

Miller Fellow Focus: Jesse Thaler



The 1977 Charles and Ray Eames documentary “Powers of Ten” offers the viewer a dizzying illustration of the vastness of the universe. Starting from an overhead image of a Chicago lakefront picnic, the view zooms out 25 orders of magnitude, past the earth, the solar system, the Milky Way, the Local Group, and the Virgo Supercluster. Then, returning back to Chicago, the view zooms in 18 orders of magnitude, into a human body, a cell, a strand of DNA, a molecule, an atom, a nucleus, and

ends at the (then) mysterious realm of quarks.

This film serves as inspiration for scientists to push the boundaries of the macroscopic and the microscopic, to explore the outer reaches of the visible universe and probe the fundamental building blocks of Nature. But for Jesse Thaler, a second-year Miller Fellow in theoretical particle physics, “Powers of Ten” also evokes more basic questions about our place in the universe: Why is the human body so much smaller than a galaxy but so much larger than an atom? Why are there 43 orders of magnitude between the largest and smallest known objects and not more or less? How do the laws of physics allow for vast hierarchies of scale in the first place?

These questions have so vexed particle physicists that they have been dubbed the “hierarchy problem.” And finding a solution to the hierarchy problem is one of the main goals of the Large Hadron Collider (LHC), a 27 kilometer proton-proton collider being built along the Swiss-French border outside of Geneva.

When the LHC first collides beams in May 2008, it will start out as a continuation of “Powers of Ten” – a power of 7.4 to be precise. The current explorer at

the short-distance frontier is the TeVatron, a proton-antiproton collider on the outskirts of Chicago. The TeVatron operates at an energy of 1.9 teraelectronvolts (TeV), allowing it to probe distances as small as 10^{-19} meters, 9 orders of magnitude smaller than an atomic radius. In 1995, the TeVatron discovered the top quark, which validated a crucial component of the so-called Standard Model of particle physics. The LHC will operate at 14 TeV, pushing our knowledge down to the tens of zeptometers.

While the LHC is likely to discover new particles to augment the Standard Model, particle physicists like Jesse also anticipate that the LHC will ultimately reveal the principles that allow the universe to exhibit scale separation. One way to pose the hierarchy problem is to ask why gravity is so weak compared to the other forces in nature. The reason the earth is so

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Deadlines To Note:

Thursday, September 13
Miller Fellowship nominations due

Thursday, September 20
Miller Professor applications due

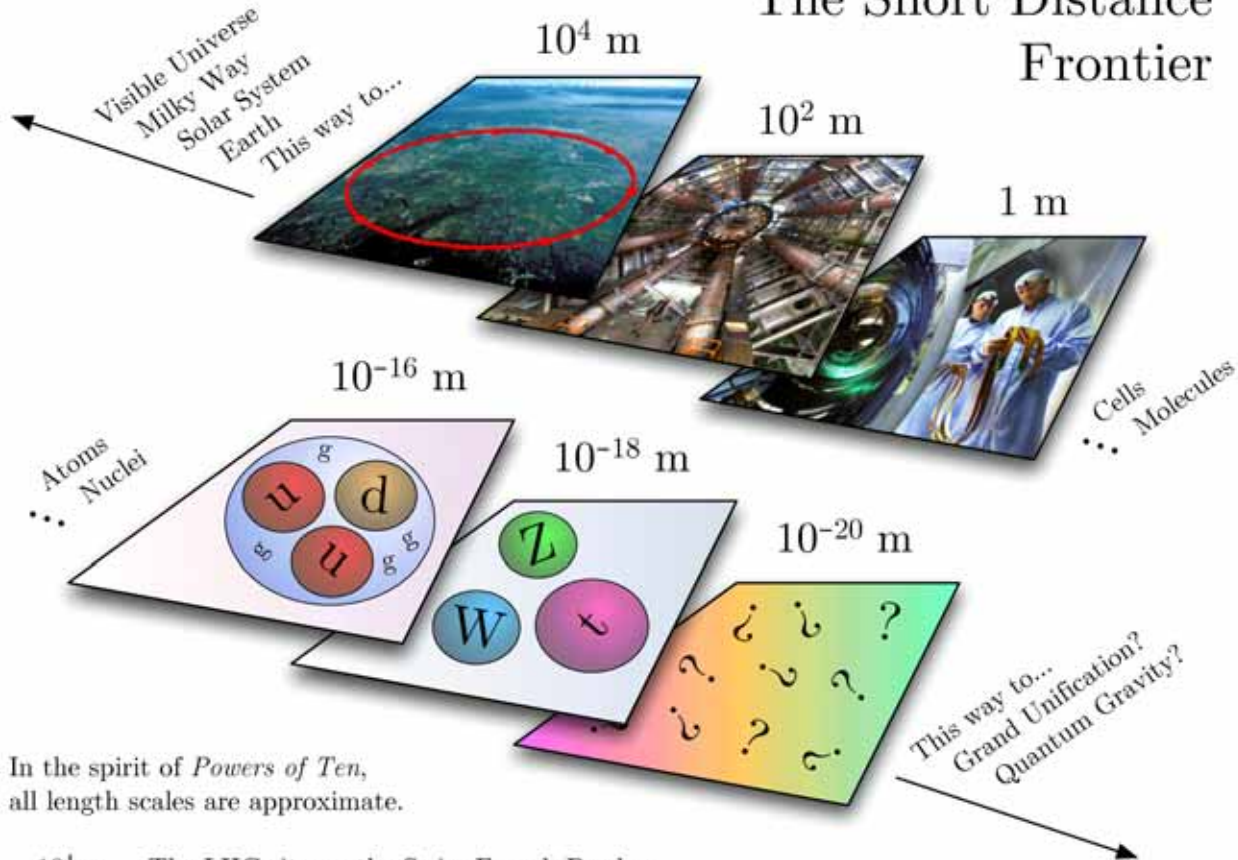
Monday, September 24
Visiting Miller Professor
departmental nominations due

More competition information
on Page 3.

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The Short Distance Frontier



In the spirit of *Powers of Ten*, all length scales are approximate.

- 10⁴ m — The LHC site on the Swiss-French Border.
- 10² m — Inside the ATLAS cavern, one of four particle detectors at the LHC.
- 1 m — Installation of the ATLAS semiconductor tracker.
- ...
- 10⁻¹⁶ m — A proton composed of three quarks. The LHC is a proton-proton collider.
- 10⁻¹⁸ m — Newest additions to the Standard Model: W and Z bosons (1983) and top quarks (1995).
- 10⁻²⁰ m — The Higgs boson? A solution to the hierarchy problem?? Something else???

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much larger than a molecule is that gravitational forces are so much weaker than intermolecular forces. Because the strength of gravity is tied to the masses of gravitational objects, another way of posing the hierarchy problem is to ask why Standard Model particles are so light. If electrons, protons, and neutrons were nineteen orders of magnitude heavier, then every atom would be a black hole, and there would be no interesting chemistry.

The Standard Model by itself lacks an explanation for the lightness of particles. For the past forty years, the so-called Higgs boson has been invoked as the origin of mass in the universe, but in this scenario, the masses of Standard Model particles are tied to the mass of the Higgs boson, raising the question of why the Higgs itself is so light. The discovery of the Higgs boson \tilde{H} or something Higgs-like \tilde{H} at the LHC will certainly be monumental, but by exploring the prop-

erties of the Higgs, particle physicists like Jesse hope to understand not only the origin of mass, but also the mechanism that allows for mass hierarchies.

As a graduate student at Harvard working with Nima Arkani-Hamed, Jesse explored different possibilities for LHC physics, from models like supersymmetry, which stabilize the Higgs mass hierarchy at the expense of introducing new partner particles for every Standard Model particle, to Little Higgs theories, which posit that the Higgs plays only a secondary role in a broader mass hierarchy mechanism.

Jesse has continued these explorations at Berkeley by looking at various Higgs-related proposals. With Lian-Tao Wang and Aaron Pierce, Jesse studied the feasibility and implications of measuring simultaneous two Higgs boson production at the LHC, an extremely

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Miller Research Competitions

REMINDER

Forms and information are available on our website at <http://millerinstitute.berkeley.edu>

Miller Research Fellowships for 2008-2011

The deadline for Receipt of Nominations is 4:00pm Thursday, September 13, 2007

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 for 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 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 \$54,000 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 for 2008-2009

The deadline for receipt of applications is 4:00 p.m. Thursday, September 20, 2007

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, 2008, or one semester of Academic Year 2008-2009, 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 for 2008-2009

The deadline for receipt of nominations is 4:00 p.m. Monday, September 24, 2007

Nominations by Berkeley faculty must be made by way of their academic Department Chair. The term for a Visiting Professorship ranges from two weeks to one full semester and must take place during Fall 2008 or Spring 2009. *It is not appropriate to request a starting date between semesters or during the summer. Non-US citizens must be eligible for J-1 Scholar visa status for the duration of the appointment. The Miller Institute does not support H1B visa status.* 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. Announcements of the awards will be made in December.

Questions concerning any of these programs may be directed to Kathryn Day at the Miller Institute office at 642-4088.

Please send materials by email, fax or mail to:

Selection Committee
Miller Institute for Basic Research in Science
2536 Channing Way #5190
Berkeley, CA 94720-5190

E-Mail Address: millerinstitute@berkeley.edu
Fax: (510) 643-7393
Web site: <http://millerinstitute.berkeley.edu>

Next Steps

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

Stacey Combes
Assistant Professor
Organismic & Evolutionary Biology
Harvard University

Erin Dueber
Postdoctoral Fellow
Molecular & Cell Biology
UC Berkeley

Greg Engel
Assistant Professor
Chemistry
University of Chicago

Chris Fromme
Postdoctoral Fellow
Molecular & Cell Biology
UC Berkeley

Jiaying Huang
Assistant Professor
Materials Science and Engineering
Northwestern University

Matt Reidenbach
Assistant Professor
Environmental Sciences
University of Virginia

Joshua Shaevitz
Assistant Professor
Physics
Lewis-Sigler Institute for Integrative Genomics
Princeton University

Yayu Wang
Professor
Physics
Tsinghua University
Beijing, China

Birth Announcement

Congratulations to **Alison Galvani** (Miller Fellow 2002 - 2005) and **Jeffrey Townsend** (Miller Fellow 2002 - 2005) on the birth of their daughter, Sarah — born January 6, 2007.

Obituaries

Harold Helgeson (Miller Professor 1975 - 1976) has died at 75. As a professor of Earth and Planetary Science at UC Berkeley, he was widely regarded as the founder and preeminent practitioner of theoretical geochemistry. He died on May 28, 2007 after a brief battle with lung cancer.

George W. Barlow (Miller Professor 1970 - 1971) suffered a stroke and died on July 14th in a hospital on the Monterey Peninsula at the age of 78. The renowned fish biologist was a professor of Integrative Biology at UC Berkeley from 1966 until 1993.

Awards & Honors

August 6, 2007: The 2007 Davy medal was awarded to **John Simons** (Visiting Miller Professor Spring 2000) for his many innovative experimental contributions to a broad area of chemical physics, including molecular reaction dynamics, molecular spectroscopy and most recently, biophysical chemistry. The Medal is awarded by the Royal Society. Further, Professor Simons was awarded the Liversidge Lectureship by the Royal Society of Chemistry.

July 17, 2007: **Alex Filippenko** (Miller Fellow 1984 - 1986, Miller Professor Spring 1996 & Spring 2005), **Gerson Goldhaber** (Miller Professor 1958 - 1959, 1975 - 1976, 1984 - 1985), and **Adam Riess** (Miller Fellow 1996 - 1998) share in Gruber Cosmology Prize recognition.

July 12, 2007: **Connie Chang-Hasnain** (Miller Professor 2003 - 2004) was honored by the Optical Society of America for her contributions and dedication to optical science. She received the Nick Holonyak Jr. Award for her "leadership, innovation, expertise, service, and quality research."

June 6, 2007: **Sheila Patek** (Miller Fellow 2001 - 2004) was awarded the Hellman Family Faculty Fund for her project, Evolutionary Physiology of Communication in the Sea. The fund supports the research of promising assistant professors who show capacity for great distinction in their research.

May 10, 2007: The Japanese Minister of Education, Culture, Sports, Science and Technology, has awarded Professor **Ryosuke Motani** (Miller Fellow 1997 - 1999) its Commendation for Science and Technology: The Young Scientists' Prize.

May 4, 2007: **Christopher Lowe** (Miller Fellow 1998 - 2001), Assistant Professor at the University of Chicago, was named a 2007 Searle Scholar.

May 2, 2007: **Karl Pister** (Miller Professor 1962 - 1963) won the Clark Kerr Award for Distinguished Leadership in Higher Education.

May 1, 2007: **Scott Emr** (Miller Fellow 1981 - 1983) and **Curtis McMullen** (Miller Professor Fall 1994) were among 72 new members chosen by the National Academy of Science.

April 30, 2007, eight Miller affiliates were elected to the American Academy of Arts and Sciences:

Arup Chakraborty (Miller Professor Spring 2000)

Michael Christ (Miller Professor 2000 - 2001)

Ehud Hrushovski (Visiting Miller Professor Fall 1997)

Raymond Huey (Miller Fellow 1975 - 1977)

Venkatesh Narayanamurti (Miller Advisory Board Member 2000 - 2006)

Mary Power (Miller Professor Spring 2002)

Joseph Silk (Miller Professor 1980 - 1981)

Jeremy Thorner (Miller Professor 1984 - 1985, Miller Professor 1999 - 2000)

April 26, 2007: **Eileen Lacey** (Miller Fellow 1994 - 1996) was one of four professors to win the University of California, Berkeley's prestigious 2007 Distinguished Teaching Award. The award is bestowed by the Berkeley Division of the Academic Senate's Committee on Teaching, which is comprised of faculty members and students.

Interdisciplinary Symposium June 2007



Lonnie Thompson



Greg Engel, Sara Robinson, and Zack Powell



Harry Swinney and Ed Feng



Bruce Ames and Jarmila Pittermann



Rory Waterman and Matt Reidenbach



Jarmila Pittermann, Erin Dueber,
Mimi Koehl, and Chris Fromme

rare phenomenon whose rate of occurrence would provide an important confirmation of any proposed solution to the hierarchy problem. Also with Aaron, he has proposed a possible relationship between the Higgs and so-called Dark Matter, as-of-yet undiscovered particles that have been probed only indirectly through astrophysical dynamics.

But with the upcoming commissioning of the LHC, Jesse's focus has rapidly transitioned from first-principles calculations to computer simulations as he confronts issues in LHC data analysis. The LHC will collide one billion proton pairs per second, and the LHC experiments only have enough bandwidth to store information about the most interesting 100 collisions per second. Most of these collisions will be well described by the Standard Model, but once every few minutes, there might be a collision that probes physics Beyond the Standard Model, including the elusive Higgs boson.

With his former advisor Nima, theoretical collaborators Philip Schuster, Natalia Toro, and Lian-Tao, and experimental and computational collaborators Bruce Knuteson and Steve Mrenna, Jesse has developed a model-independent characterization of new physics events. While any specific Beyond the Standard Model proposal will leave characteristic signatures in the LHC data, it is computationally impractical to test every hypothesis \tilde{N} along with the myriad free parameters associated with each hypothesis \tilde{N} against the data. By capitalizing on features common to nearly all new physics signatures, Jesse and his colleagues have developed a framework to efficiently generate and evaluate rapid prototype pseudo-models, in principle allowing LHC experimentalists to test many more hypotheses than by brute force alone.

But even if the LHC manages to collect enough interesting new physics events to discover new particles or provide insight into the hierarchy problem, the daunting problem of systematic uncertainties in Standard Model background estimation could complicate LHC data analysis. Though the basic framework of the Standard Model has been known for forty years, it has been notoriously difficult to pre-

dict the rate of rare Standard Model events, and these rare events can mask or mimic more interesting Beyond the Standard Model signals. To address this issue, Jesse has started a new collaboration with Christian Bauer and Frank Tackmann at the Lawrence Berkeley National Laboratory. Recently, Christian and Frank proposed a way to gain analytic control over previously ad hoc methods in Standard Model background estimation. Now with Jesse, they are developing a computer program that can not only produce simulated LHC events using the best known theoretical methods, but also keep track of all theoretical assumptions that affect the simulation.

A machine with the discovery potential of the LHC comes around once in a generation, and Jesse eagerly anticipates new breakthroughs at the short distance frontier. When “Powers of Ten” was first filmed, the Standard Model of particle physics was in its infancy, and while the Standard Model today is consistent with all 43 orders of magnitude of known phenomena, the possibility of finding a solution to the hierarchy problem makes the next power of 7.4 especially interesting to Jesse and his colleagues. With less than a year until the first LHC collision, Jesse is grateful to the Miller Institute for offering him the flexibility to pursue various research directions as the field of particle physics transitions from an era of speculation to an era of discovery.

You Can Make a Difference

The Miller Institute is experiencing a steady rise in interest by deserving scientists. Increasing our endowment is becoming necessary to maintain proportional growth in our programs. While the Institute's endowment is large and stable, a testament to the Millers' wisdom and foresight, we find a growing need for new financial support. Increasing our endowment through continued wise investment and new donations is becoming significantly more important.

Join friends and Miller alumni in contributing to this important endeavor by logging on to millerinstitute.berkeley.edu and clicking on “Make a Gift.”



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2536 Channing Way
Berkeley, CA 94720-5190
Phone (510) 642-4088
Fax (510) 643-7393
<http://millerinstitute.berkeley.edu>

Please send address corrections to:
miller_adm@berkeley.edu

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

Phil Chang Miller Fellow 2005-2008	Ed Feng Miller Fellow 2005-2008	Dustin Rubenstein Miller Fellow 2006-2009
Erin Dueber Miller Fellow 2004-2007	Greg Engel Miller Fellow 2005-2007	Josh Shaevitz Miller Fellow 2004-2007
Josh Eisner Miller Fellow 2005-2008	Chris Fromme Miller Fellow 2004-2007	Jason Stajich Miller Fellow 2006-2009
Raanan Fattal Miller Fellow 2005-2008	Jiaxing Huang Miller Fellow 2005-2008	Jesse Thaler Miller Fellow 2006-2009
	Matt Reidenbach Miller Fellow 2004-2007	

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.”