

Report of the External Review Committee for Physics

David Cassel, Cynthia Cattell, and David Weitz

Overview

The Department of Physics at the University of Colorado brings national and international prominence to Colorado in cutting edge physics, science education and technology development. It may well be the strongest department in the university. The growth in the number of faculty and the support the department has received from the University since the last external review has allowed Physics to move very rapidly into the top ten departments in the country, an achievement attempted by many universities, but very rarely achieved. This status is attested to by the large number of research and teaching honors won by individual faculty and by the department as a whole, and by the continual increase in federal research funding. The department has benefited from the close interaction with JILA that results in, arguably, the top Atomic, Molecular and Optics group in the world. To continue this upward trend, it is imperative that the department be provided with the state-of-the-art teaching and research space needed to continue to innovate in teaching and research, provide training for the anticipated larger student population, seed new companies, and educate the Science, Technology, Engineering and Mathematics (STEM) teachers and technologically trained workforce needed for Colorado's future. Without this investment in the teaching and research mission of the department, the department will not be able to continue to grow, and, ultimately, its strength and national prominence will be compromised. The University of Colorado must be commended for bringing its Physics Department to level it has; this additional investment is now essential to consolidate this achievement.

This Review Committee met with essentially all of the constituencies within the department, including the faculty in all research areas, the women faculty, the assistant professors, graduate students and women graduate students, as well as the chair and assistant chair. In addition, the committee toured the research laboratory and the teaching spaces. The morale of the department is extremely high and the faculty is an unusually cohesive group, working together to support the extremely diverse research programs of their colleagues. The graduate students were also very positive about their courses and research education.

The department is unified in recognizing the importance of implementing research-based changes to the teaching of physics courses at all levels, from the introductory courses for freshman to the discipline-specific graduate courses. Their work in this area since the previous external review has resulted in the recognition of the department as one of the leaders in STEM education reform and in research in physics teaching and learning. These reforms have undoubtedly played a significant role in the large growth in the number of undergraduate majors. The availability of exciting opportunities for participating in undergraduate research in a broad range of disciplines has dramatically improved the undergraduate experience, increasing the number of majors obtaining Latin

honors, and resulting students who are better prepared for graduate school, industry and teaching.

Need for new space

The Physics Department at the University of Colorado has undergone significant growth over the past decade. It has accomplished a goal to which many physics departments across the country aspire, but rarely succeed: It transformed itself into a top-ranked physics department both nationally and internationally. Moreover, with this success comes further success: The department is now able to successfully compete internationally for the very best candidates as new faculty is added, and it successfully competes with all the top universities for the best graduate students (Harvard now routinely loses prospective graduate students to CU Physics).

The success of the Department goes well beyond the awarding of two Nobel prizes in Physics to three faculty members. Their research is superb: The Atomic, Molecular and Optics group is arguably the best of its kind in the world; the Plasma Physics group has its own Center and a focus rare in a physics department; the High-Energy Physics group has successfully retained a large DOE block grant and participates visibly in the BaBar and CMS experiments; the Condensed Matter Group was awarded a very prestigious and intensely competitive Materials Research and Science Engineering Center (MRSEC) from the National Science Foundation (NSF); and the Nuclear Physics group is active in the key experiments in this field. Equally impressive, the CU Physics Department has established itself as a leader among all physics departments nationally, and indeed among all educational institutions, as an innovator in the teaching of science and engineering, both for the next generation of scientists and engineers, and across a much broader spectrum of students. For example, the next generation of science teachers of all levels will benefit from the innovations and efforts of the group at the CU Physics Department. An additional significant component of the educational mission of the department is the participation of undergraduates from all science disciplines in state-of-the-art research labs; this provides invaluable experience and knowledge, even for those students who do not choose physics as their ultimate career path.

The CU Physics Department has also had direct impact on society: Numerous start up companies have been established by members of the department, providing new high-quality jobs for the state of Colorado. In addition, graduates of the department are themselves now leaders throughout the state, and the nation. The department also successfully attracts considerable federal funding to the University: Current annual funding is \$23M, reflecting a substantial growth from \$13M at the time of the 2001 review. Similar increases are highly likely in the coming ten years since so many of the current faculty is junior, just starting to grow their research efforts.

The enormous success of the department has placed a heavy burden on department infrastructure. New faculty requires lab space to successfully operate, and as the young faculty grows their research efforts, they require new space for expansion. Hiring the

quality of faculty that the department is now able to attract also places large demands on lab space, and as the level of the department continues to grow, existing faculty will become targets for the top schools in the country, and retaining them will further require space. Similarly, as the science teaching programs grow and command increasing national and international attention, they will require improved space to fully highlight the contribution of CU to innovative advances in teaching. The department has been incredibly supportive of these efforts, carving out prime lab space for teaching and learning rooms. However, this space is not really suitable for the level of prominence the program now commands. Moreover, the department is bursting at the seams and can not house the new programs that are already underway.

The demands of the new teaching initiatives are so large, and so compelling, both in terms of the impact on the university and the impact on the nation, that the Review Committee very strongly supports the establishment of a new integrated innovative teaching and research center to be housed in new space constructed adjoining the current physical sciences complex. The Review Committee's picture of the nature of this center could be described by a title such as the Center for Research Excellence in Science and Teaching (CREST), although another title with its acronym could be preferred. This building would provide a fitting venue for the innovations in teaching coming from the Physics Department and indeed from the whole campus. In addition, the building would provide essential classroom and teaching lab space that would serve the needs across the university. The new building would also provide the desperately needed laboratory space to house research efforts that would provide the educational opportunities for undergraduate students. Finally, the new building would enable the caliber of faculty that the university can now attract to be successfully recruited and ultimately retained against the inevitable poaching that occurs among top universities. Finally, the building would be of enormous value in obtaining new federal funding for research centers that would greatly increase the funding level of the University; for example, even renewing the MRSEC will require strong evidence of university support.

This new building would recognize the prominence and excellence of the Physics Department, as well as the other units with the physical sciences complex, APS and JILA, both in teaching and in research.

Additional needs

Although the need for new teaching and research space is of paramount importance for maintaining and improving the department, there are also other important factors that impact the ability of the department to meet its goals for teaching and research and to maintain and improve its rank.

Startup Packages

The department contribution to startup packages is a major burden on the Department Administrative Indirect Cost Recovery, which must also provide funds for other real

costs to the department. If the 29/71 split of ICR cannot be adjusted in favor of departments, some other mechanism for funding the department contribution to startup costs should be found. Otherwise, the recruitment of excellent new faculty members in experimental physics will be seriously compromised.

Instructional Support Staff

Only one technician is dedicated to the support of the undergraduate teaching laboratories. This level of support is not adequate for the number of active experiments, their sophistication, and their complexity. An additional technician for this effort is fully justified.

Endowed Chairs

The number of named chairs recognizing accomplishments of the Colorado physics department faculty is not commensurate with the number of such awards in other universities. There is only one named chair held by a member of the department, a situation that is unusual among physics departments in major US research universities with Colorado's national and international standing. An effort to substantially increase the number of named professorships that would be available to members of the physics department and awarded to them would be a welcome recognition of the department's national standing. While this is ideally done through endowment gifts, it is also feasible for the university to grant such a chaired position to recognize outstanding faculty, even before an endowment is found. This would be highly justified for the Physics Department, given its standing and prominence.

Graduate Research Fellowships

After reputation of the department, fellowships for entering graduate students are usually the most useful recruiting tool. Increasing the availability of graduate fellowships must be a high priority for keeping the quality of the graduate student body on its current rapid upward trajectory.

Learning Assistants

Learning Assistants have demonstrated their utility in educating undergraduate students of physics and in furthering the department's efforts in educational research. The program has been funded by an NSF grant to CUTeach, which will expire. In line with funding for many new initiatives, the NSF expects that the university will provide continuing funding for the program. Loss of Learning Assistants would be a major setback for the physics education of undergraduates and for the department's research in education. For continuity, support for Learning Assistants should be a component of the base budget of the physics department.

Faculty Lines

The continued support of the Dean and university to provide the department with additional faculty lines is desirable to continue the improvement in ranking, as well as to meet the needs of several research groups and the impact from the expected expansion of the university's student body.

College of Natural Sciences

Some members of the Physics Department argue strongly for the division of the College of Arts and Sciences into two colleges, one of which would be responsible for science. The Review Committee does not understand the complexities of the university well enough to be able to understand how useful this division could be. However, given the substantial interest expressed in this outcome, a careful study of the issue is warranted, perhaps at the level of the provost and a committee of representative department chairs from the college.

Undergraduate Research Opportunities

The physics department has been very successful in utilizing Undergraduate Research Opportunity funds in department research programs. In one example, about 40 students contributed significantly to a world-class High Energy Physics research program over a period of several years. However, new limitations on this program make the successful employment of undergraduates in physics research more difficult. Currently the program can provide at most one semester of support for a given student. Usually it takes most, if not all, of a semester for a student to learn enough about a field and the research techniques to become really productive. Although the NSF allows expenditures of research funds for undergraduates, not all agencies do, so expansion of this program would have a positive impact on quality of the research experience of undergraduates and on the productivity of research groups in a substantial segment of the department.