Physics and Astronomy Academic Program Review: Report of the Review Committee

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March 16, 2005

I. Introduction

The Arizona State University is experiencing remarkable growth in undergraduate and graduate enrollment and in the quality of its academic programs. This growth is being driven by several factors, including rapid sustained expansion of the Phoenix metropolitan area.

A policy paper prepared by the president of ASU, Dr. Michael M. Crow, describes the forces driving growth of ASU and presents discussions of the design imperatives which form the template for managing the anticipated rapid growth and obtaining the required resources, while at the same time seeking to raise the standards of education and research. The goal is to have ASU emerge as the "leading public metropolitan research university in the United States."

As part of the managed growth process, and following the tradition of periodic evaluations needed to assess quality, the departments and colleges of ASU are now engaged in extensive exercises in self-evaluation and strategic planning. They are facing a broad range of tactical decisions aimed at achieving the important goal of expanding both the size and quality of the university.

The Physics and Astronomy Academic Program Review Committee has been asked to evaluate the ASU Department of Physics and Astronomy based on guidelines stated in the Policies and Procedures document covering Academic Program Reviews provided by the Division of Graduate Studies. The Review Committee was also asked by the Office of the Executive Vice President and Provost to address specifically the following points:

- Peer institutions and peers which share ASU's aspirations
- Quality of students/quality of student experience
- Curricular strengths/opportunities
- Opportunities for development/strategic growth (specifically in relation to inter-disciplinary initiatives/funding)
- Faculty quality.

Several documents were provided to assist the Review Committee in preparing their assessment.

Prior to the visit:

1) Department of Physics and Astronomy Academic Review (1997-2003)
2) Initial Study Report (Jan. 2005) *Building a 21st Century Physics Department*
3) Initial Conceptualization – The School of Earth and Space Exploration at ASU (Dec. 2004)
4) Policy Paper, Michael M. Crow, "A New American University."

During and after the on-site visit the Review Committee requested and was promptly given copies of selected slides and other data which were presented by the various units: Astronomy, Biophysics, Nuclear/High Energy, Condensed Matter, and Physics Education. The Review Committee was extremely impressed by the depth and quality of the materials (self-evaluation and planning documents), as well as the interest, intensity, enthusiasm and

commitment at all levels (from group members, group leaders, department chair, dean's office, to vice-president) aimed at improving the quality of the educational and research environment at ASU.

This committee, in reviewing the physics and astronomy programs at ASU, was privileged to witness a number of areas of existing and emerging scientific excellence, such as the outstanding research programs in biological physics, material science, and astrophysics. The new Bio-Design Institute facility at ASU is a state-of-the-art research facility providing a leading center for research and education, much of it at the interface of biology and physics. ASU has a world-class program in space science and planetary exploration. Its material science program excels in many fundamental research areas; much of it due to ASU's pioneering electron microscopy programs. A document provided to this committee entitled "Academic Review 1997-2003," conducted by the ASU Department of Physics and Astronomy, is a fine self-assessment of the existing department strengths and the current status of its instructional and research resources.

II. Overview of Findings

The Review Committee was favorably impressed by the achievements of the ASU Physics and Astronomy Department over the past seven years, as well as the strategic plans for expanding the size of the department with a focus on improving the quality of education and research. As recently as ten years ago, the ASU Department of Physics and Astronomy was known primarily for its strengths in astronomy and the Electron Microscopy Center. The reputation of both of these units has continued to grow, achieving strong national and international reputations, and new areas of scientific excellence have emerged in biological physics, materials/condensed matter physics, and astrophysics. The Department of Physics and Astronomy Initial Study Report has set an ambitious goal for the department: to "move the department to the top 20 in the country, increase annual external research funding from $7 million to $15 million, and strengthen the research capabilities of the entire university."

The projected expansion of ASU to a campus of 50,000 students, and the existence of an engineering school at ASU presents a very large service course load in basic science education, and it justifies the Department of Physics and Astronomy having 60-70 full-time-equivalent faculty. (For comparison: UT Austin with a total enrollment of 50,000 students currently has 56 physics faculty and 20 astronomy faculty). This projected growth will place the ASU Department of Physics and Astronomy near the top in ranking according to size of faculty.

In order that the Department of Physics and Astronomy reap the benefits of the expected rapid expansion of its faculty, it is imperative that the highest priority be assigned to the quality of new faculty added to the department. The department is aware of this imperative and it is keenly aware of the NRC95 ASU Department of Physics and Astronomy rankings for ASU: faculty size – 31, PhD production – 40, faculty quality – 69, and overall rank – 69/146. These rankings do matter: they strongly influence the quality of graduate student applicants and the rankings of interdisciplinary programs supported by the component departments.

The ASU Physics and Astronomy Department has now established strong nationally competitive programs in a critical number of traditional (astronomy/condensed matter) and evolving (biophysics/physics education) subfields, and it has plans for strengthening multidisciplinary research in materials science, nanometer scale science and engineering, and earth/space exploration. If the projected growth in department size can be achieved, while also improving the overall quality of faculty, the department and university would benefit from an impressive improvement in the department ranking. That said, the remainder of this Report, which follows the Guidelines for Preparing the Site Visit Report, will address both

strengths and weaknesses, as perceived by the Review Committee, in the current department operation and in the strategic plan.

III. Specific Response to the Site Visit Report Questions.

1. Mission and Goals – The mission and goals of the Department of Physics and Astronomy are clearly stated and explained in the Initial Study Report. The goals are ambitious (top 20 rank), but we believe they are attainable based on the projected expansion of faculty -- provided sufficient resources are made available and also provided that strong effective department-level leadership is in place during the rapid growth. The four core areas selected for framing the department's growth represent good judgments – they cover existing strengths, interface well with imperatives outlined in the president's policy paper, and are engineered around the reality of interdisciplinary research and education. These core areas also encompass the broad foundation of traditional scientific disciplines that must be components of a strong physics and astronomy department.

   While the department's strategic plan is judged to be sound, the Review Committee has strong reservations regarding some of the tactical decisions which are being made to achieve the goal of encouraging interdisciplinary research and education. These concerns are described in the following subsections. The Review Committee believes that the degree of success realized in achieving the proposed goals will depend primarily on the additional resources which are made available and on strong and effective leadership at the departmental level; this requires a highly respected department chairman who recognizes excellence, and who can work with senior department faculty representing core areas and with center directors.

   The Review Committee sensed a division between physics and astronomy, which, if allowed to continue would result in the astronomy group realigning itself primarily with the Geology Department. This would vastly reduce the prospects of solving current problems in the department and in achieving the objective of significantly improved national ranking in the next decade.

2. Strategic Initiatives and Future Direction - The documents provided to the Review Committee and presentations during the site visit described several innovative initiatives and innovative programs involving the department. This subsection provides comments on the strengths of the four core areas and the initiatives involving the creation or reorganization of interdisciplinary organized research units.

   Core Area #1. Complexity and Emergent Phenomena: This Core Area consists of five physics faculty working in the general area of biophysics. The Review Committee was extremely impressed by the presentation of this group which documented existing, high-quality science, good funding, and a comprehensive plan for expanding the impact of the program. The new Bio-Design Institute Facility was judged as an impressive institutional commitment to the newly evolving strength in this core area.

   The biophysics program at ASU emphasizes the ties of biology with advances in physics, including large-scale computation, new theories for the dynamics of complex systems, and new instruments. Much of the work of this group is collaborative, with strong links with other faculty working in condensed matter physics and electron transfer physics. These remarkable collaborative efforts serve as excellent models for interdisciplinary research at ASU.

One area of concern: we believe that the physics faculty itself, rather than a global university committee, should be the judge of progress toward tenure at ASU, and the senior department faculty should counsel the untenured faculty.

Core Area #2. Origins and Structure of the Universe: This Core Area covers several traditional subfields of physics, including Subatomic Physics (both theoretical and experimental programs), and Astronomy/Astrophysics. Most of the research and teaching activities associated with these subfields are not found in any engineering programs or basic science departments aside from physics – the experimental and theoretical techniques are unique to physics/astronomy departments and are therefore extremely important from the standpoint of creating a strong academic unit. ASU has a small but active research groups in particle theory and experiment, and a very strong astronomy astrophysics group as outlined below:

- **Experimental Subatomic Physics**
  Subatomic physics is a core area of physics research encompassing high energy physics, nuclear physics, and fundamental theories and phenomena underlying the evolution of the early universe, cosmology, and astrophysics. The ASU experimental groups have viable experimental programs, which are carried out at large, advanced facilities throughout the world. These include the Bates Linear Accelerator Center (MIT/BATES), the Thomas Jefferson Laboratory (CEBAF), the Paul Scherrer Institute (PSI) in Switzerland, and Brookhaven National Laboratory.

  ASU experimentalists have been conducting important research in their respective fields. However, these experimental programs are nearing completion, and several of the faculty researchers are approaching retirement. Although this causes concern, the upcoming transitions will offer several opportunities at ASU for new experimental faculty and new highly topical research programs; possible new directions are the new antiproton facility at GSI, Darmstadt, and the Large Hadron Collider now under construction at CERN. Additional long term planning is required in this area.

- **Theoretical Subatomic Physics**
  The subatomic theoretical group at ASU is a central element of the ASU Department of Physics and Astronomy. The theorists teach and counsel ASU graduate students, support the ASU experimental programs, and undertake research over a broad range of nuclear and particle physics topics.

  The theory group could have an important positive impact on the astronomy/astrophysics program at ASU, depending on hiring strategies adopted by these groups. The Review Committee was impressed by the recent addition to the ASU physics faculty of a top-ranked young theorist working in the field of quantum chromodynamics, the fundamental theory of underlying hadron and nuclear physics. This small theory group can provide the base for an outstanding theoretical physics faculty at ASU. We endorse the physics department's plan for expansion in theoretical high energy physics, particularly in the area of high energy physics phenomenology. The maximum benefit to the department and university will be achieved if a strong connection to astronomy/astrophysics can be established.

  The present theoretical physics group (two faculty members) is too small to be considered robust. It is therefore extremely important to encourage travel for collaborative work, conferences, and workshops, to support one or more

research associates, and to provide a supportive environment that encourages interactions with the particle experimentalists and with astronomy/astrophysics.

- **Astrophysics at ASU**
  The research program in Astronomy and Planetary Science at ASU is world-class, ranging from observational astronomy and theoretical astrophysics, including the solar system, the structure and physics of the interstellar medium, novae and cataclysmic variables, compact objects, galactic structure, and cosmology. ASU astronomers continue to be intimately involved in the Hubble Space Telescope (HST) project, and current research programs involve heavy use of both the HST and the Chandra X-ray Observatory. ASU's program offers many significant opportunities for graduate students, including research and course work in stellar physics and interstellar medium, galactic and extragalactic astronomy, cosmology, and observational techniques.

  The astronomy group consists of ten full-time faculty members plus two academic professionals, seven affiliated faculty, and postdoctoral fellows. ASU's astronomers enjoy national and international prominence for their work, and are involved in collaborations with researchers around the world.

  Despite this highly successful core program of physics research, there are strong tensions between the physics and astronomy faculties, due to the lack of expansion of the ASU astronomy program this past decade. The document entitled "Volume 1: Initial Conceptualization submitted by the SESE Steering Committee, December 2004" describes the formation of a new academic unit, "School of Earth and Space Exploration (SESE)" at ASU, which would remove the leading astronomy faculty from the physics department. The Review Committee believes that such a separation of the astronomy and physics faculties would be very detrimental to ASU, and would have devastating affects on the Department of Physics and Astronomy mission and ranking, which would also affect rankings of interdisciplinary institutes supported by the physics department. Graduate students working with astronomy faculty placed high value on their "Physics PhD Degree," and an opinion poll (during the site review) of the astronomy graduate students revealed that their research was judged much more closely related to work by members of the theory group, for example, than by work in geology. Transferring faculty lines and research support from the Physics and Astronomy Department to Geology/SESE will do far more damage to the Physics and Astronomy Department ranking than could be compensated by possible gains in the ranking of SESE as either an astronomy program or a geology program.

  This committee believes all of the objectives of forming SESE could be achieved through the alternative concept of an "Institute of Earth and Space Exploration" at ASU. This would be an exciting interdisciplinary research institute in which all of the faculty members hold faculty positions in either the physics or geology department. This committee believes that most ASU astronomers would want to retain their affiliation with ASU physics, provided there are guarantees for timely growth of the astronomy group within the Physics and Astronomy Department. The Review Committee believes that students should be admitted through existing departments to the new Institute rather than creating a new admission program.

Core Area #3. Quantum States of Matter: This Core Area is primarily composed of the condensed matter physics group, including the microscopy center with some overlap with the biophysics group. Plans for integrating physics faculty in this Core Area with other faculty on campus involve a the proposed School of Materials, Nanoscience Institute,

Center for Nanoelectronics, Bio-Design Institute, and other organized research units. The department hiring plan for this Core Area is framed around four subdivisions: Nanophysics, Materials Physics, Geophysics, and Sustaining Technology.

Material Science is particularly strong at ASU, with leading research in a broad area of experimental areas. The large condensed matter and materials physics group at ASU has several focus areas: electron microscopy, imaging and analysis, optical studies, including laser spectroscopy and magnetic resonance; surface science, including scanning probe microscopy, and low energy electron microscopy (LEEM). The Review Committee notes a recent major award, the Davisson and Germer Prize of the American Physical Society, for development of the LEEM. These techniques and their developments are being applied to a wide variety of materials physics problems, including thin film growth, and electronic, magnetic, optical chemical, and biological applications. Theoretical work is strong in support of all of the above programs, and is pursued competitively for its own sake. Much of this work is directly relevant to advances in semiconductor technology and nanotechnology. The material science programs at ASU benefit from the presence of advanced research tools such as the ASU ion-scattering facility and its electron microscopes.

By its very nature, material science research and education is multidisciplinary, drawing much of its strength from core disciplines such as physics and chemistry. Thus this field can only flourish in an environment with vital traditional science research departments.

The proposed changes in the materials science programs and the creation of new multidisciplinary institutes could have either positive or negative impact on the Physics and Astronomy Department.

There is a clear need to reorganize and consolidate the materials programs at ASU; also, since nanoscience/nanotechnology represents a significantly different combination of core disciplines (with strong biological science components), it is reasonable to form a second organized research unit around nanoscience/nanotechnology.

Merging the two existing academic programs in materials science (SEM and CME) into a single undergraduate academic program seems reasonable. Many universities have undergraduate materials science programs that have evolved from mechanical engineering and metallurgy departments.

Setting up a broad graduate school in materials will be very difficult, especially along the lines suggested by Fig. 1 in the document entitled “Proposal for Forming a School of Materials.” It might be wise to first organize the graduate materials science program as an institute with a director and technical support staff, but with no tenured faculty lines. This organization strategy would retain maximum flexibility within academic departments as well as supporting a hiring strategy which maximizes the strength of the department by emphasizing the quality of candidates rather than the boxes they can fill in an organizational chart that requires joint appointments.

Two groups in the Department of Physics and Astronomy can offer immediate strength and resources to a materials institute: the ion scattering group and the electron microscopy group. Ion scattering and electron microscopy are important analytical techniques used in materials characterization, and these facilities, supported through a materials institute structure, could help form the basis for a viable materials research institute.

The Review Committee strongly advises the ASU administration to consider the organized research unit structure model for interdisciplinary research and education at the graduate level. This recommendation applies to both the planned school SESE and the

School of Materials. Under this model, graduate students would be recruited and admitted through existing departments.

A model for such Institutes at ASU is the new Kavli Institute for Particle Astrophysics and Cosmology at Stanford University. Kavli Institutes in several areas of science have been funded throughout the United States through generous gifts by Fred Kavli and the Kavli Foundation. The KIPAC faculty will all have faculty positions in the High Energy Physics Department at the Stanford Linear Accelerator Center and/or the Varian Physics Department. Such an arrangement maximizes the strong links among the research faculties.

It is possible for a university to have a poorly-ranked materials science program while having very strong traditional departments in physics, chemistry, electrical engineering, etc., because of the absence of a well-conceived structure designed to foster interdepartmental and interdisciplinary research. (UT Austin was an example of this, and much effort has been devoted to correcting this problem during the past five years.)

The converse is not true. It will be impossible to build a truly outstanding materials science program without building equally strong programs in the principal academic departments. The ranking of the materials science program at ASU will not depart significantly from the average of the rankings of the most important departments, which include physics, chemistry, electrical engineering, and chemical engineering.

The best strategy for creating a strong, effective, and highly-ranked materials science program at ASU is to provide the resources and hiring flexibility to the supporting academic departments, allowing each department to achieve the highest degree of improvement possible within the resources available. Equally important will be to provide organizational units (centers, institutes with directors and support staff) to foster interactions between individual faculty and subgroups within the academic departments.

Core Area #4. Physical Sciences in Society: This Core Area offers a variety of proposed outreach activities designed to promote wider public appreciation of the benefits of science.

One of the important ways that ASU is currently elevating science education in Arizona is its unique Master of Natural Science (MNS) program for in-service teachers. There appears to be no comparable program at any other university in the United States, and it stands as an exemplary model of how physics departments can improve high school physics education. Unfortunately, this program is threatened with termination by the end of the NSF grant which supported teachers during their course period at ASU. The Review Committee believes that it is essential for ASU to continue this invaluable program, perhaps with a grant from a corporate source, a private foundation, or through direct state support. The university's development office should assist with this goal.

3. Learning Objectives and Curricular Effectiveness - The field of physics provides the fundamental understanding and theories underlying and linking virtually all areas of research and technology studied at ASU. An intensive education in physics is critical to a student's progress in virtually all areas in science. However, the Review Committee observed a number of troubling problems limiting physics education at ASU:

    (1) There appears to be an acute problem in dealing with the large and growing enrollment in introductory and service courses. The astronomers assert that AST 111 could attract nearly 1000 students if adequate TA support and faculty were available. PHY 101 enrollment is limited due to limited TA, lecture, and laboratory resources. Undergraduate students are being used as service course TAs.

(2) The number of physics faculty is too small to provide a first class physics education. This is exemplified by the fact that some critical graduate courses, including quantum field theory, are being taught by retired faculty as unpaid volunteers. The problem will be accentuated by upcoming retirements of a number of current physics faculty. This committee strongly endorses the physics department's plans for expansion. We believe that a core Physics and Astronomy faculty of approximately 60 members would be an appropriate goal.

(3) The undergraduate curriculum was revamped in the years since 1994, and the graduate curriculum was restructured in 2003. Despite this, this committee believes that the range of undergraduate and graduate courses offered in physics and technology is still too limited. Graduate level courses in biological physics are rarely taught, despite the concentration of ASU research in these areas.

(4) Required undergraduate physics courses are taught only once a year in rooms too small to accommodate all of the physics majors. This has led to students having to take an otherwise unnecessary fifth year of undergraduate studies.

(5) The undergraduate physics program needs to be enriched beyond the standard curriculum. The ASU enrollment is large enough to consider honors courses in physics and astronomy. An excellent suggestion, requested by the undergraduate physics majors, is to have a special course devoted to advanced computer and computational methods for science. The proposed reduction in language requirements leaving more flexibility for elective courses is judged to be a very good idea.

(6) The most capable teachers in advanced graduate physics courses are physicists working at the leading edge of theory and experiment. It is not clear to this committee that the ASU faculty with the most expertise is teaching such courses.

(7) The written comprehensive Ph.D. qualifying exam was viewed as an effective learning tool by graduate students; some faculty expressed a less favorable viewpoint.

(8) There is little or no evidence of grade inflation in the lower division undergraduate courses (which is good), and the faculty is sensitive to objective criteria (SAT and GRE scores for example) that provide a gauge of the quality of the students. The large number of National Merit Scholars was judged by this committee to be a very important factor in helping to provide excellence in undergraduate programs at ASU.

(9) Several undergraduate students expressed concern regarding advising and the sequence of coursework. These problems are viewed as additional evidence of a lack of adequate resources in the instructional budget.

4. Student Recruitment, Retention, and Placement - The most effective means of improving the quality of the applicant pool for graduate programs is to raise the department national ranking. Generally speaking, both undergraduate and graduate students expressed satisfaction with their educational experience at ASU. Some additional effort could be focused on placement of graduating students at both the undergraduate and graduate levels.

5. Faculty Quality - Faculty quality continues to improve at ASU, especially since the most recent (NRC 95) ranking. The improvement has been achieved through attracting high caliber senior tenured as well as new untenured faculty. Pockets of strong research support were noted, but in general, the level of overall department research support must be raised to improve the department's national reputation. If one imperative were to be identified as the most important goal to focus on during the expansion of the Physics and Astronomy Department and the establishment of the new organized research units, the Review Committee suggests that the imperative be to focus on the quality of the new faculty recruited into the department.

6. Resource Utilization - Resource utilization appears to be good. There are obvious needs for additional laboratory and classroom resources, possibly a teaching center with some rooms seating 350-400 students. The operating budget of the Physics and Astronomy Department appears to be inadequate (comparison with peer department provided in Recommendations and in the Appendix).

IV. Conclusions and Recommendations

State demographics are driving the need to expand higher education in Arizona. The Tucson campus apparently is resisting growth by adopting a strategy of promoting excellence through selectivity; the Phoenix campus (ASU) has accepted the reality of growth and has begun to develop a plan that is designed to achieve excellence by taking advantage of the growth imperative.

The Review Committee perceives significant opportunities for improving the quality and scope of research and education in the Department of Physics and Astronomy at ASU, and of the related disciplines connected with the department. But there are also significant risks associated with rapid growth accompanied by massive reorganization of academic units. The following recommendations are offered representing the Review Committee's judgment of the best approach to addressing existing problems and improving the strength of the Department of Physics and Astronomy at ASU

Department Identity – the most critical issue the Department of Physics and Astronomy must deal with during the anticipated period of growth and reorganization is to reach a consensus on how the department should emerge from this activity. The Review Committee sensed that the reorganization of the Physics and Astronomy Department faculty and working groups within the department into new schools and centers was being driven "from the top." The department's strategic plan has been designed around the creation of new "academic units" (schools). The proposed reorganization of academic structure at ASU poses the following question: is the academic structure that exists today (with the associated academic and research rankings) the optimal result of reasonably-managed evolution within the constraints imposed by available resources? If the answer is yes, or even a qualified yes, then the question must also be raised whether dismantling the existing academic organizations to create a new paradigm (while facing a period of rapid growth and presumably a new influx of resources) is the best alternative.

The Review Committee feels very strongly that solving the existing problems and achieving the goal of improving the educational and research environment at ASU can best be achieved by maintaining the strength and integrity of the Department or Physics and Astronomy as a traditional academic unit.

The Review Committee agrees with the stated imperatives to establish interdisciplinary research programs that draw on strengths that exist within traditional academic departments. However, the creation of new academic units will require unnecessary duplication of efforts in student recruiting, faculty recruiting and promotion activities, and will dilute department resources through joint appointments and redistribution of staff and instructional resources.

Joint appointments which include some department faculty while excluding others from organized research activities supported by dedicated funds can lead to a group of disenfranchised faculty.

The fragmentation of the department through joint appointments and weakening of the department through redistribution of limited campus resources to new academic units was viewed by some faculty as a serious threat to the department's future. Other faculty (mostly from the astronomy group) viewed the formation of SESE as the only means of advancing their agenda of acquiring leverage to increase the size of their group.

Recommendation – The Review Committee believes that all of the objectives associated with the proposed creation of new academic units (SESE and the School of Materials) can be accomplished through the formation of (nonacademic) research centers and institutes. This approach reduces the risks associated with fragmenting the department through joint appointments, and other consequences that will tend to disenfranchise some faculty. This approach also offers greater promise of effectively dealing with many instructional problems resulting from inadequate resources including service courses, honors courses, and advising, because fewer departments imply larger departments and the economy of scale can be an advantage in a well-managed department.

Department Level Leadership – Prior department leadership has enabled the Department of Physics and Astronomy to achieve significant improvement as judged by nationally-recognized rankings (US News). The Department is fortunate to be able to look forward to continued and substantial growth in its size, but it faces serious challenges in dealing with the rapidly-expanding population of undergraduate students, service course loads, inadequate number of TAs and faculty and instructional resources (lecture halls and teaching lab space). These problems will be amplified if the astronomy group becomes realigned with geology, and if other physics department faculty become strongly aligned with the School of Materials through joint appointments. The ability of the department and associated institutes to attract high-quality TAs and new faculty will most likely be reduced by stagnant or lower rankings. The current problems will persist, and prospects of significant improvement in the academic and research opportunities will evaporate.

Recommendation: The term of the current Department Chairman is nearly complete. Strong leadership at the department level will be required to guide the department through the projected department growth and its integration into the envisioned organized research units. The steering committee and present department chairman have done an excellent job of presenting a vision for expanding and improving the department. The primary flaw in the plan, in the judgment of the Review Committee, is the formation of SESE and the School of Materials as new academic units.

The Review Committee recommends that the Department of Physics and Astronomy establish a search committee to seek a new chairman who can work with senior members of all Core Areas of the department and with new center directors to rebuild a strong Department of Physics and Astronomy community. The department will never achieve the highest degree of success in their educational and research missions without establishing a culture of mutual respect and cooperation focused on advancing department-wide goals and aspirations.

Peer Institutions and Resources – Most of the current problems in the ASU Physics and Astronomy Department are a consequence of rapid growth accompanied by inadequate resources. The teaching load is expanding faster than the instructional resources available to support it. The problem will persist until the instructional resources are brought into equilibrium with what is required to support the teaching activity. The desired quality of the academic experience enters into required level of support for both teaching and research activities.

Achieving the expansion and improvements in the academic programs at ASU will require a realistic assessment of the required resources. At the level of academic departments, meaningful guidance can be provided by comparison with departments in peer institutions.

The institutions listed in Table 4 of the department self-evaluation document represent peer institutions compiled by the ASU Provost's Office. Institutions on this list that have physics/astronomy departments comparable to ASU's current department are judged to be Florida State, U of I/Chicago, U of Kansas, U of Nebraska, and U of Oklahoma. Institutions representing the goal of achieving a top 25 ranking include UCLA, U of Colorado, Rutgers, Ohio State, U of Washington, U of Maryland, and U of Texas. Additional institutions in the latter category could be U of Minnesota, SUNY, and U of Wisconsin.

One of the Review Committee members (Erskine) has access to a detailed breakdown of the Physics Department instructional and Research Budgets of one of the peer departments (Texas). These budgets and some additional statistics for the UT Austin Physics Department are attached as an Appendix to this report as additional useful information. Comparison of the instructional budget for UTA Physics Department with information provided in the self-evaluation document suggests that the ASU instructional budget is low even allowing for the current higher enrollment at UT Austin.

Teaching and Research Facilities – The Review Committee was made aware of many examples that illustrate the need for additional space. With adequate TA support, service courses can be effectively taught in lecture halls that seat over 250 students. Apparently no very large lecture halls are available for physics service courses. Comments from undergraduate students indicate that enrollment in required upper division physics courses is often limited by classroom seating capacity, and there is a clear need for additional teaching lab space. The Society of Physics Students indicated that their assigned meeting space was inadequate. The anticipated growth in faculty will require significant expansion of both office and lab space.

Recommendation: A new building for the Department of Physics and Astronomy at ASU, housing new institutes in material science and astrophysics may well be very attractive to donors, particularly from Arizona. The committee urges the university development office to find foundation or individual donors who would be interested in funding such a facility, emulating the Kavli foundation. There are many other foundations which have given large sums to fund technology centers in the U.S. A representative list is given at http://www.kirschfoundation.org/why/major.html.

V. Thanks

The Review Committee wishes to thank all of the physics faculty and members of the ASU administration who have made this intensive review so informative and successful. The hospitality of ASU has been outstanding. We also thank the impressive groups of undergraduate and graduate physics students for their astute and thoughtful comments.

Appendix I

Peer Institution Physics Department Budget

The attached information may be useful in assessing resources required to support teaching and research missions (physics and astronomy) at a peer institution with a strong, engineering program and total enrollment of 50,000 students.

UT Austin Physics Department (56 FTE faculty, 280 Graduate Students)

Instructional Budget (State, Faculty Salaries)			$5,530,000
TA, AI, Graders (75% State, 25% Fees)			$1,800,000
Classified Staff ($1,072,000 State, $394,000 Fees)			$1,460,000
Maintenance and Operation (State, $150,000 + Soft, $60,000)			$ 210,000
Total Instructional Budget			$9,000,000
Research	AMO Group	$ 900,000	
	Solid State	$2,300,000	
	High Energy	$1,350,000	
	Nuclear	$ 460,000	
	Nonlinear Dyn.	$1,600,000	
	Theory Group	$ 925,000	
	Education	$ 25,000	
	Fusion	$6,000,000	
Total Research Budget			$13,560,000

A substantial fraction of the Classified Staff budget supports research and transferring $1M from the Instructional Budget to the Research Budget would provide a more accurate indication of expenditures.

UT Austin Astronomy Department (20 FTE faculty, 42 Graduate Students)

Instructional and research expenditures of the astronomy department are approximately 1/3 of the totals for the physics department.

Total TAs	Physics	104
	Astronomy	18

Applicant Pool (2004 Physics) US 162, Foreign 326

TA offers $14,700 + health insurance and tuition