fall 2008

### **Jonathon Shlens**

Miller Fellow 2008 - 2009

### **Lucy Pao**

Visiting Miller Professor Fall 2008

### **Jesse Thaler**

Miller Fellow 2006 - 2009

### **Leo Radzihovsky**

Visiting Miller Professor Fall 2008

# Interdisciplinary Symposium June 2009



Pre-Symposium Hike



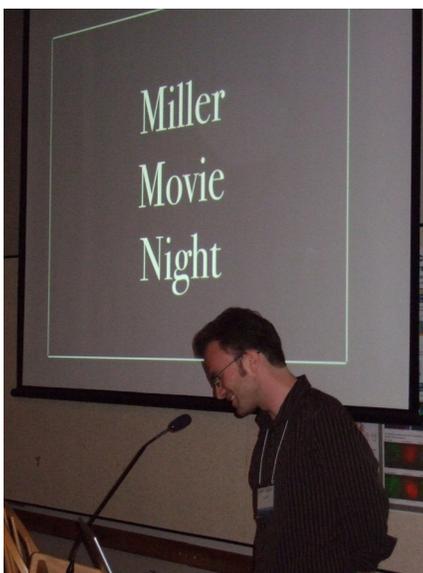
Tessa Burch-Smith and Pascal Audet



Jerry Mitrovica and Joe Dufek



Chris Somerville, Inez Fung, and Randy Schekman

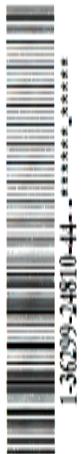
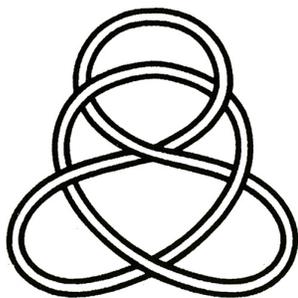


Jesse Thaler



Dinner time

**For more pictures from the Symposium, visit:**  
<http://millerinstitute.berkeley.edu/page.php?nav=142>



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## Birth Announcements

Congratulations to the following Miller Institute members on the newest additions to their families:

Markus and **Birgit Schwickert** (Miller Fellow 1999-2002) on the birth of their twins Mona Sophie and Nikolas Alexander Schwickert, born April 15, 2009.

Kate and **Dustin Rubenstein** (Miller Fellow 2006-2009) on the birth of Renna Alessa Rubenstein, born May 11, 2009.

**Alison Galvani** (Miller Fellow 2002-2005) & **Jeffrey Townsend** (Miller Fellow 2002-2005) on the birth of Evan David Galvani-Townsend, born May 31, 2009.

Bo Xie and **Yue Wu** (Miller Fellow, 2006-2009) on the birth of Sean Shaoang Wu, born July 8, 2009.

Kate Liesinger and **Scott Morrison** (Miller Fellow, 2009-2012) on the birth of Simon Liesinger, born August 2, 2009.

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*The Miller Institute is “dedicated to the encouragement of creative thought and the conduct of research and investigation in the field of pure science and investigation in the field of applied science in so far as such research and investigation are deemed by the Advisory Board to offer a promising approach to fundamental problems.”*