PROPOSAL FOR ESTABLISHING A CENTER FOR THEORETICAL PHYSICS AT THE UNIVERSITY OF MICHIGAN

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1 Purpose

It is proposed to establish a multi-disciplinary Center for Theoretical Physics within the Physics Department at the University of Michigan. Michigan has a long tradition of excellence in Physics and the main purpose of such a Center would be to build on its current strengths and recover the pre-eminence that it enjoyed in earlier times. The Department ranks 13 nationally and is poised to move even higher, but this will require the extra resources in theoretical physics that other top research universities are currently investing. Without the need for expensive apparatus, theory is a very cost-effective way of contributing to the prestige of the University.

The Physics Department 5-year plan calls both for an increased emphasis on theory in the Physics Department and a breaking down of barriers between the various sub-disciplines. The ideal way to achieve these ends is to put all the theorists (high energy, astrophysics and cosmology, condensed matter, complex systems, atomic and biophysics) under the same umbrella and, ideally, in the same location. The emphasis of the proposed Center would thus be interdisciplinary, with the aim to make it more than the sum of its parts. Theoretical Physics is particularly suited to such a collective venture; it is a highly collaborative enterprise, publications are almost always multi-authored and physicists of all stripes share a common world view and intellectual discourse. The intention is also to include other departments within the University and to explore non-traditional applications.

Theorists have needs and aspirations that cut across these various fields of interest. Such a center would also give them a collective voice in the department that would complement the other established programs of Applied Physics, Ultrafast Optics, Complex Systems and the Biophysics initiative.

The creation of a Center for Theoretical Physics at the University of Michigan represents an important investment in the future of the Department. By attracting the best international scholars to participate in workshops and conferences, the Center will serve as a continuous stimulus to theoretical research activities at the University. Once the reputation of the program is established, it will help us to recruit the highest caliber faculty, postdocs, and graduate students. The increased visibility of the theoretical physics program at the University of Michigan should increase the prospects for external funding.

The award of the 1999 Nobel Prize to Michigan theoretical physicist Martinus Veltman
provides the ideal timing to launch such an initiative. The hosting of the forthcoming Strings 2000 international conference \(^1\) on the Michigan campus next July will also be an opportunity to focus attention on the strength of theoretical physics in the department.

## 2 Interdisciplinary scientific program

A main thrust of the Center’s activities would be a vigorous visitor and conference program consisting of visits by individual leading theoreticians, visits by collaborators of the current faculty, one large conference per year (~1 week long and 50 participants) and two medium-term workshops (2–3 months long and 10–20 participants). The lifeblood of any physics research program is provided by the younger physicists and the Center intends to support 2 postdocs and 3 graduate students (to be chosen worldwide). Summer salary will also be provided to two students to carry out undergraduate research projects.

The center we propose is a natural venue for encouraging interdisciplinary work because the methods and point of view of theoretical physics have influenced many scientific disciplines ranging from mathematics to economics. We hope to devote some substantial fraction of the workshops that we will organize to subjects that cut across boundaries of University departments. This would have the added benefit that many scientists on our own campus would be natural members in these programs. This would leverage the strength of the University in attracting prominent outside participants, and would open up our department to closer links with the rest of the campus. With a view to enhancing the public understanding of science in general, the Center would host public lectures by leading scientists intended for the University as a whole and the Ann Arbor community.

A few examples of the kinds of work we have in mind and the likely areas of overlap are: 1) The study of turbulence and fractal dynamics (Engineering, Mathematics, Physics); 2) Statistical physics, polymer physics, complex fluids, biocomplexity and the mechanics of biological materials (Chemistry, Engineering, Physics, Biological Sciences, Medical Sciences, Physics); 3) Complex adaptive systems (Social Sciences, Physics); 4) Superstring Theory and M-theory, differential geometry and topology (Mathematics, Physics); 5) Particle Physics and astrophysics (Astronomy, Mathematics, Space Sciences, Physics); 6) General aspects of quantum field theory (Mathematics, Physics); 7) Quantum information and quantum

\(^1\)http://feynman.physics.lsa.umich.edu/strings2000/
3 Administration

The administration will consist of a Director and a 4-person Executive Committee. They will produce an annual report. The Director will be appointed for a 4-year term and will teach half-time (the time commitment of the Director is expected to be comparable to that of an Associate Chair in Physics or to the Director of other research centers on campus). In contrast to many other comparable centers, all other members of the Center will continue their full teaching duties. However, the Center’s mission would be greatly enhanced by an increase in the number of 600 level research-oriented advanced courses in theoretical physics. Ideally, the topics taught would be correlated with the current themes of the Center’s program. In addition, there will be an External Advisory Committee made up of internationally renowned senior theoretical physicists. An external review of the Center’s progress should be carried out every three years.

The staff requirements are one senior secretary/administrative assistant and one computer manager. In terms of space needs, the Center will be housed within the Physics Department; it requires the appropriate reallocation of present office space (about 10-15 offices or the equivalent).

Membership and participation in the Center is open to all members of the Physics faculty, postdocs, and graduate students involved in theoretical physics research. These numbers currently stand at 18 faculty, 7 postdocs, and 16 graduate students. Members will have access to the Center’s resources and faculty members will have a voice in its governance. Participation by and interaction with our experimental colleagues will, of course, be welcomed and encouraged. It is our hope and expectation that members of other departments at the University of Michigan will actively participate once the Center becomes established.

4 Computing needs

In order to bring researchers together and foster collaborations that might not otherwise occur, a unified computing environment is essential, including both basic communications
resources (such as email, word processing, internet access) and substantial computational ability.

The computing needs can be placed within three broad classes: 1) Hardware: 4 Pentium PCs ($12K), 1 workstation ($10K), printers etc ($5K); 2) Software: ($5K); 3) Staff support: ($35K). The Physics Department presently maintains an Office of Computing Support; an additional 0.5 full time equivalent (FTE) position must be added to this computing office and will be officially designated for support of the Center’s computers and other needs.

5 Budget

Personnel: 2 postdoctoral students ($50K each, including standard benefits), 3 graduate students at 0.5 time ($80K); 2 undergraduate summer salaries ($6K); senior visitors ($80K), 1 secretary ($40K), director administrative differential ($5K), computer staff at 0.5 time ($35K).

Activities: 2 medium-term workshops of 2-3 months ($75); 1 major conference ($25K)

Telephone and supplies: ($4K)

We have not included the cost of new faculty hires in theoretical physics since these are, in any case, part of the Department’s five year plan.

This brings the total to $450K annually. This proposal asks the University to contribute $425K per year, the remaining $25K to be supplied by the Physics Department to fund the major conference. The Physics Department will also contribute $60K in the first year for computer hardware and for Director release time.

The Center will also be seeking outside funding from federal funding agencies.

6 Comparisons with similar theory institutes

Well-established centers for Theoretical Physics include the Institute for Theoretical Physics, UCSB, which is broadly based ($700K per year from the University) and the C. N. Yang Institute for Theoretical Physics SUNY Stony Brook, which is predominantly high energy physics, ($400K per year from the University). Recently, however, theoretical physics has witnessed exciting breakthroughs on several different fronts which many of the top universities have
recognized with increased funding. Some more recent initiatives include the University of Minnesota Theory Institute, Rutgers High Energy Theory Institute, San Diego Institute for Nonlinear Sciences, the Isaac Newton Institute for Mathematical Sciences, Cambridge, UK, the Center for Advanced Mathematical Sciences, American University of Beirut, Lebanon, and the Center for Theoretical Astrophysics, University of Toronto. Just in the last year, Stanford, Berkeley and Caltech/USC have each started theory initiatives of roughly the same order envisioned for Michigan (about $500K per year).

7 Impact Summary

Research

This proposed Center for Theoretical Physics is expected to have a substantial positive impact on the Physics Department and on the University of Michigan as a whole. First and foremost, the Center will facilitate research in theoretical physics at the University of Michigan; we plan to extend and improve upon Michigan’s long tradition of excellence in physics and science in general, and make the Physics Department and the LS&A greater than the sum of its parts.

Links outside physics

The Center will also establish a platform for interdisciplinary research and will provide opportunities for collaboration that would not otherwise exist; this synergy cannot be overemphasized. With the activities described in section 2, links will be established to the Departments of Mathematics, Astronomy, Chemistry, Computing, Engineering, Space Sciences, Biological Sciences and Social Sciences.

Although there is a long tradition of overlap between theoretical physics and applied mathematics, the last several years have witnessed dramatic and somewhat unexpected collaborations between theoretical physicists and pure mathematicians (so much so that physicists are even winning Fields Medals!). This is due, in large part, to the realization that superstring theory, and its successor M-theory, require abstract concepts from algebraic topology and differential geometry. This has been a two-way process with pure mathematicians frequently drawing their inspiration from string theory and quantum field theory. Preliminary contacts with our colleagues in Mathematics (Al Taylor, Paul Federbush, Daniel Burns, Joel Smoller,
Igor Dolgachev, Alejandro Uribe) have elicited an enthusiastic response.
Graduate education

In addition to providing a stimulating environment for physics graduate students to learn and carry out their research, and in addition to the funding of 3 extra graduate students, it is intended that there be an increase in the number of 600 level research-oriented advanced courses in theoretical physics; the topics taught to be correlated with the current themes of the Center’s program.

Undergraduate education

In several areas of theoretical physics, for example condensed matter and statistical physics, undergraduates routinely participate in research projects. The Center intends to fund two students summer salaries for this purpose. The interdisciplinary nature of the Center will further contribute to the success of the growing number of courses for non-physics-majors. For example, theoretical investigations into the far future of the universe has already led to a new course (now Physics 105) that uses the results of original research to teach the fundamentals of physics to a general student audience.

Visibility

Because of the high profile nature of theoretical physics, our successes in this area will greatly increase the stature and visibility of the Department and the University; this boost, in turn, will be invaluable in future recruiting of faculty, graduate students, and postdoctoral fellows. Finally, the Center will provide a showcase for the theoretical research done here at Michigan, both to the physics community (through conferences, workshops, and visitor programs) and to the general public (through public lectures and other outreach activities).