

# THE MICHIGAN CENTER FOR THEORETICAL PHYSICS\*

**MCTP**

## PAST, PRESENT, AND FUTURE

May 8, 2008

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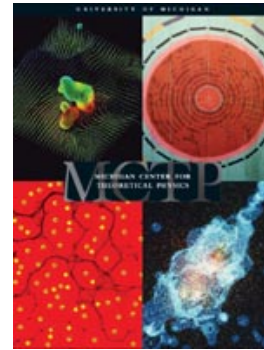
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\* <http://www.umich.edu/~mctp/>

## **SUMMARY**

The missions of The Michigan Center for Theoretical Physics (MCTP) are to carry out quality research, to educate, and to perform services. It focuses on promoting explorations in theoretical physics and related mathematical sciences through a program of workshops, conferences, individual and collaborative research, colloquia, and public lectures. Since its inception in 2001 the MCTP has gained a strong international reputation for its intellectual and organizational activities. It is now poised to have an even larger impact as the world of theoretical and mathematical sciences increasingly takes advantage of the MCTP infrastructure to focus national and international activities at the MCTP. This report documents the structure and achievements of MCTP, and its goals for the future.

Basically, within certain guidelines, the MCTP functions by responding to proposals from full members (typically with internal and external colleagues) for workshops, conferences, visitor programs, research projects, colloquia, and outreach. The Center co-sponsored a Science Café program with the Natural History Museum in fall 2007, the “Scales of the Universe” Public Lectures Series also in fall 2007, and hosted the “1<sup>st</sup> Midwest Undergraduate Women in Physics” conference where over 100 women undergrad/graduate students from the Midwest area participated. The MCTP has brought in over 1600 total scientists from around the world.

This report documents the past activities of MCTP, and provides the foundation for continuing its support for an extended period, in such a way that total resources are at least as large as they have been. Some of the support is for maintaining the strong infrastructure that allows the MCTP to effectively host a number of workshops, visitors, and speakers. The budget is very constrained -- we award most proposals at a lower level than organizers request. Section 5 contains the actual budget for the current fiscal year indicating the activities awarded and at what funding levels.

The present MCTP Director is Gordon Kane. There are three Associate Directors (Len Sander, Research; Jim Liu, Budget; and Katie Freese, Outreach) and one Administrative Assistant. The present executive committee is Leopoldo Pando Zayas (particle physics), Luming Duan (condensed matter physics), Gus Evrard (astrophysics and cosmology), and Dan Burns (mathematics). Executive Committee elections were held at the winter General Meeting to replace Luming Duan with Michal Zochowski (physics/biophysics) and Dan Burns with Alejandro Uribe (mathematics) to begin July 1, 2008.

With this report and proposal we request that the College continue to recognize the success and value of the MCTP by continuing its support indefinitely. Section 6.7 contains a proposed three year budget for 2009-2011, described in detail by the budget justification that follows. In particular, as described in section 4.7, we have begun to reestablish the famous old Michigan physics schools. The first is a two week school on Quantum Information and Fundamentals in June 2008. There will be a summer school in 2009 on Observational Cosmology, and we have convinced NSF, DoE, and the national TASI Advisory Board to allow us to submit a proposal to bring the TASI school here in 2010 and following years.

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# 1 The Michigan Center for Theoretical Physics

*“Things are happening rapidly and Michigan’s Center will have lots to do”*

Sheldon Glashow, Boston University, Nobel Laureate

*“I have fond memories of the annual summer schools in theoretical physics at the University of Michigan. I am glad that your Center will, in a way, resume these summer schools.”*

Hans Bethe, Cornell University, Nobel Laureate

## 1.1 Theoretical Physics at Michigan

Theoretical physicists like to ask big questions: When and how did the universe begin? What are its basic constituents and the laws of nature that govern them? How do effective laws of nature emerge and evolve from scale to scale, from the subatomic level to the molecular level to the complex systems around us, and the size of the universe? How will these fundamental understandings and discoveries benefit humanity? The practice of theoretical physics is a process of entering vast and uncharted territory, mapping unknown domains, and probing some of the biggest yet most intensely relevant mysteries of creation. It is a quest for knowledge that began centuries ago with extraordinary and courageous thinkers such as Sir Isaac Newton and one that continues to the present day, strengthened by the work of James Clerk Maxwell, Albert Einstein, Stephen Hawking, and scores of other gifted theorists. Relativity, quantum mechanics, the Big Bang, black holes, the statistical theory of phase transitions, and the standard model of subatomic particles are all examples of theoretical concepts that have now been experimentally established.

Although theoretical physics is inherently abstract, based on invention, imagination, and mathematical formulae, many of its outcomes are relevant, in highly significant ways, to everyday life. The methods and approaches of theoretical physics are remarkably relevant to areas outside of the traditional concerns of physics. For example, physicists are playing a central role in bringing mathematical techniques to bear in life sciences. The world around us seems complicated and lacking regularities but physicists have found patterns everywhere, and organized deep understanding of the complexity.

For over a century, the University of Michigan Department of Physics has made seminal contributions to the ongoing process of exploration and discovery. Among the many intellectual pioneers who gained international prominence in the past as UM faculty are Samuel Goudsmit and George Uhlenbeck, discoverers of electron spin; David Dennison, whose work revealed the proton spin; Otto Laporte, who discovered the concept of parity; Joachim Luttinger, discoverer of the Luttinger liquid and Oskar Klein, creator of the Klein-Gordon equation and the Kaluza-Klein theory of extra dimensions of space. See Figure 1:



**Figure 1:** *“Returning to my Ann Arbor attempts, I became immediately very eager to see how far the mentioned analogy reached, first trying to find out whether the Maxwell equations for the electromagnetic field together with Einstein’s gravitational equations would fit into a formalism of five-dimensional Riemann geometry.”* Oskar Klein, “From My Life in Physics”

The idea for a fifth dimension came to Klein during his stay as an assistant professor at the University of Michigan, 1923-25. He was hired by H. M. Randall on the recommendation of the father of quantum theory, Niels Bohr, with whom he had been working in Copenhagen. He was a contemporary of two other famous Michigan faculty members, George Uhlenbeck and Samuel Goudsmit, discoverers of electron spin. See Figure 2:



**Figure 2:** Left to right: Oskar Klein, George Uhlenbeck and Samuel Goudsmit (American Institute of Physics)

The most influential founder of theoretical physics at Michigan was Uhlenbeck, who did seminal work in statistical physics and the theory of stochastic processes during his long stay in Ann Arbor. In fact, two of his distinguished students, theorists G. W. Ford and R. L. Lewis (both now emeritus professors) were long-time members of our faculty. Uhlenbeck’s last student, Robert Ziff (who received his Ph.D. at Rockefeller after Uhlenbeck left Michigan) is now a professor of Chemical Engineering at Michigan and an active full member of the Center.

Under the leadership of Uhlenbeck, David Dennison and others, our department became world famous for the Ann Arbor summer schools in theoretical physics which ran from the 1930’s to the 1950’s. It is fair to say that many of the European

developments in physics, such as quantum mechanics, were introduced in this country by the Ann Arbor schools.



**Figure 3: A photo at the Ann Arbor summer school. Two future Nobel prize winners are in this picture, Maria Goeppert Mayer (far left) and Lars Onsager (far right). Others are Joseph Mayer, Robert Atkinson, and Paul Ehrenfest.**

The University of Michigan is, in many respects, an ideal venue for interdisciplinary research. Long considered one of America's leading public universities, the UM actively promotes collaboration among its highly ranked colleges, departments, specialized laboratories, and centers of excellence.

### ***1.2 The Creation of the MCTP***

In 2000, the physics department presented a Long Range Plan for 2000-2004 and Beyond. It identified two important priorities for the department.

- To increase the emphasis on theoretical physics
- To increase the emphasis on interdisciplinary activities

For a few years physics department theorists had been discussing with University administrators the possibility of creating a theoretical physics center. Moreover, since some of the top physics departments in the nation already had such theory centers, this seemed to be more of a necessity than a luxury if Michigan is to fulfill its goal of competing with the best. (Michigan's Center has evolved toward being, to a significant extent, an international facility, which also enhances local benefits, while most other centers are mainly for the use of local theorists. Appendix 9.5 is a list of U.S. Centers for Theoretical Physics.

Stimulated by Veltman's Nobel Prize, this effort gained momentum. Then Chair Ctirad Uher appointed a Committee to Propose a Center for Theoretical Physics at the University of Michigan: Fred Adams, Paul Berman, Michael Duff (Chair), Len Sander and Bob Savit. The Proposal may be found on the web: <http://www.umich.edu/~mctp/history.html>.

We were pleased to learn on September 19, 2000, that Dean Neuman had approved the Center under the conditions set out in a letter to Chair Ctirad Uher shown in

Appendix 9.6.

We were further pleased to learn on May 14, 2001 that, as a result of the early successes of the MCTP, the Dean extended the period of seed funding for a further 18 months, totaling five years from January 2001, as set out in the letter to the Director shown in Appendix 9.7.

The Michigan Center for Theoretical Physics was officially launched in 2001. Its mission is to seek to build on the current strengths of the Department, continue Michigan's long tradition of leadership in theoretical physics, and make significant contributions to theoretical and mathematical science and the larger world. Leveraging the University of Michigan's breadth and depth of academic excellence, the research emphasis of the Center includes interdisciplinary and non-traditional areas.

At present, the MCTP has 72 Full Members drawn from faculty in the University of Michigan departments of Aerospace Engineering, Astronomy, Biology, Biophysics, Chemical Engineering, Complex Systems, Electrical Engineering, Materials Science, Mathematics, and Physics. It includes a number of experimentalists who take an active interest in theory. In addition, the Center has attracted 75 Associate Members from numerous UM departments and the wider community. Membership lists are given in Appendices 8.7 and 8.8. In addition to facilitating research and collaboration, the MCTP offers some programs of study, academic opportunities for graduate and undergraduate students in theoretical physics and maintains a program of community outreach.

The MCTP has a three-fold mission of research, education, and service. However, as its primary objective, the Center strives to promote explorations in theoretical physics and related mathematical sciences through a program of workshops, conferences, individual and collaborative research, seminars, colloquia, and public lectures. As an interdisciplinary center for theoretical science, the MCTP enables the UM Department of Physics to meet the two major strategic challenges mentioned above: increasing the emphasis on theoretical physics and expanding interdisciplinary activities. The Center also helps to assure that Michigan will continue to play a leadership role in this important field by remaining in the vanguard of discovery.



**Figure 4: Kane Symposium, January 19-20, 2007**



### 1.3 Recruiting impact

MCTP has had significant and growing impact on physics recruitment at all levels. According to the Graduate Student Advisor, “the applicant pool of those wishing to do theoretical physics is quite strong and getting even stronger because of the MCTP.” Postdocs and junior faculty who accepted positions in the department, in a very competitive market, have stated that the opportunities provided by MCTP played a major role in their decision to join us.

### 1.4 Governance

One immediate challenge for the MCTP was to fulfill its interdisciplinary mission while at the same time recognizing the role played by the Physics Department in the funding arrangements. The way this is achieved is set out in the MCTP bylaws that were revised (approved Jan. 25, 2007) by the bylaws committee in light of the wisdom gained in the initial five year of the MCTP. The new bylaws are posted on the MCTP website and can be seen at: <http://www.umich.edu/~mctp/bylaws.html>

The bylaws called for the Director to be elected and a four person Executive Committee to be elected each representing one of the following four areas: (1) Particle Theory, (2) Condensed Matter, Atomic and Molecular Physics and Optics and Biophysics, (3) Astrophysics, Cosmology and Relativity, (4) Interdisciplinary. Conditions of term limits are set out in the bylaws. The MCTP has a General Meeting each fall and winter semester. At the fall meeting an annual report on the State of the MCTP is delivered, and at the winter Meeting Executive Committee elections are held.

Previous leadership has been from the following:

Director:	M. Duff 00-05 G. Kane 06-present
Executive Committee Members:	
<i>Particle Theory</i>	R. Akhoury 01-02 J. T. Liu 03-05 F. Larsen 06-07 L. Pando Zayas 08-09
<i>Condensed Matter/AMO/Biophysics</i>	L. Sander 01-02 R. Savit 03-04 F. Nori 04-05 L. Duan 06-08 M. Zochowski 09-10
<i>Astrophysics/Cosmology/Relativity</i>	K. Freese 01-02 G. Evrard 02-05 F. Adams 06-07 G. Evrard 08-09

*Interdisciplinary*

P. Berman 01-02  
C. Doering (Mathematics) 02-04  
A. Bloch (Mathematics) 04-05  
D. Burns (Mathematics) 06-08  
A. Uribe (Mathematics) 09-10

The make-up of all MCTP committees may be found in Appendix 9.10. It is worth mentioning that MCTP administration is very efficient and cost-effective. For example, a number of other centers release the Director and sometimes also the Deputy Director from other responsibilities, but here the Director and the Associate Directors currently carry out all their normal duties. Most centers that arrange workshops and conferences have several staff while the MCTP has effectively one, yet is widely known for its efficient and effective workshops, conferences, and visitor arrangements.

**1.5 Facilities**

In order to create space for the MCTP within the Physics Department, the Executive Committee, the Department, and the College jointly approved:

1. The conversion of 3424 Randall (previously Keith Riles's Lab) into 3 faculty offices (cost: \$61,000).
2. The addition of two smaller offices on either side of 3246 (the fishbowl) New Randall (cost: \$50,000).

These spaces were completed in fall 2001. Since the main purposes of the MCTP emphasize hosting visitors, conferences and workshops, there is clearly the need for much more space and this will continue to be a priority. The original proposal submitted to the Dean called for 10-15 offices or equivalent to be allocated to the MCTP. As MCTP looks toward the future, it will be important to develop a plan to add some offices in order to have an optimum situation for successful workshops. Now, with the UM Wireless Network, we are able to provide visitors with temporary usernames and passwords for computing.



**Figure 5: Michigan Center for Theoretical Physics, Randall Laboratory**

## 2 Research

*“The MCTP excels at research on particle physics both from a purely mathematical and more phenomenological point of view”*

Martinus Veltman, University of Michigan, Nobel Laureate

### 2.1 Proposals

Within qualitative guidelines, basically the MCTP functions by responding to proposals from full members or associate members represented by a full member, perhaps with internal or external colleagues. Each winter the Executive Committee invites proposals for programs for the next fiscal year 1 July – 30 June. Any of the Center’s activities may be considered: conferences, workshops, visitors, research projects, graduate, undergraduate research and outreach activities. Additional weight is attached to proposals that fulfill the Center’s interdisciplinary mission of being “more than the sum of its parts”. More weight is attached also to proposals that can offer some degree of cost sharing. Members are encouraged to make external grant proposals submitted under the aegis of the MCTP, which would then be eligible for MCTP cost sharing. MCTP proposals can be brief (one or two pages), plus vitae in the case of long-term visitors for collaborations. Full guidelines are available on <http://www.umich.edu/~mctp/proposalguidelines.html>.

It is good to determine much of the allocation of funds at one time in order to be able to compare and weigh different proposals. It is also desirable to retain some flexibility for workshops about exciting new data or ideas, or exceptional visitor opportunities, and we try to do that at the 10-15% level.

The research activities of the MCTP have been thought of as divided roughly into two broad categories. As a guideline the two categories each receive about half the MCTP funding. On one side there is astronomy, astrophysics, relativity, particle physics, string/M-theory and pure mathematics. On the other side there is condensed matter physics, atomic, molecular and optical physics, biophysics, complex systems, dynamical systems theory, and non-traditional applications such as sociology, economics and medicine.

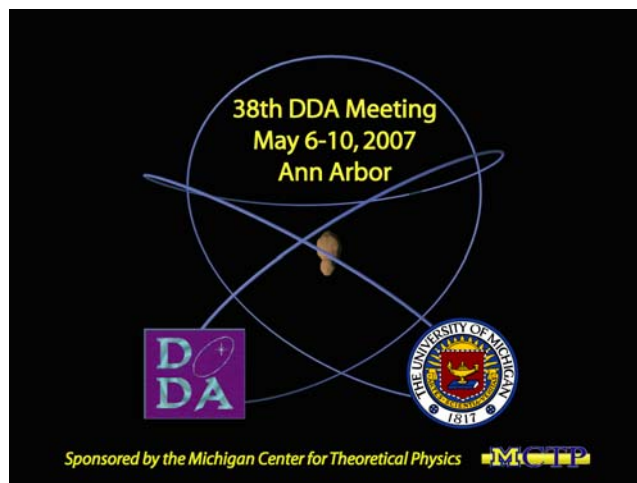
### 2.2 Publications

Thanks in part to the structure and support provided by the Michigan Center for Theoretical Physics members have produced a total of 610 publications so far, each carrying the MCTP byline. They span subjects that include high energy physics; string theory and M-theory; condensed matter physics; atomic, molecular and optical physics; relativity and cosmology; astrophysics; and biophysics. A complete publications list may be found in the Appendix 9.11.

### 3 Conferences and Workshops

*“MCTP has enabled truly interdisciplinary work at Michigan... I hope that MCTP can continue to play the kind of galvanizing role that it so effectively has in recent years.”*

Charles Doering, Professor of Mathematics, University of Michigan



**Figure 6: The 38<sup>th</sup> Annual AAS Meeting of the Division on Dynamical Astronomy, May 6-10, 2007**

*“During the last few years, there has been tremendous progress in the search for the deepest laws governing the universe. The MCTP has been instrumental to these developments through critical discoveries made by the center’s scientists and also through its hosting of lively conferences that have facilitated key scientific interactions. The next decade will be a formative time and holds the promise of fundamental breakthroughs in our understanding of the cosmos. The MCTP will play a vital role in our achieving these advances.”*

Brian Greene, Professor of Physics, Columbia University, author of “The Elegant Universe” and “The Fabric of the Cosmos”.

We begin the summary of the main MCTP activity with descriptions of three recent workshops.

### 3.1 From Microscopic to Macroscopic – Mechanisms Underlying Epileptic Seizures



The MCTP workshop “From microscopic to macroscopic - mechanisms underlying epileptic seizures” was held May 8-10, 2007 organized by Michal Zochowski (Physics, Biophysics, MCTP, Neuroscience program), and Robert Savit (Physics, MCTP) with help from the organizing committee consisting of Victoria Booth (Mathematics and Anesthesiology), Daniela Minecan (Neurology), Geoff Murphy (Physiology), Jack Parent (Neurology), Gina Poe (Anesthesiology and Physiology), and Oren Sagher (Neurosurgery). It assembled a set of experimental, theoretical and clinical researchers, spanning the range of micro- meso- and macroscopic research on epilepsy. Also represented were a number of scientists who work on the computational properties of epilepsy, or other problems in computational neuroscience. The conference participants were charged with stepping out of their usual regime of research to engage in a discussion of epilepsy across spatio-temporal scales. The proceedings from the conference will be published in *Epilepsia*, one of the leading epilepsy journals.

The specific aims of the conference were several: 1) to establish collaboration between scientists researching epilepsy on different spatio-temporal scales, 2) to establish the University of Michigan as a center for these types of interdisciplinary endeavors, and, 3) to solidify a collaboration between researchers from the Department of Physics (and members of MCTP) and researchers from the UM medical school using different approaches to answer common questions in epilepsy. 25 invited external speakers, who are considered to be the top representatives of their particular fields in the epilepsy research, attended the conference. We had also between 30-40 local participants from various departments in LSA, the Medical School and Engineering. The presentations were highly cross-disciplinary and bridged different scales. The conference stimulated the formulation of novel questions in epilepsy research, and codified the reputation of the interdisciplinary Michigan epilepsy research group as a source of novel approaches to the study of epilepsy.

The MCTP funding for this conference proved crucial for its success and provided the largest single portion of the support. It allowed us to obtain substantial additional funding for the conference. In addition to MCTP funding we secured significant support from ICAM (Institute for Complex Adaptive Matter) and various units of Medical School and Mathematics Department. It would have been extremely difficult to raise these additional funds without the initial contribution from MCTP.

### 3.2 Theory and Applications of Large Deviations Statistics Workshop



A workshop entitled “Large Deviations: Theory and Applications” was held June 4-8, 2007. The organizers were Anna Amirdjanova (Department of Statistics), Charlie Doering (Departments of Mathematics, Physics & MCTP), and Len Sander (Department of Physics & MCTP).

The background of the subject is as follows: extinctions, large floods, and stock market crashes are all examples of rare events that cannot be ignored, and can be studied using probability theory and mathematical statistics. A good deal is now known about how to treat such rare fluctuations from the work of Wentzell, Friedlin and others. The theory is quite different from the statistics of typical events, and has applications in areas such as operations engineering, computer science, ecology, epidemiology, and economic modeling, statistical physics, and chemistry.

The purpose of the workshop was to bring researchers working on the abstract side of the theory together with those concerned with applications of the methods to see how a common language could be forged. This workshop included talks by mathematicians, statisticians, and applied scientists on frontier research topics, as well as a few tutorial lectures to introduce all the participants to the common threads of the field. Twenty-three senior participants plus many students and postdocs attended. There was significant participation from the broader University community; funding was also received from the Center for the Study of Complex Systems with additional contributions from the Statistics Department and the Mathematics Department.

The workshop also included a special session to celebrate the 70<sup>th</sup> birthday of Professor Alexander Wentzell, one of the founders of the subject, and one of our speakers. The encounters engendered by this workshop were very fruitful, and we think that the entire University community benefited from the event.

### 3.3 LHC New Physics Signatures Workshop

The recent LHC signatures workshop (January 6-11, 2008) was extremely successful. While about 30 outside participants were anticipated, the actual number was about 60. Almost all stayed the full week of the workshop, and several stayed longer, illustrating both the attractiveness of the research environment and the way that having such workshops can strengthen the physics opportunities for the faculty, postdocs and students, providing extra opportunities for research interactions. With the strong

administrative infrastructure, the additional participation was handled easily. This workshop was made an official one by the LHC ATLAS and CMS detector groups, who sent official speakers as well as a number of participants.

### **3.4 List of all other conferences and workshops 06-09**

Similar descriptions hold for a number of conferences in several MCTP areas. A complete list of MCTP conferences and workshops for the past three years plus those approved for 2008-2009, and their organizers, is given below:

#### ***Inflation after WMAP Workshop***

May 18-20, 2006

Organizer: Katherine Freese

#### ***LHC Inverse Problem Workshop***

April 12-15, 2006

Organizers: Gordon Kane and Nima Arkani-Hamed

#### ***Inaugural Great Lakes Strings Conference***

March 31- April 2, 2006

Organizers: F. Larsen, J. Liu, L. Pando Zayas

#### ***Kane Symposium***

January 19-20, 2007

Organizers: J. Wells, C.-P. Yuan, H. Haber



#### ***The Physics and Mathematics of G2 Compactifications***

May 3-5, 2007

Organizers: G. Kane, F. Larsen, J. Liu

#### ***AAS Meeting of the Division on Dynamical Astronomy Conference***

May 6-11, 2007

Organizers: F. Adams, D. Scheeres

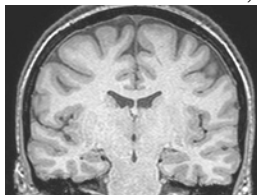




***Mechanisms of Epileptic Seizure Formation Symposium***

May 8-10, 2007

Organizers: M. Zochowski, R. Savit



***Large Deviations Conference***

June 4-8, 2007

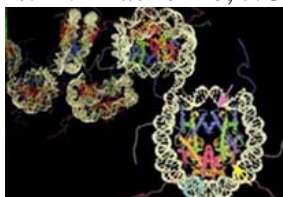
Organizers: A. Amirdjanova, C. Doering, L. Sander



***Mechanics of Life: From Biomolecules to Molecular Machines***

June 11-13, 2007

Organizers: A. Tkachenko, J.C. Meiners



***The Globular Clusters-Dwarf Galaxies Connection***

August 27-29, 2007

Organizer: Oleg Gnedin

***LHC New Physics Signatures Workshop***

January 5-11, 2008

Organizers: A. Pierce, G. Kane, J. Wells



***1<sup>st</sup> Midwest Conference for Undergraduate Women in Physics***

January 18-20, 2008

Organizers: J. Olgivie, T. McKay



***Dark Side II Workshop***

May 27-June 14, 2008

Organizers: K. Freese, D. Huterer, T. McKay

***Michigan Quantum Summer School***

June 16-27, 2008

Organizers: L. Duan, A. Leanhardt, C. Monroe

***40<sup>th</sup> Midwest Theoretical Chemistry Conference***

June 26-28, 2008

Organizers: E. Geva, B. Dunietz

***The Inverse Problem in Cosmology Workshop***

October 2008 (dates TBA)

Organizers: R. Akhoury, A. Vikman, G. Shiu

***LHC and Dark Matter Workshop***

January 2009 (dates TBA)

Organizers: G. Kane, K. Freese, A. Pierce, S. Watson, J. Lykken, P. Binetruy, F. Gianotti,  
M. Spiropulu

***Strings and Gauge Theories Workshop***

Spring/Summer 2009 (dates TBA)

Organizers: F. Larsen, J.T. Liu, L. Pando Zayas

***Star Formation and the Initial Mass Function Workshop***

May 2009 (dates TBA)

Organizers: F. Adams, C. Doering, A. Bloch

## 4 Collaborations

*“One of the most exciting intellectual explorations of our time concerns the mathematical structure underlying our physical universe. The Michigan Center for Theoretical Physics is a focal point in this activity, and attracts many of the outstanding mathematicians and physicists working in this area. It deserves the support of all who value intellectual discovery at the highest level.”*

Sir Michael Atiyah, University of Edinburgh, Fields Medalist, former President of the Royal Society, former Master of Trinity College, Cambridge

*“The very successful activities of the Center put it on a par with such world-renowned programs as the KITP at Santa Barbara, the Newton Institute at Cambridge, and the Yukawa Institute for Theoretical Physics in Kyoto.”*

Professor Baruch Meerson, Racah Institute, Hebrew University of Jerusalem

### 4.1 Memberships

The bylaws state that there are two grades of membership: Full Members and Associate Members. The initial Full Membership was all of the Theoretical Physics faculty, with the intention that Full Members from other departments would be elected beginning with the first Fall General Meeting on December 18, 2000. New members from Aerospace Engineering, Astronomy, Biology, Biophysics, Chemical Engineering, Complex Systems, Electrical Engineering, Materials Science and Mathematics were duly elected at that (and subsequent) general meeting(s). The new Bylaws provide for election of new Members by the Executive Committee. We are happy to note that the Full Membership includes several experimental colleagues who take an active interest in theory.

Associate Membership is open to all with a current or past affiliation with the University of Michigan and there are now representatives from an even more diverse list of departments as well as outside of the University.

There are currently 72 Full Members and 75 Associate Members. The membership lists may be found in Appendices 9.8 and 9.9.

### 4.2 Visitor programs

The MCTP provides an attractive venue for visiting academics. Guest faculty and researchers engage in individual and collaborative research, interact with undergraduate and graduate students, and share their expertise with the wider community through public lectures and other activities. Some visitors have been part of systematic programs, others as individuals at their own instigation or at the invitation of Full Members.

- “*CM and Quantum Computing visitor Program*”, July 05-June 06 (F. Nori)
- “*Young High Energy Theorists Visitor Program*”, July 05-June 06 (Larsen/Liu/Pando Zayas)
- “*Visitor Program in Computational Physics and Biology*”, July 06-June 07 (Nori, Estabrook)
- “*Young High Energy Theorists Visitor Program*”, July 06-June 07

(Larsen/Liu/Pando Zayas)

- Cost Sharing on “*ADVANCE: Young String Theorists Visitor Program*”, July 06-June 08 (Larsen, Liu, Pando Zayas)
- “*Young High Energy Theorists Visitor Programs*”, July 07-June 08 (J. Liu, S. Cremonini, F. Larsen, L. Pando Zayas)
- “*Visitor program in Applications of Mathematical Dynamics to Physics*”, July 07-June 08 (Bloch)
- Visit and Public Lectures by Nobel Laureate Martinus Veltman, jointly with Physics Department and Provost: 2 annual visits, each of one month July 06-June 07 (Duff)

The MCTP has an active young high energy theorist visitor program which generally brings in one new visitor every week or two during the Michigan academic year. The visitors cover a broad field of research and are intended to be at the junior (postdoc or advanced student) level. In past years, the visitor programs have had an excellent track record of attracting outstanding visitors that are making an impact in the field. Recent visitors include:

- Aristos Donos (Brown University), September 16-23, 2006
- Dmitriy Belov (Imperial College), October 1-14, 2006
- Heng-Yu Chen (Cambridge), October 15-22, 2006
- Ian Ellwood (Wisconsin), October 16-20, 2006
- Joan Simon Soler (Berkeley), October 22-27, 2006
- Oleg Lunin (Chicago), November 22-27, 2006
- Simone Giombi (Stony Brook), November 27 – December 1, 2006
- James Sparks (Harvard University), January 14-17, 2007
- Jeremy Michelson (Ohio State University), January 21-27, 2007
- Tristan McLoughlin (Penn State), January 28-February 2, 2007
- Eric Gimon (Berkeley), February 4-10, 2007
- Hitoshi Murayama (Berkeley), February 21, 2007
- Liam McAllister (Princeton), March 4-9, 2007
- Willie Merrell (Maryland), March 5-16, 2007
- Claudia de Rham (Perimeter), March 13-22, 2007
- Yuji Tachikawa (IAS), March 12-23, 2007
- Andrew Tolley (Perimeter), March 13-22, 2007
- Chris Beasley (Harvard), March 26-30
- Norihiro Iizuka (KITP), March 24-April 6, 2007
- Martin Schnabl (IAS), April 16-20, 2007
- Amos Yarom (Munich University), Sept. 16-20, 2007
- Takuya Okuda (KITP), Sept. 24-Oct. 2, 2007
- Ben Burrington (Tel-Aviv University), Sept. 30-Oct. 6, 2007
- Bernardo Uribe (Andes University), October 2-6, 2007
- Louis Leblond (Texas A&M), October 7-19, 2007
- Sergio Benvenuti (Princeton University), October 19, 2007
- Timo Weigand (U Pennsylvania), October 22-26, 2007
- Henriette Elvang (MIT), October 29-Nov. 4, 2007
- Diego Trancanelli (KITP), nov. 4-10, 2007
- Allan Adams (MIT), November 26, 2007
- Matt Johnson (Caltech), Nov. 25-Dec. 12, 2007
- Gaston Giribet (Buenos Aires University), Nov. 26-Dec. 7, 2007

- Brian Wecht (IAS), December 2-7, 2007
- Veronica Sanz (Boston University), December 6, 2007
- Sean Hartnoll (KITP), December 6-12, 2007
- Sergey Cherkis (Trinity College, Dublin), December 10-14, 2008
- Hong Lu (Texas A&M), January 6-12, 2008
- Ari Pakman (Stony Brook), January 11-14, 2008
- Andrew Frey (McGill University), January 27-Feb. 2, 2008
- Giovanni Villadoro (Harvard), February 3-9, 2008
- Shunji Matsuura (Tokyo U and Perimeter Institute), February 10-16, 2008
- Nick Halmagyi (University of Chicago), February 18-20, 2008
- Kory Stiffler (Iowa University), March 10-18, 2008
- Eugene Lim (Columbia University), March 19-26, 2008
- Justin Vasquez-Poritz (Baruch College), March 23-26, 2008
- Sebastian Franco (Princeton University), March 31-April 4, 2008
- Li-Sheng Tseng (Harvard), April 8-11, 2008
- Jessie Shelton (Rutgers), April 13-18, 2008
- Sameer Murthy (LPTHE, Universite de Paris VI), April 20-25, 2008

These and previous visitors have led to collaborations resulting in numerous publications; more are actively being pursued. Once developed, many of these collaborations continue well past the initial visit to the MCTP.

#### **4.3 Short and long term visitors**

In addition to those of the visitor programs, the MCTP has played host to about 170 visitors. Theoretical physics is a very interactive, collaborative activity. As one Full Member said, “We’ll see how important this work finally is, but it is clear the work could not have been done without the extended visits made possible by MCTP.” Recent individual visitors (both short and long term) include the following:

- Fabio Marchesoni (Universita di Perugia, Italy)
- Bernardo Uribe (North Dakota State University)
- Eshel Ben Jacob (Tel Aviv University)
- Douglas Spolyar (UC Santa Cruz)
- Chuanwei Zhang (Maryland University)
- Congjun Wu (University of California, Santa Barbara)
- Giovanni Russo (University of Catania, Italy)
- Martinus J. Veltman (MacArthur Emeritus Professor, University of Michigan)
- Peter Milonni (Los Alamos National Lab)
- Eung Jin Chun (KAIST)
- Malcolm Perry (Cambridge)
- Valya Zakharov (Max Planck Institute, Germany)
- Lu Sham (UCSD)
- Shiliang Zhu (South China Normal University)
- Bobby Acharya (ICTP, Trieste)
- Giovanni Russo (University of Catania, Italy)
- David Kessler (Bar Ilan University, Israel)

The MCTP initially encouraged support for postdocs, but as the center was given long term stability in 2005, the university and the MCTP agreed that priority should be given to the activities that have the most impact nationally and internationally,

namely the workshops and conferences, plus visitors that could play a large role in MCTP theory activities and strengthen workshop areas. In recent years, the MCTP has had one postdoc in high energy theory ending in August 2007, Diana Vaman, with support from matching funds, and one in condensed matter theory, Evgeniy Khain ending in August 2007. Vaman is now faculty at the University of Virginia. While here Vaman collaborated with Kane, Larsen, Liu, Pando Zayas, and Yao. Khain is now at Oakland University

In addition to the formal workshops, a very significant use of the matching funds went to supporting the development of the first blackbox model (“the Michigan Model”) for the “LHC Olympics”. The LHC Olympics has had a large effect in leading to user-friendly and versatile software that can help interpret any signals of physics beyond the Standard Model at the LHC or the Tevatron, and is essential for turning theoretical ideas into forms testable with data. The matching funds supported two small meetings of collaborators involved in developing and implementing an appropriate blackbox model. Visitors to these meetings included Joe Lykken, Liantao Wang, and Brent Nelson. Although several people internationally were active in organizing the LHC Olympics, constructing the first blackbox model played a crucial role without which the LHC Olympics may have been much less successful, and the DoE matching funds plus MCTP support were essential in making this happen.

The LHC Olympics was mentioned above, with its strong positive effect on making more useable software available to facilitate translating theoretical ideas into testable form, and in bringing theorists to beyond the SM phenomenology who otherwise might not have moved in that direction. The LHC Olympics would have been less effective without the MCTP and matching funds that led to the construction of the Michigan blackbox. Finally, we anticipate increasingly having rapid response workshops when data or new ideas emerge. We had one such workshop, on inflation after the 3 year WMAP data.

#### ***4.4 MCTP and the International Center for Theoretical Physics***

Here we report an exciting opportunity that also shows how the MCTP has achieved significant international recognition. The Director of the Abdus Salam International Center for Theoretical Physics (ICTP), located in Trieste, Italy, has proposed an interaction between the MCTP and our Physics Department, and ICTP. The interaction is to be based on a Memorandum of Understanding for Educational and Scientific Cooperation, reproduced in Appendix 9.3.

The ICTP was founded in 1964. It operates under the aegis of two United Nations agencies (UNESCO and the International Atomic Energy Agency (IAEA)). Its staff scientists are international experts who do leading research on frontier topics. It brings to its campus many scientists from developing countries, as well as leading scientists from the developed world, about 5000 scientists a year of which about half are from developing countries. The development of ICTP was spearheaded by Abdus Salam, who won a Nobel Prize in 1979 for the Standard Model of Particle Physics. Salam frequently said, “Scientific thought is the common heritage of ManKind.”

The scientific goals of the MCTP and the ICTP are similar, both being broad-based and stimulating research via workshops, conference, and visitors. Prof. Bobby Acharya from the ICTP has been an MCTP visitor, and is collaborating on research with both theorists and with members of the Michigan LHC ATLAS collaboration. These and other connections led the ICTP director, Prof. K.R. Sreenivasan, to suggest in early 2008 a stronger collaborative effort, as summarized in the MoU in Appendix 9.3. Planning of joint activities is underway.

#### 4.5 MCTP colloquia

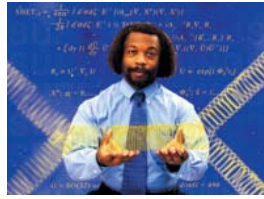
In keeping with its interdisciplinary mission, the MCTP hosts not-so-technical Colloquia designed to help us learn more about what our colleagues in other fields are doing. The talks are designed to be accessible to anyone curious about recent scientific developments. Presentations are made by scientists from the UM and other universities. Refreshments are served to encourage interactions and discussions. Recent topics have included:

- *What Does Quantum Field Theory Have In Common With Quantitative Marketing of Automobiles?*  
Dr. Suzhou Huang (Ford Research and Advanced Engineering)  
March 30, 2006
- *Inflation After WMAP*  
Professor Paul Steinhardt (Princeton University)  
May 18, 2006
- *Enceladus: An Active Ice World*  
Professor John Spencer (Southwest Research Institute)  
September 27, 2007
- *The Methane Hydrological Cycle on Titan*  
Jonathan Lunine (University of Arizona)  
March 27, 2008
- *Black Holes and Gravitational Waves*  
Saul Teukolsky (Cornell)  
April 3, 2008

#### 4.6 Outreach

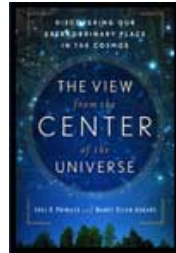
In a world that relies increasingly on science and technology, and one in which important decisions affecting all of our lives frequently require some level of scientific expertise, it is vital that the general public have a fundamental understanding of current trends and issues in theoretical physics. To meet that need, the MCTP offers an ongoing series of public lectures and other outreach activities. All events are designed to generate both understanding and support of work now underway in theoretical physics. MCTP members are actively involved in public outreach: writing books for the popular market, publishing magazine and newspaper articles, making television and radio appearances, and interacting with local schools. The recent Public Lectures that MCTP hosted are listed below:

- *Concerto-I and Opus by A. Einstein*, January 17, 2006  
S. James Gates, Jr., John S. Toll Professor of Physics and Center for String and Particle Theory Director (University of Maryland)

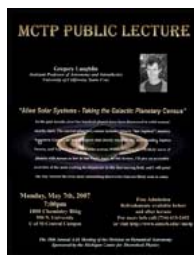


S. James Gates, Jr. (University of Maryland)

- *Public Lecture: The View from the Center of the Universe*  
Joel R. Primack (University of California Santa Cruz) and Nancy Ellen Abrams, April 9, 2007



- *Alien Solar Systems – Taking the Galactic Planetary Census*  
Gregory Laughlin (University of California, Santa Cruz), May 7, 2007



- *Exploring the Outer Solar System: Present and Future*  
Jonathan I Lunine (University of Arizona, Tucson) Professor of Planetary Science and Physics, March 27, 2008

The MCTP co-sponsored a Physics Graduate Student Symposium during the summer of 2007. Students from the Physics, Applied Physics, and Astronomy Departments contributed research talks to the weekly Physics Graduate Student Symposium (PGSS). For 13 weeks, 22 speakers provided 20- or 40-minute talks in a range of fields consisting of astrophysics, biophysics, optics, particle physics, solid state physics, complex systems, and environmental sciences. Funding from several sponsors made possible weekly lunches for an average of 44 undergraduate and graduate students. The graduate student symposium encourages interdisciplinary exploration, enhances solidarity within the student population, and offers an opportunity to stretch and hone communication skills. To further unite the student community and develop scientific skills, the symposium is designed to engage a broad audience, discuss a variety of physics sub-fields, and provide a relaxed atmosphere, in which the audience is comfortable participating. Last year was the inaugural year for the PGSS and they were very pleased with the results. They exceeded their goals, both for graduate student attendance and for number of talks given. Following the success of the 2007 program, they are already planning for the PGSS 2008. They are

anticipating a 25% increase in average attendance.

The MCTP co-sponsored a Science Café program with the Natural History Museum in fall 2007. MCTP Full member Aaron Pierce led one meeting on the dark matter of the universe.

#### **4.7 Michigan Summer Schools**

In the 1930's and 1940's a world-famous summer school was held at the University of Michigan, with major impacts on both the development of frontier areas of physics, and on the quality of physics at the University. In 1984 we initiated a national summer school on frontier topics in particle physics and cosmology, for advanced graduate students and beginning postdocs. The logic was that no department could present courses in several frontier areas, both because few departments has faculty who were expert in all of them, and any particular department had too few students to allow offering such courses. The school, "Theoretical Advanced Study Institute or TASI", has been annual and very successful. Its location moved for some years, and then stayed at the University of Colorado.

The MCTP plans to again have the University of Michigan become a leader in summer schools. A school on quantum information science will be held in summer 2008, directed by Luming Duan, Aaron Leanhardt, and Chris Monroe. MCTP has just approved a second school on observational cosmology for summer 2009. We are entering negotiations to have the TASI school return to Ann Arbor, and the national TASI Advisory Board has just agreed to re-compete the TASI funding, with proposals due to NSF and DoE July 1, 2008. We hope to eventually have 2-3 schools every summer. In addition to contributing to frontier areas of science, these schools will bring distinguished lecturers, leading students and recent PhDs here, which makes it more likely they can later be recruited, and that they will encourage their students, postdocs, and colleagues to come here. Similarly, they are more likely to recognize the abilities and accomplishments of our students and Postdocs, and to hire them later.

Such schools are focused on intellectual frontiers, with distinguished lectures, and recent top PhDs and finishing students as participants. They require significant funding. We anticipate that in some areas MCTP support can leverage additional support from outside sources. NSF and DoE combines have been supplying about \$115,000 for the TASI school, about two-thirds of its cost.



**Figure 7: Nobelist Enrico Fermi, several times lecturer at the previous summer schools, on a Michigan canoe trip**



## 5 Fiscal Years 2006-2008 Budgets

### 5.1 2005-2006 budget (actual)

Income statement  
For the fiscal year ending June 30, 2006

<b>Income</b>		
LS&A allocation		\$400,000
Physics allocation		\$50,000
Surplus from 2004-2005		\$31,882
Unspent funds recovery		
Baryogenesis workshop (FY03) closeout	\$1,390	
String Phenomenology (FY04) closeout	\$16,871	
Total unspent funds recovery		<u>\$18,261</u>
<b>Total income</b>		<b>\$500,143</b>
<b>Expenses</b>		
Secretaries		\$63,560
Computing		\$2,349
Office supplies, postage, telephone		\$4,543
Development		\$2,467
Discretionary funds		\$19,765
Outreach and public lectures		\$4,951
Benefits recharge and year end accruals		\$6
Cost sharing commitments		
Fronts, Fluctuations and Growth (NSF)	\$38,954	
NASA grant	\$17,527	
Total cost sharing commitments		\$56,481
Visitor programs		\$91,607
Conferences and workshops		
Expenses for workshops prior to FY06	\$10,680	
MG-06-07: Great lakes strings	\$10,000	
MG-06-09: Exotic atom physics	\$8,000	
MG-06-10 SDSS galaxy clusters	\$1,080	
MG-06-26: Relativistic jets	\$15,000	
LHC inverse workshop	\$7,500	
Total conferences and workshops		\$52,260
1.5 MCTP postdoctoral fellows		\$93,193
Postdoctoral travel		\$8,009
6 Graduate student fellowships		\$23,051
4 Undergraduate research scholars		<u>\$15,119</u>
<b>Total expenses</b>		<b>\$437,361</b>
<b>Surplus (deficit)<sup>1</sup></b>		<b>\$62,781</b>
Funds encumbered for FY07 workshops		\$151,000
Funds encumbered for FY07 visitors		\$58,945
<b>Surplus (deficit) after encumbrances</b>		<b>(\$147,164)</b>

Note: Numbers may not add up due to rounding.

## 5.2 2006-2007 budget (actual)

Income statement	
For the fiscal year ending June 30, 2007	
<b>Income</b>	
LS&A allocation	\$300,000
Physics allocation	\$175,000
Surplus from 2005-2006	\$62,781
Unspent funds recovery	
MG-04-12: Modeling cancer closeout	\$4,694
Top quark symposium closeout	\$3,212
Total unspent funds recovery	\$7,906
MCTP apartment rental income	\$6,826
<b>Total income</b>	<b>\$552,513</b>
<b>Expenses</b>	
Secretaries*	\$79,506
Director administrative differential (two years)*	\$16,456
Computing	\$24,806
Office supplies, postage, telephone	\$2,707
Discretionary funds	\$7,834
MG-07-21: Tidal stripping of DM halos	\$1,000
Benefits recharge and year end accruals*	\$1,305
Outreach and public lectures	\$8,475
MCTP apartment	\$14,300
Cost sharing on NASA grant*	\$15,453
Visitor programs	\$83,210
Conferences and workshops	
MG-07-02: AAS meeting	\$12,000
MG-07-04: Observing all the Baryons	\$10,000
MG-07-05: Large deviations	\$25,000
MG-07-07: Strings and gauge theories	\$25,000
MG-07-12: 3 <sup>rd</sup> LHC inverse workshop	\$12,000
MG-07-14: Microscopic to macroscopic	\$22,000
MG-07-15: The Dark Side II	\$35,000
MG-07-23: Mechanics of life	\$5,000
Total conferences and workshops	\$146,000
1 MCTP postdoctoral fellow*	\$59,416
Postdoctoral travel	\$4,926
Graduate student fellowships*	\$54,155
Teaching fellowships	\$15,000
<b>Total expenses</b>	<b>\$534,549</b>
<b>Surplus</b>	<b>\$17,964</b>

Note:\* The distribution of fringe benefits among personnel is only an estimate.

## 5.3 2007-2008 budget (projection)

For the fiscal year ending June 30, 2008<sup>1</sup>

<b>Income</b>		
LS&A allocation		\$200,000
Physics allocation		\$250,000
Surplus from 2006-2007		\$17,964
MCTP apartment rental income		<u>\$9,956</u>
<b>Total income</b>		<b>\$477,920</b>
<b>Expenses</b>		
Secretaries*		\$73,331
Director administrative differential*		\$8,255
Computing		\$62,315
Office supplies, postage, telephone		\$2,549
Discretionary funds**		\$6,296
Outreach and Public Lectures		\$4,160
MCTP apartment		\$13,713
Michigan Quantum Summer School program		\$20,000
Visitor programs		\$40,336
Conferences and workshops		
MG-07-05: Large Deviations	\$2,437	
MG-07-23: Mechanics of Life	\$12,000	
MG-08-03: LHC New Physics Signatures	\$22,000	
MG-08-06: Globular Clusters - Dwarf Galaxies		
Connection	\$15,000	
MG-08-12 (b): Cosmology Inverse Problem	\$6,000	
MG-08-15: Physics grad student symposium	\$750	
MG-08-16: SWIP/undergrad workshop	\$10,000	
MG-08-27: Midwest Theoretical Chemistry		
Conference	\$10,000	
Total conferences and workshops		\$78,187
MCTP postdoctoral fellow (final 2 month's salary and travel)		\$7417
Graduate student fellowships		\$123,000
Teaching fellowships		<u>\$15,000</u>
<b>Total expenses</b>		<b>\$454,559</b>
<b>Surplus</b>		<b>\$23,361</b>

\*Note: The distribution of fringe benefits among personnel is only an estimate.

\*\*Note: The distribution of discretionary funds includes coffee supplies, miscellaneous supplies, Theory Journal Club weekly lunches, and furniture items for MCTP offices.

<sup>1</sup> Budget is actual through March; May, June, and July expenditures are based on estimates.

## 6 Funding

### 6.1 Expenditures (2001-2005)

A summary of the MCTP expenditures of LSA and department funds for 2001–2005 is given in the pie-chart of Figure 8:

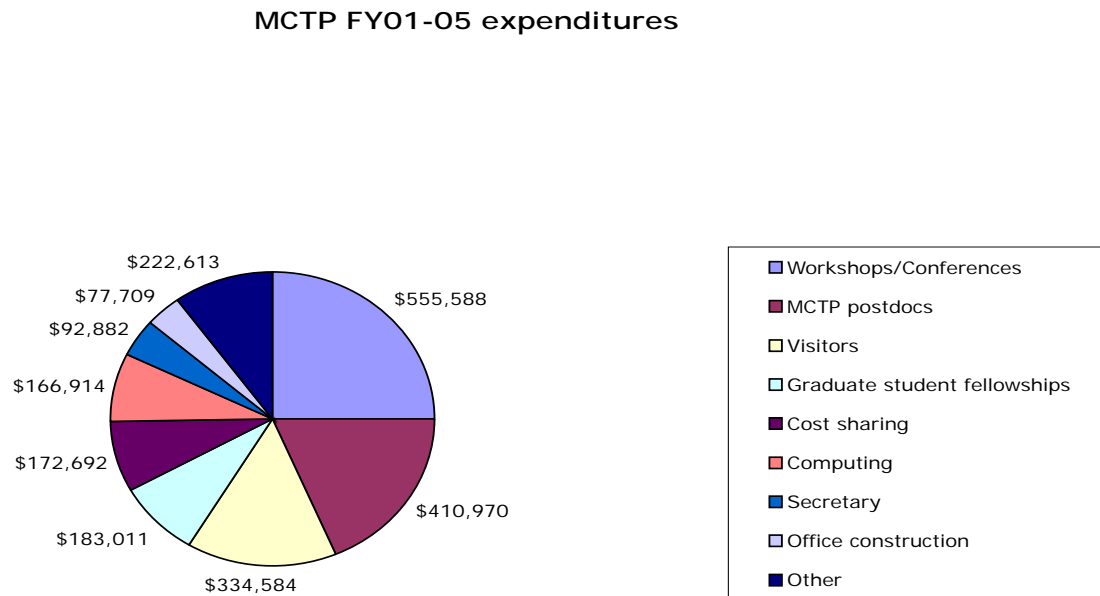


Figure 8: MCTP Expenditures, FY01-05

### 6.2 Expenditures (2006-2008)

A summary of the MCTP expenditures of LSA and department funds for 2006–2008 is given in the pie-chart of Figure 9:

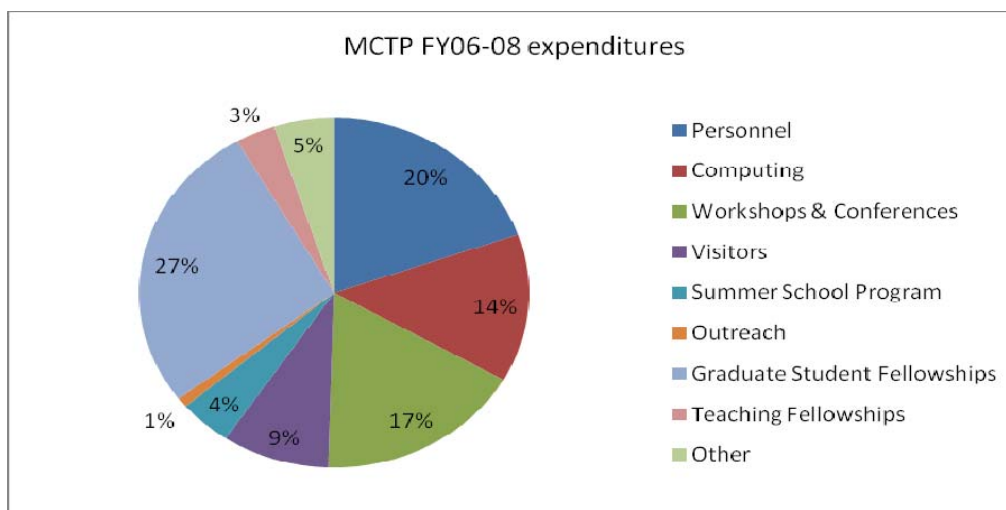


Figure 9: MCTP Expenditures, FY06-08

### 6.3 *Matching funds from the DOE*

Major external funding for MCTP activities have been provided by a \$1,575,000 Matching Funds Grant for High Energy Theory from the DoE. The current PIs are Gordon Kane, Myron Campbell, and James Liu. These MCTP matching funds (denoted Task T) are separate from, and in addition to, the regular high energy theory DOE grant (denoted Task G). Task T PIs have complete autonomy on Task T expenditures which are independent of the MCTP Executive Committee.

Task T matching funds are quite interdisciplinary, covering those subjects of importance to the DOE High Energy Physics Program: particle physics, string/M theory, stringy mathematics, astrophysics, cosmology, and relativity. Some of the benefits of Task T include:

1. More graduate student time spent on research
2. Improvement in quality of MCTP postdocs and longer term visitors (e. g. by offering a third year to supplement two year appointments, Michigan can compete for the best candidates).
3. Otherwise unaffordable visitors and quick, flexible response.
4. Strengthening the MCTP workshop and visitor programs.
5. Benefits entire US high energy community via workshops and visitor programs.

The Department of Energy has emphasized explicitly that the Task T level of support is closely tied to the University funding for MCTP. The very recent reorganization of DoE will have some effect on how such matching support is structured, but it is too soon to know how this will work.

### 6.4 *Major External funding*

- \$10,000 Clay Foundation “Inaugural conference” 2001 (Duff,Liu)
- \$10,000 DOE “Inaugural conference” 2001 (Duff,Liu)
- \$7,500 OVPR “Inaugural conference” 2001 (Duff,Liu)
- \$12,500 NASA “Inaugural conference” 2001 (Freese)
- \$15,000 NASA “DLA workshop” 2001 (Sander)
- \$5,000 Schlumberger “DLA workshop” 2001 (Sander)
- \$10,000 Complex systems “DLA workshop” 2001 (Sander)
- \$3,000 Murray Deutsch Gift 2001
- \$5,000 Veridian Gift 2001
- \$1,575,000 DoE “Michigan Center for Theoretical Physics Matching Funds” 2002-2005 (Duff, Kane, Campbell),
- \$300,000 AFOSR “Quantum Computing with Superconducting Qubits” 2001-2004 (Nori), MCTP Cost Sharing \$10,000 in the form of graduate student support.
- \$216,000 NSF “Fronts Fluctuations and Growth” 2003-6 (Doering, Conlon, Sander, Smereka, Ziff) 2003-2006, MCTP Cost Sharing \$160,000 in the form of graduate student support.
- \$165,000 NASA “Solar Systems with Habitable Planets” 2003-2006 (Adams), MCTP Cost Sharing \$63,000 in the form of graduate student support.
- \$15,000 FOCUS “Workshop on Decoherence Control and Quantum

- Computing” 2002 (Berman and Monroe)
- \$30,000 ADVANCE “Young string theorists” 2004-2007 (Larsen, Liu, Pando Zayas), MCTP cost sharing \$5,000
- \$100,000 FOCUS “Joint MCTP/FOCUS postdocs” 2003-2005
- \$60,000 Office of the Provost “ Distinguished visitors” 2005-2008
- \$15,000 Physics Department “ Distinguished visitors” 2005-2008
- \$7,000 Complex systems “Von Neumann workshop” 2005
- \$1,500 Lynn and Kenneth Marko Gift 2005 (check date: 12/17/04)
- \$10,000 Stan and Iris Ovshinsky Gift, January 2005
- \$500 S. Stegeman Gift, November 2005
- \$500 Mr. & Mrs. Kenneth Marko Gift, December 2005
- \$5,000 Mr. & Mrs. Stephen D’Arcy Gift, December 2005
- \$5,000 PricewaterhouseCoopers Foundation Matching funds, April 2006
- \$250 Mr. & Mrs. Kenneth Marko Gift, January 2007
- \$12,500 Mr. & Mrs. Stephen D’Arcy Gift, August 2007
- \$12,500 Mr. Al Glancy Gift, August 2007
- \$12,500 Mr. Christopher Charlton Gift, August 2007
- \$12,500 Mr. Frank Hennessey Gift, 2007
- \$7,500 PricewaterhouseCoopers Matching Funds contribution, August 2007
- \$500 Hudson-Webber Foundation Gift (Matching funds for David Egner), December 2007
- \$5,000 Mr. & Mrs. Stephen D’Arcy, December 2007
- \$5,000 PricewaterhouseCoopers Gift, December 2007
- \$25,000 Mr. Stanford Ovshinsky Gift, December 2007
- \$500 Mr. D. Bogle Gift, January 2008
- \$500 Mr. W. Laule Gift, January 2008
- \$1,000 Mr. R. Anthony IV, January 2008

TOTAL: \$2,001,250

### **6.5 Funding opportunities**

During its relatively short history, the Michigan Center for Theoretical Physics has amassed an impressive list of accomplishments. In the process, the Center is becoming a major force in shaping our understanding of the physical world, and the implications and opportunities provided by that undoubtedly. While a great deal has already been achieved, much more remains to be done. Some of the possible funding opportunities for donors are:

1. More two - four week workshops convened by experts from around the world, \$20,000–40,000
2. Postdoctoral fellowships, 2-3 @\$65,000 each
3. Graduate student fellowships, 2-3 @ \$12,000 each
4. Undergraduate research scholars, 6 @ \$2,000 each
5. Support of a larger conference, \$100,000
6. Visiting Faculty who are typically paid \$5,000–12,000 for one month; they visit for 1–3 mos, \$5,000–36,000 (This would also be a great endowment opportunity for \$720,000)
7. Outreach, \$10,000

8. Endow the Michigan Center for Theoretical Physics, \$10,000,000 - \$20,000,000.
9. We welcome outside interest and support. To learn more about contributing to the work of the MCTP, we invite you to contact Peggy Burns or Gordon Kane, or Scot Weiner, [scotw@umich.edu](mailto:scotw@umich.edu).

### **6.6 MCTP Visiting Committee**

We have been excited to set up our Visiting Committee, under the leadership of Stephen D'Arcy, composed of about 20 business and community leaders from Southeastern Michigan. They have agreed to help the MCTP achieve its goals and to strengthen the MCTP financially. The Visiting Committee is in contact with the LSA Development Office. In addition to some personal donations, they are examining ways to use their contacts and experience to generate support toward achieving the MCTP goal. See the letter from S. D'Arcy and members in Appendix 9.2.

The Visiting Committee has also gathered about twice a year for lunch or dinner, plus an update on MCTP activities and a short talk and discussion with a leading scientist on frontier topics. The Visiting Committee membership consists currently of the following:

- Stephen D'Arcy, Chair (Partner, PricewaterhouseCoopers LLP)
- Robert Anthony III (Retired PwC Partner)
- David Bogle (Venture capitalist, Capital Strategies Group)
- Carl Camden (COO, Executive Vice President Kelly Services)
- Christopher T. Charlton (President, Charlton Group)
- Michael Duggan (CEO & President, Detroit Medical Center)
- Clark Durant (President, New Common School Foundation)
- Tony Earley (Chairman and CEO DTE Energy)
- David Egner (Hudson-Webber Foundation)
- Larry Garberding (Retired CEO, DTE Energy)
- Allan Gilmour (Retired Vice Chairman Ford Motor Company)
- Alfred Glancy (Retired CEO (MCN) Unico Investment, Chairman Glancy GKW Enterprises, LLC)
- Frank Hennessey (Chairman & CEO Hennessey Capital)
- David W. Joos (CEO, CMS Energy)
- Bill Laule (CEO TI Automotive)
- Eugene (Gene) Miller (Retired CEO, Comerica Inc.)
- James Nicholson (Chairman PVS Chemicals)
- Stanford R. Ovshinsky (Chairman & Chief Executive Officer, Ovshinsky Innovation LLC)
- Stephen Polk (Chairman & CEO, R. L. Polk & Co.)
- Alan S. Schwartz (Honigman Ciller Schwartz and Cohn LLP)
- Alan Taub (Executive Director GM, Research & Development)

6.7 *Three Year Budget Proposal*

<b>Expenses</b>	<b>FY09 request</b>	<b>FY10 request</b>	<b>FY11 request</b>
<b>Fixed Expenses</b>			
Administrative			
Secretaries	\$87,878	\$90,094	\$92,377
Director release time	\$9,039	\$9,310	\$9,589
Computing	\$5,000	\$7,000	\$8,000
Office Supplies (postage, copying, telephone)	\$4,000	\$4,000	\$4,000
Miscellaneous			
MCTP Apartment	\$14,000	\$16,000	\$18,000
Development	\$2,000	\$2,000	\$2,000
Outreach and Public lectures	\$10,000	\$10,000	\$10,000
Teaching Support	\$15,000	\$15,000	\$15,000
Discretionary	\$15,000	\$15,000	\$15,000
<b>Funded Proposals</b>			
Major Programs			
Workshops/Conferences	\$73,746	\$55,596	\$54,000
Visitors/Visitor programs	\$47,300	\$40,000	\$36,034
Summer Schools	\$30,000	\$40,000	\$40,000
Students			
Graduate Student Fellowships	\$114,000	\$114,000	\$114,000
Other			
Legato computer storage system	\$14,400	\$0	\$0
Computing	\$32,000	\$32,000	\$32,000
<b>Total Expenses</b>	<b>\$473,363</b>	<b>\$450,000</b>	<b>\$450,000</b>
<b>Income</b>			
Carryover from previous fiscal year	\$23,363	\$0	\$0
Request for renewed funding	\$450,000	\$450,000	\$450,000
<b>Total income</b>	<b>\$473,363</b>	<b>\$450,000</b>	<b>\$450,000</b>

**BUDGET JUSTIFICATION****1. Fixed Expenses***a. Secretaries*

Angela Milliken @ 40% and Nicolle Wahla @ 100%; the remaining appointment fractions are shared with High Energy Theory and the Physics Department.

*b. Computing*

Funds allocated for system upgrades in the MCTP computer room, MCTP visitor offices and for MCTP administration (i.e. web design software licenses). Also, software and hardware needs arise that are not provided to the Center by the University or Department Computing Office.

*c. Supplies*

- i. Copying and office supplies (\$2,500)
- ii. Postage and shipping (\$1,000)



iii. Telephone (\$1,500)

*d. MCTP Apartment*

The MCTP leases a one bedroom furnished apartment with Maynard house located ON Central Campus. This is extremely useful for the extensive visitors and visitor programs the MCTP hosts, and saves a significant amount of money compared to hotels.

*e. Development*

Expenses related to MCTP Visiting Committee meetings as well as hosting fund-raising activities.

*f. Outreach and Public Lectures*

The MCTP will co-host the Theme Marquee Lecture series with the Astronomy department again this year. This consists of monthly Public Lectures for the fall and winter terms. Co-host the second annual Physics Graduate Student Symposium and co-sponsor a Science Café program with the Natural History Museum again.

*g. Discretionary*

The MCTP solicits major proposals on an annual cycle coinciding with the fiscal year. Part of the discretionary funds is intended to cover proposals under \$1,000 submitted outside of the regular cycle. Discretionary funds cover travel and hosting for visitors invited through the Executive Committee (such as MCTP colloquium speakers), weekly Theory Journal Club meetings, coffee supplies for visitors, and may also be used to cover unforeseen expenses.

**2. MCTP funded proposals**

Major proposals are solicited on an annual basis. Proposals for FY09 have already been received and reviewed. The MCTP encourages activities involving: Workshops and conferences; Visitors; and Graduate student support.

*a. Workshops and conferences*

One of the major activities of the center is to host workshops and major conferences. In the past few years, the MCTP ran about five workshops a year on average. We anticipate a similar workshop program in the next three years. While the specific workshops are not yet determined for FY10 and FY11, we have approved the following for FY09:

MG-09-02: Great Lakes Strings Conference 2009	\$15,000.00
MG-09-06: Star Formation and the Initial Mass Function	\$5,000.00
MG-09-07: Cosmology of field theory actions	\$9,000.00
MG-09-11: LHC and dark matter	\$15,000.00

Typically one or two additional workshops are approved during the year.

*b. Visitors/Visitor Programs*

Outside of workshops, the MCTP supports both short-term and long-term visitors. Typically there will be anywhere from one to four long-term visitors in residence during the academic year. For visits of up to one month, the

MCTP reimburses travel and local expenses. Longer visits are supported at up to \$4,000-\$5,000 per month, based on requested amount, possible matching support, and seniority.

The MCTP also expects to fund general visitor programs proposed by the membership. Past programs include the CM/AMO visitor program and the Young String Theorists visitor program. The visitor budget for FY09 has been allocated as follows:

MG-09-01: Young High Energy Theorists	\$20,000.00
MG-09-09: Menghetti and Mazzotta (Raisa, Evrard)	\$2,400.00
MG-09-10: Dolag (Raisa, Evrard)	\$2,400.00
MG-09-12: Acharya (Kane, Pierce)	\$8,000.00
MG-09-13: Gondolo and Spolyar (Freese)	\$5,000.00
MG-09-15: Giovanni Russo (Smereka)	\$3,500.00
MG-09-17: E. Ben-Jacob & R. Dzakpasu (Zochowski)	\$6,000.00

Typically some visitors will be added during the year.

*c. Summer School Programs*

The MCTP expects to fund the following Summer School programs in FY09:

MG-09-14: Summer School in Cosmology	\$20,000.00
MG-09-16: Michigan Quantum Summer School	\$10,000.00

*d. Other*

The MCTP expects to fund the Legato storage system at a level of \$14,400 during FY09. The remaining fraction of cost for computing is shared with the Physics Department and other sources.

## **7 Taking Stock: Current State & the Future**

The Michigan Center for Theoretical Physics has begun to take a leadership role in the search for answers to a broad range of important questions. It is a focal point for exciting and productive research and thinking in theoretical physics.

The Center has, in a very few years, established an international reputation as a useful and distinguished venue for scientific interaction and communication. In fact, this distinguishes the MCTP from many of the other theoretical physics centers in the country. In most centers, the main activities are internal to the host university, and, in fact, mostly internal to the host physics department or part of it. Our view of our mission has been much more ambitious, in that we seek to be of service to the theoretical science community as a whole. (Of course, this kind of service is of inestimable value to our department and the University!) In this respect, the best comparison to the MCTP is the well-known Kavli Institute for Theoretical Physics in Santa Barbara, or the Newton Institute at the University of Cambridge.

In order to help assess the impact that we have made, we sought the opinions of scientists from outside of Michigan who have participated in our activities. We include some of these in the appendix. We were very pleased by the warmth of the reactions to our activities.

Another thing that distinguishes us from other centers is our broad multidisciplinary emphasis. This aspect of our work has involved, as well as outside researchers, many faculties from other LSA departments and Colleges. We are particularly encouraged by the strong ties that we have established with Mathematics, which includes a joint NSF grant directly inspired by the existence of the MCTP and significant collaborative research. We include in an appendix, below, a set of statements from the Michigan faculty, outside of Physics. We think that we have made a significant impact on the intellectual environment of the University. Our recent MoU toward cooperation with the International Center for Theoretical Physics, located in Trieste, Italy, is a significant recognition of our breadth and our success, and an opportunity for more international achievements.

In the future we hope to continue and strengthen our core activities. In addition we expect to be active in new areas. Theoretical physicists are taking a leading role in the life sciences throughout the world. This introduction of the methods of theoretical statistical physics into the life sciences is an extraordinarily promising area. We think that the MCTP can play a creative role in bringing together the expertise in this new area that is present at Michigan, but scattered among departments and colleges.

We urge that the College support the MCTP at least at the level it has, so that its impact and productivity is not reduced. Since the MCTP has had and will have more significant reach not only in other departments but in other Colleges, perhaps some funding connections could be established to the broader University. We have made a promising start in external fund-raising. We are encouraged by the activities of the Visiting Committee.

Our hopes for this enterprise are very high. The enthusiasm of the Michigan community for our work is widespread. We think that our future prospects are bright, and that we can make an important and lasting contribution to the university community, and scientific research worldwide.

## 8 Acknowledgments

We would like to take this opportunity to thank the present and past Executive Committee members, Fred Adams, Dan Burns, Luming Duan, Gus Evrard, Finn Larsen, as well as members of the other MCTP committees, for their wisdom and hard work. We are particularly grateful to the MCTP secretaries, Angela Milliken, Nicolle Wahla, and Deborah Stark-Knight (who recently left) for their valuable work and support.

The Members of the MCTP (and the international theoretical physics community) are very grateful to Interim President Emeritus Homer Neal, Provost Paul Courant, Deans Shirley Neuman and Terry MacDonald, and Chairs Ctirad Uher and Myron Campbell for their support and encouragement.

## 9 Appendices

### 9.1 Endorsements

In order to assess our impact, we collected some present and past endorsements for MCTP and its activities. One email message was sent to Members and to Workshop participants (not Conference participants), and the following responses arrived. All were positive. They came from other departments and colleges in the University, nationally, and internationally. The full text of the endorsements is available at the following site:

<http://www.umich.edu/~mctp/reports/>

#### 9.1.1 Sample quotes from endorsements received

*'I spent an extended period of two months this year at the MCTP. I realized that the MCTP is one of the unique centers in the world in which string theorists, phenomenologists and experimentalists (high energy and astro-particle) interact on a daily basis in an extremely stimulating, productive and friendly environment. This balance is very difficult to achieve and find elsewhere and should be heartily supported in the future. My visit was extremely productive and has lead me to new research areas and I eagerly look forward to returning in the future.'*

Bobby Acharya

International Center for Theoretical Physics, Trieste, ITALY

*'I think I got my NSF CAREER award (PHY-0547794) in part due to being an Associate Member of MCTP...'*

Alexey Petrov

Professor of Physics, Wayne State University

*'I have had the pleasure to participate in four MCTP workshops or conferences in the last three years. I have found these events to be some of the most fruitful that I have attended over that time period. In every occasion I have come away with new ideas or new ways of thinking about previously held scientific viewpoints. The mission of the MCTP -- to bring together experts across disciplines in order to attack specific problems -- inevitably produces the right combination of talent to produce meaningful results and truly make progress in a certain direction of theoretical physics. My own*

*interests lie in string phenomenology, which is to say connecting string theory to experimental physics. It is not a stretch to say that the emergence of this field as a bona fide area of study in the high energy community owes a large debt of gratitude to the efforts of the MCTP and its membership.'*

Brent Nelson

Northeastern University

*'This is a letter of endorsement for the Michigan Center for Theoretical Physics. In the past years the center has spawned interaction among the leading thinkers of my discipline by innovative and creative programs. The results are multiple publications with ground-breaking ideas that I expect will be assisting the field as the LHC is about to turn on and collect data. It is impressive that the center has created strong links between experimentalists and theorists and has instigated collaboration between them that is especially crucial and timely. It is also remarkable that the center is a pole of attraction for the very bright young researchers as well as for the mavericks of the field. I have and will continue participating in the center activities myself and will support the center with great enthusiasm as its effectiveness and intellectual leadership is manifested by the work spawned and produced.'*

Dr. Maria Spiropulu

Research Physicist, CERN-Physics Department

*'I attended a workshop at the MCTP in January and appreciated the stimulating and lively atmosphere there, as well as the laudable determination to be at the forefront of exploiting the results of the LHC when they come out.'*

Joe Conlon

Professor of Mathematics, University of Michigan

*'Getting support from bodies such as NSF and NASA sounds easy, but in fact both have little to offer in this area. NSF specifically funds conferences only through remnant funds; the sums are limited and availability comes down to chance. Thus MCTP funds are a godsend. But the impact is enormous. To be able to offer support for attendance, when people are most used to being asked for money, often comes as a very welcome surprise.'*

*With a contribution from MCTP (and matching funds from the NSF -- we got lucky!) we were able to bring in people from Eastern Europe and the FSU, as well as provide some support to people for whom the trip would otherwise have been prohibitive -- e.g., Japan. Facilitating attendance for those from now struggling institutions was really appreciated.'*

Philip A. Hughes

Research Scientist Emeritus and Intermittent Lecturer in Astronomy, University of Michigan

*'It is my pleasure to say that I was highly impressed by the recent jet conference held at Ann Arbor. Indeed, it was a seldom example of a highly focused meeting with a well arranged order of very interesting presentations.'*

*Thank you very much for inviting and bringing me to the meeting, I was indeed happy to meet people and learn (and arrange in my head) a number of the jet physics ideas, models, and observations.'*

Gregory Fleishman  
Ioffe Physico-Technical Institute, Russian Federation

*'I am writing this to acknowledge the recent MCTP workshop "LHC New Physics Signatures Workshop (Jan. 5-11, 2008)" for providing me a good opportunity to learn LHC related physics. I enjoyed discussions with many participants, and could get a new idea on applying my previous work on the collider variable  $m_{T2}$  to the measurement of the top mass at the LHC, which I am currently working on.*

*I think MCTP has been doing a great job for physics community worldwide, and strongly hope it continues for the future.'*

Kiwoon Choi  
Professor of Physics, KAIST, South Korea

*'I was a participant in the 1st Annual Midwest Conference for Undergraduate Women in Physics. It was a great event and I am one of the participants from University of Illinois at Urbana Champaign who is helping to organize the event for next year. The conference was a great opportunity for women around the Midwest to come together with other women in physics and also show what can be done after our undergrads. There were conferences that were hard to get to on the east and west coasts and it was great that it was brought to the Midwest.'*

Leslie Bubel  
University Of Illinois at Urbana-Champaign

*'I attended the G2 Holonomy workshop. I found this workshop to be extremely enlightening and stimulating. The interactions I had with other participants of the workshop enabled me to develop a new outlook on the subject of string theory and string model building. I hope to be able to do some research in this area in the near future.'*

Stuart Raby  
Professor of Physics, The Ohio State University

*'I'm happy to reply in detail, for my own experience is that MCTP has been a remarkably stimulating force for interdepartmental activities here at Michigan. ... I hope that MCTP can continue to play the kind of galvanizing role that it so effectively has in recent years.'*

Charlie Doering  
Professor of Mathematics, University of Michigan

*'I have attended 4 MCTP workshops or conferences in recent years, i.e., the 2004 String Phenomenology Conference, the 2007 Kane Symposium, the 2007 G2 Compactification Workshop, and the 2008 LHC Workshop. I have found these to be extremely useful, stimulating, and pleasant. The physics and formal lectures were excellent, the mix of people from different disciplines (especially in the G2 workshop) was very good, and the relaxed schedules that allowed plenty of time for discussions were ideal. Perhaps most important for me is that I have met many excellent young scientists at these meetings. The MCTP is performing a very important function and I hope it will continue permanently.'*

Paul Langacker  
Professor of Physics, School of Natural Sciences

Institute for Advanced Study, Princeton

*'In the past three years, I have attended three workshops hosted and organized by the MCTP. These workshops have been great success, in fact they are probably the most beneficial conferences I have attended over this time period. This is a result of well thought-out structure and organization, an atmosphere conducive to collaboration and discussion, and an emphasis on new and emerging results in topics critical to physics beyond the Standard Model. I strongly endorse the activities of the MCTP in this area.'*

Stephen P. Martin  
Northern Illinois University

*'For me, it has been a great source of help in having interdisciplinary interactions with members of the physics department and has given me a reason to come to central campus on a regular basis from the engineering college.'*

Robert M. Ziff  
Professor of Chemical Engineering, Univ. of Michigan

*'The MCTP is an exciting and stimulating resource for physics, Mathematics and science in general at the University of Michigan that greatly Benefits students and faculty ... I have found that in visits to other universities people really know about MCTP and that this has Michigan put theoretical science on the map in a way that individual departments here cannot do...'*

Anthony Bloch,  
Professor of Mathematics, University of Michigan

*'To summarize, from many decades' experience in our field, MCTP has brought back the glory days of UM Physics and I fervently hope that this initial period's success will be continued in the next cycle you so richly deserve.'*

Stanley Deser  
Ansell Professor of Physics, Brandeis University, Member, National Academy of Sciences

*'As far as I can see, the very successful activities of the Center put it on a par with such world renowned programs as the KITP at Santa Barbara, the Newton Institute at Cambridge and the Yukawa Institute for Theoretical Physics in Kyoto.'*

Baruch Meerson  
Professor of Physics, Racah Institute, Hebrew University of Jerusalem

*'I sincerely hope that the MCTP funding can continue or hopefully even be enhanced. Such funding enables international research to flourish, and collaborations to be maintained across international boundaries, resulting in high quality research to be performed that would not otherwise be possible.'*

S.F.King,  
Professor, Department of Physics and Astronomy, University of Southampton, UK

*'It was really a great thing to open the Michigan Center for Theoretical Physics. As a person from abroad, I must state, that the Center has brought a lot for the visibility of the whole your University from the outside: I still remember a nice posters which I have seen in Freiburg (where I was at that time) when the Center was opened. This*

*poster immediately attracted my attention, ...'*

Igor M. Sokolov

Statistische Physik und Nichtlineare Dynamik Institut fuer Physik

Humboldt-Universitaet zu Berlin

*'Funding of the MCTP not only demonstrates the Univ of Michigan's commitment to excellence in Physics research but it also puts the international spotlight on U. Mich. in our field.'*

R. N. Mohapatra

Professor of Physics, University of Maryland

*'The University of Michigan has played an important role in the History of High Energy Physics. MCTP gives the University the opportunity to become one the leading actor of this new century in the race to discover the ultimate secrets of matter at the tiniest scales ever explored. Let us make MCTP that exciting place where everybody wants to visit.'*

Christophe Grojean.

Staff Scientist, Theoretical Physics Division, French Atomic Energy Commission, Saclay

*'I am currently an undergraduate student at the University of Chicago, and I attended the Midwest Conference for Undergraduate Women in Physics in January. I thought the conference was very successful and very well organized. I had recently submitted my application for Michigan's Ph.D. program in physics, and the conference gave me an excellent view into Michigan's physics department and allowed me to meet several professors and graduate students. This experience was instrumental in my decision to attend Michigan's program this coming year.'*

Melinda Morang

University of Chicago

*Dear Prof. Kane:*

*We are writing to document the importance of MCTP as a means of facilitating collaboration between the Physics Department and the Mathematics Department here at the University of Michigan. Over the past four years, the two of us have actively collaborated on a series of projects that span the interests of both the Math and Physics Departments. MCTP played a key role in bringing about this collaboration. We have appreciated their support in hosting visitors and meetings of interest to both of us. A brief outline of this work is given below:*

*[1] Our first paper explores orbits in extended mass distributions that arise in many astrophysical settings, including dark matter halos, galactic bulges, and young star clusters. For the relevant potential, one can readily calculate orbital solutions as a function of energy and angular momentum using numerical methods; in contrast, we present a number of analytic results for this potential and prove a series of general constraints showing that orbits have similar properties for any extended mass distribution. This work discusses circular orbits, radial orbits, zero energy orbits, definitions of eccentricity, analogs of Kepler's law, definitions of orbital elements, and the relation of these orbits to spirograph patterns (epicycloids).*



[2] Our next paper uses the results of paper [1] to construct an analytic framework for calculating the assembly of galactic disks from the collapse of gas within dark matter halos, with the goal of determining the surface density profiles for galactic disks. In this formulation of the problem, gas parcels (baryons) fall through the potentials of dark matter halos on nearly ballistic, zero energy orbits and collect in a rotating disk. This calculation is carried out for a variety of pre-collapse mass distributions with varying amounts of angular momentum. For simple initial conditions, the resulting disk surface density profiles have nearly power-law forms with well-defined edges determined by the centrifugal barrier of the problem. Using statistical methods, however, we can generalize this basic scenario to include multiple accretion events (e.g., due to gas being added to the halo via merger events). With this complication, the composite surface density attains a nearly exponential form, consistent with profiles of observed galaxies.

[3] As the next generalization, we construct an analytic form for a triaxial potential that describes the dynamics of a wide variety of astrophysical systems (including dark matter halos, galactic bulges, and young star clusters). Using this analytic form of the potential, and the corresponding force laws, we construct orbit solutions and show that a robust orbit instability exists in these systems. For orbits initially confined to any of the three principal planes, the motion in the perpendicular direction can be unstable. We discuss the range of parameter space for which these orbits are unstable, find the growth rates and saturation levels of the instability, and develop a set of analytic model equations that elucidate the essential physics of the instability mechanism. This orbit instability has a large number of astrophysical applications, including understanding the formation of dark matter halos, the structure of galactic bulges, the survival of tidal streams, and the evolution of embedded star clusters. This instability also provides a direction for new mathematics, as described next.

[4] Motivated by the problems in astrophysics described above [1–3], we consider solutions to Hill's equation with forcing strength parameters that vary from cycle to cycle. The results are generalized to include period variations from cycle to cycle. The development of the solutions to the differential equation is governed by a discrete map. For the general case of Hill's equation in the unstable limit, we consider separately the case of purely positive matrix elements and those with mixed signs; we then find exact expressions, bounds, and working estimates for the growth rates. We also find exact expressions, estimates, and bounds for the infinite products of several  $2 \times 2$  matrices with random variables in the matrix elements. In the limit of sharply spiked forcing terms, we find analytic solutions for each cycle and for the discrete map that matches solutions from cycle to cycle; for this case we find the growth rates and the condition for instability in the limit of large forcing strength, as well as the widths of the stable/unstable zones.

[5] Continuing our study of stochastic problems at the interface of mathematics and astrophysics, we next consider the effects of turbulence on mean motion resonances in extrasolar planetary systems and predict that systems rarely survive in a resonant configuration. A growing number of systems are reported to be in resonance, which is thought to arise from the planet migration process. If planets are brought together and moved inward through torques produced by circumstellar disks, then disk turbulence can act to prevent planets from staying in a resonant configuration. We study this process through numerical simulations and via analytic model equations,

*where both approaches include stochastic forcing terms due to turbulence. If turbulence is common in circumstellar disks during the epoch of planet migration, with the amplitudes indicated by current MHD simulations, then planetary systems that remain deep in mean motion resonance are predicted to be rare. This result has important implications for ongoing searches for extrasolar planets. The above five projects have been the fruitful result of our collaboration between the Math and Physics Departments. Note that the interaction goes both ways: The existing expertise in math has helped resolve a number of outstanding issues in astrophysics, whereas these physical problems have provided grist for new mathematics. We look forward to continuing interactions in the future and hope that MCTP will support such work.*

Sincerely,

Fred Adams, Professor of Physics, fca@umich.edu

Anthony Bloch, Professor of Mathematics, abloch@umich.edu

#### REFERENCES

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- [3] Adams, F. C., Bloch, A. M., Butler, S. C., Druce, J. M., and Ketchum, J. A. 2007, "Orbital Instabilities in a Triaxial Cusp Potential," *The Astrophysical Journal*, 670, pp. 1027 – 1047, astro-ph/0708.3101
- [4] Adams, F. C., and Bloch, A. M. 2008, "Hill's Equation with Random Forcing Terms," *SIAM Journal of Applied Mathematics (Society for Industrial and Applied Mathematics)*, 68, pp. 947 – 980, math-ph/0705.1779
- [5] Adams, F. C., Laughlin, G., and Bloch, A. M. 2008, "Turbulence in Extrasolar Planetary Systems Implies that Mean Motion Resonances are Rare," submitted to *The Astrophysical Journal*

### **9.1.2 List of all endorsements received**

#### **University of Michigan**

- Fred Adams, Professor of Physics, University of Michigan
- Antony Bloch, Professor of Mathematics, University of Michigan
- Joe Conlon, Professor of Mathematics, University of Michigan
- Charlie Doering, Professor of Mathematics, University of Michigan
- Rachel Goldman, Associate Professor Depts. of Materials Science & Engineering and Electrical Engineering & Computer Science, University of Michigan
- Philip Hughes, Research Scientist, Astronomy, University of Michigan
- Robert M. Ziff, Professor of Chemical Engineering, Univ. of Michigan
- Peter Smereka, Professor of Mathematics, University of Michigan
- Trachette L. Jackson, Associate Professor of Mathematics, University of Michigan

#### **Other US Institutions**

- Alexey Petrov, Associate Professor of Physics and Astronomy, Wayne State University
- Pran Nath, Matthews Distinguished Professor of Physics, Northeastern University
- Steve Martin, Professor of Physics, Northern Illinois University
- Paul Langacker, Professor of Physics, Institute for Advanced Study, Princeton University
- David Shih, Institute for Advanced Study, Princeton University
- Stuart Raby, Professor of Physics, Ohio State University
- Jesse Thaler, Miller Institute for Basic Research in Science, University of California, Berkeley
- Stanley Deser, Ansell Professor of Physics, Brandeis University, Fellow, National Academy of Sciences
- Eric Linder, Lawrence Berkeley Laboratory
- Michael R. Douglas, Professor of Physics and Astronomy, Rutgers University
- Frederick J. Mayer, President, Mayer Applied Research Inc, Ann Arbor, MI
- Michael Ratz, Postdoctoral Fellow, Physikalisches Institut der Universität Bonn, Germany
- Arkady Tseytlin, Professor of Physics, Ohio State University
- Howard Schnitzer, Edward and Gertrude Swartz Professor of Theoretical Physics, Brandeis University
- Rafael Nepomechie, Professor, Physics Department, University of Miami
- R. N. Mohapatra, Professor of Physics, University of Maryland
- Michael Dine, Professor of Physics, University of California Santa Cruz
- William Kinney, Assistant Professor of Physics, University of Buffalo

#### **Foreign Institutions**

- Bobby Acharya, Professor of Physics, International Center for Theoretical Physics, Trieste, Italy

- Gregory Fleishman, Professor, National Radio Astronomy Observatory & Ioffe Physico-Technical Institute, Russia
- Sasha Dolgov, Professor of Physics, ITEP, Moscow & INFN, Ferrara
- Kiwoon Choi, Professor of Physics, KAIST, Taejon
- Baruch Meerson, Professor of Physics, Racah Institute, Hebrew University of Jerusalem, Israel
- Eshel Ben-Jacob, Professor of Physics, The Maguy-Glass Chair in Physics of Complex Systems, Tel Aviv University, Israel, Past President, Israel Physical Society
- Joe Silk, Savilian Professor of Astronomy, Oxford University, UK
- S.F.King, Professor, Department of Physics and Astronomy, University of Southampton, UK
- Giovanni Russo, Professor of Mathematics, University of Catania, Italy
- Igor M. Sokolov, Professor, Statistische Physik und Nichtlineare Dynamik Institut für Physik , Humboldt-Universität zu Berlin, Germany
- Jeanette E. Nelson, Dipartimento di Fisica Teorica, Università di Torino and Istituto Nazionale di Fisica Nucleare, Sezione di Torino, Italy
- George Papadopoulos, Department of Mathematics, King's College London, UK
- Sacha Davidson, Institut de Physique Nucleaire, Univ Claude Bernard, Lyon, France
- Fabio Marchesoni, Professor, Dipartimento di Fisica, Università di Camerino Camerino, Italy
- Marc Henneau, Professor of Theoretical Physics, Université Libre de Bruxelles & Director, International Solvay Institutes, Belgium
- Ignacio Cirac, Director, Max-Planck Institut für Quantenoptik , Garching, Germany
- Christophe Grojean., Staff Scientist, Theoretical Physics Division, French Atomic Energy Commission, Saclay, France
- Eric Bergshoeff, Professor, Theoretical High Energy Physics, Groningen University, Netherlands

**9.2 External Funding Prospects**

May 7, 2008

Dean Terrence J. McDonald  
School of Literature, Science and the Arts  
University of Michigan

Dear Dean McDonald:

I am the Chairman of The Visiting Committee of the Michigan Center for Theoretical Physics. Our membership has asked that I write to you on all of our behalf's to convey to you our very strong commitment to the mission of MCTP. The MCTP is a vital component of the University's research mission. More than that, it is already contributing to meeting the vital challenge of economic transformation in the State of Michigan.

We believe that continued (and, if possible, enhanced) funding of the MCTP by the University is of the highest importance. We know that you share our passion for the MCTP and look forward to working with you, Gordy Kane, Myron Campbell and the University community on this important enterprise.

Very truly yours,

Stephen R. D'Arcy and on behalf of

Robert Anthony III  
David Bogle  
Carl Camden  
Christopher Charlton  
Michael Duggan  
Clark Durant  
Anthony Early  
David Egner  
Larry Garberding  
Allan Gilmour  
Alfred Glancy  
Frank Hennessey  
William Laule  
Eugene Miller  
Stanford Ovshinsky  
Alan Taub

### 9.3 Memorandum of Understanding

**MEMORANDUM OF UNDERSTANDING  
FOR EDUCATIONAL AND SCIENTIFIC COOPERATION BETWEEN  
THE DEPARTMENT OF PHYSICS, UNIVERSITY OF MICHIGAN (UM) AND  
THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS  
(ICTP)**

ICTP and UM will explore the possibilities for cooperation in research, education and international outreach initiatives. In particular, this will involve the Michigan Center for Theoretical Physics (MCTP) and the UM ATLAS group. Particular focus of the collaboration will be devoted to researchers from developing countries.

Given the current areas of specialization and expertise at the two institutions, the following general forms of cooperation may be appropriate:

1. Coordination of various aspects of relevant research programs and scientific events including workshops, conferences, summer schools and courses, and shared international visitor programs;
2. Exchange programs for relevant postdoctoral researchers and graduate students for short periods (of 3 months or less);
3. Exchange, association, and/or cross appointment of faculty members/Institute researchers for research, lectures and discussions, potentially including “frequent visitor” status for select faculty at either institution to promote greater opportunities for informal collaboration between relevant researchers;
4. Co-supervision of graduate students by respective staff at both institutions;
5. Joint coordination of outreach activities (courses, lectures, demonstrations, workshops, pedagogical materials) involving students, teachers and the general public throughout the international community, including, but by no means limited to, the developing world;
6. The cooperation is intended to enrich both institutions and will not interfere with their respective missions. All arrangements will be financially neutral unless explicitly agreed upon.

Themes of joint activities and the conditions for utilizing the results achieved, and arrangements for specific exchanges and other forms of cooperation, including financial arrangements, will be developed mutually for each specific case. All such collaborative activities will be subject to the normal review and approval processes at each institution and implemented by signed agreements. This Memorandum of Understanding will be for a period of five years, renewable by mutual consent and terminable by either party on three months' notice.

UM

ICTP

\_\_\_\_\_  
UM Representative

\_\_\_\_\_  
DIRECTOR: K.R. Sreenivasan

Date: \_\_\_\_\_ Date: \_\_\_\_\_

#### **9.4 *Initial MCTP Proposal***

The original MCTP proposal may be found on the web:  
<http://www.umich.edu/~mctp/history.html>

#### **9.5 *Other U.S. Theoretical Physics Centers***

UC, Berkeley: Berkeley Center for Theoretical Physics  
Caltech/USC: Center for Theoretical Physics  
University of Colorado: Center for Theoretical Atomic, Molecular, and Optical  
Physics  
University of Chicago: Enrico Fermi Institute  
University of Florida: Institute for Fundamental Theory  
University of Minnesota: Theoretical Physics Institute  
MIT: Center for Theoretical Physics  
Texas A&M: Mitchell Institute for Fundamental Physics  
Penn State: Center for Gravitational Physics and Geometry  
UC, Santa Barbara: Institute for Theoretical Physics  
SUNY Stony Brook: C.N. Yang Institute for Theoretical Physics  
Stanford: Theoretical Physics Center  
Ohio State: Center for Theoretical Science  
Rutgers: Center for Theoretical Physics and Mathematical Sciences  
University of Washington: Institute for Theoretical Particle and Nuclear Physics  
Simons Center for Mathematical Physics, State University of New York, Stony Brook

### **9.6    *The Dean's approval***

Dear Ctirad,

We seem finally to have found our way through the budget thicket and I write to inform you that I will be funding the Center for Theoretical Physics, from LS&A Enrichment funds given by donors, on the following terms:

- For the current fiscal year, LS&A will provide the Institute with \$213,000 in funding. The Department is expected to contribute a further \$25,000 from its own discretionary funding.
- For the three years from July 2001 until July 2004, the Center will receive \$400,000 per annum from LS&A. In each of those years, Physics will be required to partially “match” this funding with an allocation of \$50,000 from internal departmental resources. I will review with you in each budget cycle your commitment of funds to the Institute and the actual use made of the funding.
- In the fall of 2003, the Institute is to prepare a small self-study report, outlining at least the following:
  - ⇒ the research that has been done by Center members, with a description of the extent to which the Center enabled that research
  - ⇒ the grant funding that has accrued directly to the Center, and the indirect costs that have been returned to the University as a consequence of that research funding
  - ⇒ collaborative research initiatives that have been undertaken as a consequence of the center, both with UMichigan scholars and with scholars from other universities
  - ⇒ training activities that have taken place in the Center, including training grants and graduate supervision
  - ⇒ for purposes of bench-marking, a comparison of each of the above with the level of activity in theoretical physics in the department in the 1999- 2000 academic year
  - ⇒ a description of seminars, workshops, invited speakers, symposia, and outreach activities undertaken by the Center
  - ⇒ an outline of external funding received to support the ongoing activities of the Center (in addition to funding for specific research projects) this information will provide the basis of an evaluation of the activities of the Center for funding beyond the fiscal 04 year.

I trust that this will enable Professor Duff and his colleagues in theoretical physics to undertake the ambitious program they have projected and will very much look forward to knowing about the work in the field which it enables.

Sincerely,

Shirley Neuman



**9.7 Further funding by the Dean**

Dear Mike,

Given the early successes of the Michigan Center for Theoretical Physics (MCTP), I am extending the current level of “seed funding” for an additional 18 months (that is, you will now have five years of funding from the date that funding commenced, rather than three and one-half). Funding will be at the same level as in the initial period.

I wish you well in your continued endeavors on behalf of MCTP.

Sincerely,

Shirley Neuman

### **9.8 Full membership list**

As the list of members show, the membership is strongly interdisciplinary, across departmental and college boundaries.

F. Adams (Physics)  
K. Akerlof (Physics)  
R. Akhoury (Physics)  
J.W. Allen (Physics)  
P. Berman (Physics)  
A. Bloch (Mathematics)  
J. Bregman (Astronomy)  
D. Burns (Mathematics)  
M. Campbell (Physics)  
T. Chupp (Physics)  
S. Cremonini (Physics)  
C. Doering (Mathematics)  
I. Dolgachev (Mathematics)  
L. Duan (Physics)  
M. Duff (Physics, Imperial College)  
M. Einhorn (Physics, KITP)  
G. Estabrook (Biology)  
A. Evrard (Physics)  
M. Falk (Materials Science and Engineering)  
P. Federbush (Mathematics)  
J. Fornæss (Mathematics)  
K. Freese (Physics)  
K. Garikipati (Mechanical Engineering)  
D. Gerdes (Physics)  
E. Geva (Chemistry)  
S. Glotzer (Chemical Engineering/Physics/Materials Science and Engineering)  
O. Gnedin (Astronomy)  
K. Hecht (Physics)  
P. Horja (Mathematics)  
P. Hughes (Astronomy)  
T. Jackson (Mathematics)  
G. Kane (Physics)  
S. Krimm (Biophysics)  
J. Krisch (Physics)  
I. Kriz (Mathematics)  
F. Larsen (Physics)  
R. Lewis (Physics)  
J. Liu (Physics)  
D. Lubensky (Biophysics)  
T. McKay (Physics)  
S. Moukouri (Physics)  
H. Neal (Physics)  
M. Newman (Physics)  
F. Nori (Physics)  
L. Pando-Zayas (Physics)

A. Pierce (Physics)  
G. Raithel (Physics)  
D. Richstone (Astronomy)  
B. Roe (Physics)  
N. Rosenberg (Human Genetics, Biostatistics & Ecology/Evolutionary Biology)  
L. Sander (Physics)  
R. Savit (Physics)  
D. Scheeres (Aerospace Engineering)  
C. Simon (CSCS)  
P. Smereka (Mathematics)  
J. Smoller (Mathematics)  
R. Spatzier (Mathematics)  
G. Tarle (Physics)  
A. Tkachenko (Physics)  
Y. Tomozawa (Physics)  
A. Uribe (Mathematics)  
J. Vandermeer (Biology)  
M. Veltman (Physics)  
J. Wells (Physics)  
D. Williams (Physics)  
J. Wilson (Philosophy)  
H. Winful (Electrical Engineering)  
P. Woolf (Engineering)  
A. Wu (Physics)  
E. Yao (Physics)  
R. Ziff (Chemical Engineering)  
M. Zochowski (Physics)

**9.9 Associate membership list**

K. Augustyn (General Dynamics Advanced Information Systems)  
J. Bernstein (Astronomy)  
T. Bersano-Begey (Physics)  
B. Blinov (Physics)  
K. Bobkov (Physics)  
F. Bookstein (Gerontology)  
J. Bourjaily (Physics)  
M. Brehob (Electrical Engineering and Computer Sciences)  
M. Bowen (Washington University)  
A. Castro (Physics)  
J. Chapman (Physics)  
Y. Chushak (Chemistry)  
T. Cohen (Physics)  
J. Conlon (Mathematics)  
Y. Cui (Physics)  
J. Dai (University of Utah)  
L.C. Davis (Ford Motor Research)  
T. Donahue (Physics)  
R. Dupke (Astronomy)  
A. Farmany (Institute of Theoretical Physics and Mathematics IPM Tehran Iran)

G. Flynn (Pharmacy)  
R. Freeling (General Dynamics Advanced Information Services)  
H. Garcia (Computer and Information Science)  
D. Garfinkle (Oakland University)  
C. Gauthier (Physics)  
G. Ghoshal (Physics)  
E. Glass (University of Windsor)  
A. Greenspoon (Mathematical Reviews)  
C. Hayward (Physics and Astronomy)  
P. Ion (Mathematical Reviews)  
L. Ji (Mathematics)  
J. Kieffer (Materials Science and Engineering)  
T. Kamalov (Moscow State University)  
S. King (University of Southampton)  
R. Krasny (Mathematics)  
J. Krick (Astronomy)  
J. Krick (IPAC/Caltech)  
E. Kuflik (Physics)  
P. Kumar (University of California, Berkeley)  
D. Li (Physics)  
Y. Li (Physics)  
H. Lin (Physics)  
R. Lindner (History)  
S. Linic (Chemical Engineering)  
F. Marchesoni (Physics)  
D. Maxwell (Romance Languages and Literature)  
F. Mayer (Mayer Applied Research)  
B. McNaughton (Physics)  
P. McRobbie (Chemistry)  
J. Mullunchick (Materials Science and Engineering)  
D. Moehring (Physics)  
K. Mohamed (UPMS, Morocco)  
D. Morrissey (Physics)  
K. Myrie (Physics)  
B. Nord (Physics and Astrophysics)  
R. O'Connell (Physics)  
T. O'Donnell (Physics)  
D. Oros (Physics)  
S. Ovshinsky (Energy Conversion Devices)  
A. Petrov (Physics)  
N. Petrov (Mathematics)  
D. Phalen (Physics)  
C. Rangan (Physics)  
D. Reid (Eastern Michigan University)  
A. Rojo (Physics)  
M. Ross (Physics)  
M. Ryan (School of Information)  
I. Salmeen (Ford Motor Company)  
R. Stanek (Astrophysics)  
P. Smereka (Mathematics)

N. Soparkar (Electrical Engineering and Computer Sciences)

R. Stanek (Astronomy)

K. Rhornton (Physics)

S. Watson (Physics)

W. Zhou (Physics)

**9.10 Personnel**

- *Director:* Gordon Kane
- *Associate Directors:* Len Sander (Research), Jim Liu (Budget), Katie Freese (Outreach)
- *Executive Committee:* Dan Burns, L. Duan, G. Evrard, L. Pando Zayas
- *Computing committee:* J. Liu (Chair), A. Evrard
- *Diversity committee:* K. Freese (Chair), J. Krisch, L. Pando Zayas
- *Facilities committee:* A. Akhoury, P. Berman, D. Gidley, A. Milliken (Chair)
- *Secretaries:* A. Milliken, N. Wahla

### 9.11 Publications

- MCTP-06-01 Benjamin A. Burrington, James T. Liu and Leopoldo A. Pando Zayas *Heisenberg Algebras in Quiver Gauge Theories*
- MCTP-06-02 Jason Kumar, James D. Wells *M-theory as an Effective Theory of Quantum Gravity*
- MCTP-06-03 Benjamin A. Burrington, James T. Liu and Leopoldo A. Pando Zayas *Central Extensions of Finite Heisenberg Groups in Cascading Quiver Gauge Theories*
- MCTP-06-04 Leopoldo A. Pando Zayas and Norma Quiroz *From Boundary States to Gravity Solutions in 2-D String Theory*
- MCTP-06-05 Benjamin A. Burrington, James T. Liu, Manavendra N. Mahato and Leopoldo A. Pando Zayas *Finite Heisenberg Groups and Seiberg Dualities in Quiver Gauge Theories*
- MCTP-06-06 Jason Kumar, James D. Wells *Multi-Brane Recombination and Standard Model Flux Vacua*
- MCTP-06-07 Gordon L Kane, Piyush Kumar, Jing Shao *From Inclusive Signatures to String Theory?*
- MCTP-06-08 Leopoldo A. Pando Zayas and Cesar A. Terrero-Escalante *Black Holes with Varying Flux: A Numerical Approach*
- MCTP-06-09 R. Akhoury and Y.-P. Yao *Further Considerations of the Hydrogen-like Atom with Non-Commuting Coordinates*
- MCTP-06-10 James T. Liu, Manavendra Mahato and Diana Vaman *Mapping the G-structures and the supersymmetric vacua of N=4 d=5 supergravity*
- MCTP-06-11 Jason Kumar, James D. Wells *Large Hadron Collider and International Linear Collider probes of hidden-sector gauge bosons*
- MCTP-06-12 Bobby Acharya, Konstantin Bobkov, Gordon Kane, Piyush Kumar, Diana Vaman *An M theory Solution to the Hierarchy Problem*
- MCTP-06-13 Yanou Cui *Adjoint Chiral Supermultiplets and Their Phenomenology*
- MCTP-06-14 David E Morrissey, James D Wells *Holomorphic selection rules, the origin of the mu term, and thermal inflation*
- MCTP-06-15 Joshua L. Davis, Finn Larsen, Ross O'Connell, Diana Vaman *Integrable Deformations of  $\hat{c}=1$  Strings in Flux Backgrounds*
- MCTP-06-16 Chris Savage, Katherine Freese, Paolo Gondolo *Annual Modulation of Dark Matter in the Presence of Streams*
- MCTP-06-17 Brooks Thomas and Manuel Toharia *Lepton Flavor Violation and Supersymmetric Dirac Leptogenesis*
- MCTP-06-18 Alex Buchel and James T. Liu *Gauged supergravity from type IIB string theory on  $Y^{p,q}$  manifolds*
- MCTP-06-19 James D. Wells *Supersymmetry without Naturalness: Detection Prospects and Sensitivities*
- MCTP-06-20 Aaron Pierce, Jesse Thaler and Lian-Tao Wang *Disentangling Dimension Six Operators Through Di-Higgs Boson Production*
- MCTP-06-21 Willie Merrell, Leopoldo A. Pando Zayas and Diana Vaman *Gauged (2,2) Sigma Models and Generalized Kaehler Geometry*
- MCTP-06-22 Ram Brustein, Martin B. Einhorn, Amos Yarom *Entanglement and Nonunitary Evolution*
- MCTP-06-23 Christopher Savage, Katherine Freese, William H. Kinney *Natural*

- Inflation: Status after WMAP 3-year Data*
- MCTP-06-24 Katherine Freese and James T. Liu *Chain inflation with four-form fluxes in the landscape*
- MCTP-06-25 X. Liu, L. A. Pando Zayas, V. G. J. Rodgers and L. Rodriguez *A Geometric Action for the Courant Bracket*
- MCTP-06-26 Hai Lin *Instantons, supersymmetric vacua, and emergent geometries*
- MCTP-06-27 E. Golowich, S. Pakvasa, and A. Petrov, *New Physics Contributions to the Lifetime Difference in  $D0$ -anti- $D0$  Mixing*
- MCTP-06-28 J. de Boer, P. de Medeiros, S. El-Showk, A. Sinkovics, *Open  $G_2$  Strings*
- MCTP-06-29 Edward N. Glas, *Magnetovac Cylinder to Magnetovac Torus*
- MCTP-06-30 Selcuk Bayin, E.N. Glass, J.P. Krisch *Fractional Boundaries for Fluid Spheres*
- MCTP-06-31 James T. Liu and Wafic Sabra *All  $1/2$  BPS solutions of IIB supergravity with  $SO(4) \times SO(4)$  isometry*
- MCTP-06-32 Jason L. Evans, David E. Morrissey, James D. Wells *Higgs Boson Exempt No-Scale Supersymmetry and its Collider and Cosmology Implications*
- MCTP-06-33 Fred C. Adams, Gordon L. Kane, Malcolm J. Perry, Scott Watson *Inflation without Inflaton(s)*
- MCTP-06-34 Bobby Acharya, Konstantin Bobkov, Gordon Kane, and Piyush Kumar *Stabilizing the Hierarchy and Moduli in M Theory*
- MCTP-06-35 Daniel Phalen, Brooks Thomas, James D. Wells *Model Independent Description and Large Hadron Collider Implications of Suppressed Two-Photon Decay of a Light Higgs Boson*
- MCTP-06-36 James D. Wells *Weak-scale supersymmetry and the mu term*
- MCTP-06-37 Gordon L Kane, Piyush Kumar, David E Morrissey, Manuel Tohari *Connecting (Supersymmetry) LHC Measurements with High Scale Theories*
- MCTP-06-38 Adams, F. C., Proszkow, E. M., Fatuzzo, M., and Myers, P. C. *Early Evolution of Stellar Groups and Clusters: Environmental Effects on Forming Planetary Systems*
- MCTP-06-39 Adams, F. C., and Laughlin, G. *Effects of Secular Interactions in Extrasolar Planetary Systems*
- MCTP-06-40 Adams, F. C., and Laughlin, G *Long Term Evolution of Close Planets Including the Effects of Secular Interactions*
- MCTP-06-41 Adams, F. C., and Laughlin, G *Relativistic Effects in Extrasolar Planetary Systems*
- MCTP-06-42 Adams, F. C., and Bloch, A. M. *Baryonic Collapse Within Dark Matter Halos and the Formation of Gaseous Galactic Disk*
- MCTP-06-43 Fatuzzo, M., Adams, F. C., Gauvin, R., and Proszkow, E. M. *A Statistical Analysis of Earth-like Planetary Orbits in Binary Systems*
- MCTP-06-44 Fatuzzo, M., Adams, F. C., and Melia, F. *Enhanced Cosmic Ray Flux and Ionization for Star Formation in Molecular Clouds Interacting with Supernova Remnants*
- MCTP-06-45 P. Kraus and F. Larsen *Holographic Gravitational Anomalies*
- MCTP-06-46 J. L. Davis, F. Larsen, R. O'Connell, and D. Vaman *Integrable Deformations of  $c(\hat{h})=1$  Strings in Flux Backgrounds*
- MCTP-06-47 J. P. Krisch *Fractional Israel Layers*
- MCTP-06-48 S. Bayin, E. N. Glass and J. P. Krisch *Fractional Boundaries for Fluid*

*Spheres*

- MCTP-06-49 Eugene Golowich, Sandip Pakvasa, Alexey Petrov *New Physics contributions to the lifetime difference in  $D^0$ -anti- $D^0$  mixing*
- MCTP-07-01 Benjamin A. Burrington, James T. Liu and Leopoldo A. Pando Zayas *Finite Heisenberg Groups from Nonabelian Orbifold Quiver Gauge Theories*
- MCTP-07-02 Matthew Bowen, Yanou Cui, James D. Wells *Narrow Trans-TeV Higgs Bosons and  $H \rightarrow hh$  Decays: Two LHC Search Paths for a Hidden Sector Higgs Boson*
- MCTP-07-03 Yukio Tomozawa *The CMB Dipole and Circular Galaxy Distribution*
- MCTP-07-04 Alex Buchel, Stan Deakin, Patrick Kerner and James T. Liu *Thermodynamics of the  $N=2^*$  strongly coupled plasma*
- MCTP-07-05 Igor Kriz, Leopoldo A. Pando Zayas and Norma Quiroz *D-branes on Orbifolds and K-theory*
- MCTP-07-06 E.J.Chun, S. Scopel *Analysis of leptogenesis in supersymmetric triplet seesaw model*
- MCTP-07-07 E.J.Chun, K.Turzynski *Quasi-degenerate neutrinos nad leptogenesis*
- MCTP-07-08 E.J.Chun, L. Velasco-Sevilla  *$SO(10)$  unified models and soft leptogenesis*
- MCTP-07-11 Aaron Pierce and Jesse Thaler *Natural Dark Matter from an Unnatural Higgs Boson and New Colored Particles at the TeV Scale*
- MCTP-07-12 James T. Liu, H. Lu, C.N. Pope and Justin F. Vazquez-Poritz *Bubbling AdS black holes*
- MCTP-07-13 James T. Liu, H. Lu, C.N. Pope and Justin F. Vazquez-Poritz *New supersymmetric solutions of  $N=2$ ,  $D=5$  gauged supergravity with hyperscalars*
- MCTP-07-15 B. Chen, S. Cremonini, A. Donos, F.-L. Lin, H. Lin, J.T. Liu, D. Vaman, W.-Y. Wen *Bubbling AdS and droplet descriptions of BPS geometries in IIB supergravity*
- MCTP-07-16 Daniel J. Phalen and Aaron Pierce *Sfermion Interference in Neutralino Decays at the LHC*
- MCTP-07-17 C.A. Ballon Bayona, H. Boschi-Filho, N.R.F. Braga and L.A. Pando Zayas *On a Holographic Model for Confinement/Deconfinement*
- MCTP-07-18 Eung Jin Chun, Stefano Scopel *Quintessential Kination and Leptogenesis*
- MCTP-07-19 Willie Merrell and Diana Vaman *T-duality, quotients and generalized Kahler geometry*
- MCTP-07-20 Jason Kumar, Arvind Rajaraman, James D. Wells *Probing the Green-Schwarz Mechanism at the Large Hadron Collider*
- MCTP-07-23 Manavendra Mahato, Leopoldo A. Pando Zayas and César A. Terrero-Escalante *Black Holes in Cascading Theories: Confinement/Deconfinement Transition and other Thermal Properties*
- MCTP-07-24 M. R. Becker, T.A. McKay, B. Koester, R. H. Wechsler, E. Rozo, A. Evrard, D. Johnston, E. Sheldon, J. Annis, E. Lau, R. Nichol, C. Miller *The Mean and Scatter of the Velocity Dispersion-Optical Richness Relation for maxBCG Galaxy Clusters*
- MCTP-07-25 A. M. Stein and L. M. Sander *Estimating the Cell Density and Invasive Radius of 3d Glioblastoma Tumor Spheroids Grown in Vitro*
- MCTP-07-26 A.M. Stein, D.A. Vader, T.S. Deisboeck, E.A. Chiocca, L.M. Sander, and D. Weitz *Directionality of Glioblastoma Invasion in a 3d in Vitro*



*Experiment*

- MCTP-07-27 James D. Wells *Status of the Standard Model: Lectures at the Particle Physics, Cosmology and Strings Summer School at Perimeter Institute*
- MCTP-07-28 Yanou Cui, Stephen P. Martin, David E. Morrissey, James D. Wells *Cosmic Strings from Supersymmetric Flat Directions*
- MCTP-07-29 Michael Gerbush, Ten Jian Khoo, Daniel J. Phalen, Aaron Pierce, David Tucker-Smith *Color-Octet Scalars at the LHC0*
- MCTP-07-30 A. Faraggi, L. A. Pando Zayas and C. Terrero-Escalante *Holographic Entanglement Entropy and Phase Transitions at Finite Temperature*
- MCTP-07-31 Cedric Delaunay, Christophe Grojean, James D. Wells *Dynamics of Non-renormalizable Electroweak Symmetry Breaking*
- MCTP-07-32 C. Savage, K. Freese, P. Gondolo *Annual modulation of dark matter in the presence of streams*
- MCTP-07-33 Douglas Spolyar, Katherine Freese, Paolo Gondolo *Dark matter and the first stars: a new phase of stellar evolution*
- MCTP-07-34 Cosimo Bambi, A.D. Dolgov, K. Freese *Baryogenesis from Gravitational Decay of TeV-Particles in Theories with Low Scale Gravity*
- MCTP-07-35 Cosimo Bambi, A.D. Dolgov, K. Freese *A Black Hole Conjecture and Rare Decays in Theories with Low Scale Gravity*
- MCTP-07-36 Quintana, E. V., Adams, F. C., Lissauer, J. J., and Chambers, J. E. *Terrestrial Planet Formation around Individual Stars within Wide Binary Star Systems*
- MCTP-07-37 Thomas-Osip, J., McWilliam, A., Phillips, M. M., Morell, N., Thompson, I., Folkers, T., Adams, F. C., and Lopez-Morales, M. *Calibration of the Relationship between Precipitable Water Vapor and 225 GHz Atmospheric Opacity*
- MCTP-07-38 Busha, M. T., Evrard, A. E., and Adams, F. C. *Asymptotic Form of Cosmic Structure: Small Scale Power and Accretion History*
- MCTP-07-39 Moorhead, A. V., and Adams, F. C. *Eccentricity Evolution of Giant Planet Orbits Due to Circumstellar Disk Torques*
- MCTP-07-40 Watson, S., Perry, M. J., Kane, G. L., and Adams, F. C. *Inflation without Inflaton(s)*
- MCTP-07-41 Adams, F. C., Bloch, A. M., Butler, S. C., Druce, J. M., and Ketchum, J. A. *Orbital Instabilities in a Triaxial Cusp Potential*
- MCTP-07-42 S.Cremonini, R. de Mello Koch, A. Jevicki *Matrix Model Maps and Reconstruction of AdS SUGRA Interactions*
- MCTP-07-43 Adams, F. C., and Shu, F. H. *Ambipolar Diffusion in Molecular Cloud Cores and the Gravomagneto Catastrophe*
- MCTP-07-44 Jeroen S. van Zon, David Lubensky, Pim R.H. Altena, Pieter ten Wolde *An allosteric model of circadian KaiC phosphorylation*
- MCTP-07-45 David K. Lubensky *Equilibrium-like behavior in far-from-equilibrium chemical reaction networks*
- MCTP-07-46 A.O. Sboychakov, S. Savel'ev, A.L. Rakhmanov, F. Nori *Why macroscopic quantum tunnelling in Josephson junctions differs from tunnelling of a quantum particle*
- MCTP-07-47 Shrihari Gopalakrishna, Sunghoon Jung, James D. Wells *Higgs boson decays to four fermions through a broken abelian hidden sector*
- MCTP-07-48 S.J. Bending, D. Cole, S. Savel'ev, F. Nori, T. Tamegai *Ratchet without spatial asymmetry: Controlling the motion of magnetic flux*

- quanta using time-asymmetric drives*
- MCTP-07-49 V.A. Yampol'skii, A.V. Kats, M.L. Nesterov, A.Yu. Nikitin, T.M. Slipchenko, S. Savel'ev, F. Nori *Excitation of surface Josephson plasma waves in layered superconductors*
- MCTP-07-50 A.Yu. Smirnov, L.G. Mourokh, F. Nori *Forster mechanism of electron-driven proton pump*
- MCTP-07-51 James D. Wells *How to find a Hidden World at the Large Hadron Collider*
- MCTP-07-52 E.G. Galkina, B.A. Ivanov, S. Savel'ev, F. Nori *Chirality tunneling and quantum dynamics for domain walls in mesoscopic ferromagnets*
- MCTP-07-53 V.A. Yampol'skii, S. Savel'ev, Z.A. Mayselis, S.S. Apostolov, F. Nori *Anomalous temperature dependence of the Casimir force for thin metal films*
- MCTP-07-54 V.A. Yampol'skii, S. Savel'ev, F. Nori *Voltage-driven quantum oscillations in graphene*
- MCTP-07-55 S.N. Shevchenko, A.N. Omelyanchouk, A.M. Zagoskin, S. Savel'ev, F. Nori *Distinguishing quantum from classical Rabi oscillations in a phase qubit*
- MCTP-07-56 A.Yu. Smirnov, S. Savel'ev, L.G. Mourokh, F. Nori *Unidirectional rotary nanomotors powered by an electrochemical potential gradient*
- MCTP-07-57 S. Ooi, S. Savel'ev, M.B. Gaifullin, T. Mochiku, K. Hirata, F. Nori *Nonlinear nanodevices using magnetic flux quanta*
- MCTP-07-58 M. Grajcar, S. Ashhab, J.R. Johansson, F. Nori *Lower limit on the achievable temperature in resonator-based sideband cooling*
- MCTP-07-59 A.N. Omelyanchouk, S.N. Shevchenko, A.M. Zagoskin, E. Il'ichev, F. Nori *Pseudo-Rabi oscillations in superconducting flux qubits in the classical regime*
- MCTP-07-60 A.O. Sboyshakov, S. Savel'ev, A.L. Rakhmanov, K.I. Kugel, F. Nori *A mechanism for phase separation in copper oxide superconductors*
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