Department of Physics: Plan of Action

The Ohio State University

February 23, 2019
Version 1.2

The Department of Physics

Mission:

The Ohio State Department of Physics seeks to develop a new and transformative understanding of the physical universe through a research program whose excellence is recognized internationally; to educate a large, diverse group of students to obtain a mastery of the subject and critical skills necessary for solving 21st-century challenges; and to disseminate our knowledge, for the betterment of society and the field, through impactful publications, education, and service & outreach.

Vision:

The Department of Physics seeks to raise its visibility and impact through systematic strengthening of its research, education, and service & outreach programs. It will:

- Enhance existing research efforts, grow efforts in areas of emerging interest, and expand interdisciplinary collaborations between these efforts, other departments, and institutions.
- Expand its role as a national leader in the training of students by improving its educational programs through the use of contemporary pedagogical techniques and by increasing the representation of women and under-represented minorities.
- Increase its impact on society through national service as well as vibrant outreach programs that target a wide range of public audiences.

To achieve these aspirations, a foundational element is a highly qualified and diverse faculty, staff, and student body working in an inclusive and supportive environment as engaged scientists and citizens.

1 Introduction

Investments in the department 10–15 years ago, through Targeted Investment for Excellence (TIE), expanded our research program, created opportunities for large center-like funding, brought outstanding new faculty to the department, and provided a rich research experience for students. With another investment, the Department of Physics is poised to take the next big step forward.

Last year, the Department of Physics conducted an Academic Unit Review, the first since 2010. A thorough Self Study highlighted the strengths and weakness of the department and brought clarity to the department's strategic path forward. Departmental committees critically reviewed each area of the department and input was sought from all stakeholders. In September 2018, a review committee visited campus to meet with department stakeholders and university leaders. This plan of action was developed to address challenges and opportunities discussed in the Self-Study document and the recommendations of the committee.

The committee described the department as a "...very good department with an upward trajectory in many key areas, strong leadership, and a clear vision of who they are and where they are going." Recently, US News and World Report rankings placed the department at 26^{th} in the world out of 827 ranked physics departments, the 15^{th} US institution, and the 6^{th} US public institution. A growing interest in the discipline, and STEM fields in general, has led to a doubling of the number of majors in the last ten years and a large increase in introductory physics enrollment.

Serious challenges place the department is at a crossroads. Expected retirements in the next five years (10–15 faculty, a 20–30% loss), if not aggressively addressed, will seriously erode advances made in the last several decades. The growing instructional program, without commensurate funding, stresses the resources of the department and has resulted in pedagogical compromises. The external report states, "Overall, it is a critical time for the long-term evolution of this department. The program is in a very good position, and there are opportunities to become even better if they can focus on a creative strategy and harness the resources they need to find and follow the right path." As part of the Self Study, the department began to explore ways to address these challenges and find this path forward. These are described more fully below.

Diversity and Inclusion

The lack of diversity in the department has long been recognized and is a problem that is systemic to our discipline. The department has sought ways to increase diversity through programs such as the APS Bridge Program for graduate students from underrepresented minorities. As the external committee noted, while progress has been made in some areas, the department must have a continued emphasis on improving diversity in all areas. The department is committed to increasing its efforts, and recent changes, such as the establishment of a Climate and Diversity Committee, reflect this commitment. Our pursuit of diversity and inclusion must be an integral part of everything we pursue, whether it be faculty hiring, student recruitment and retention, mentoring, curricular reform, department policies and procedures, or any other pursuit of excellence. We must work to mitigate implicit bias in all aspects of the department and eliminate unnecessary barriers to success. To achieve our aspirations, the full department must exemplify the statement in the American Physical Society's 2019 Strategic Plan: *As we look to the future we embrace inclusion and diversity, so that all who want to practice physics find a welcoming and supportive environment.* In the sections below, we integrate this strategic goal into our specific plans of action.

2 Research

A strong and broad research program is the foundation for excellence. It attracts world-class faculty, creates a rich learning environment for students both inside and outside the classroom, and draws national and international recognition. The review committee found the program to be strong, with leading roles in astrophysics and condensed matter. It was highlighted that the Center for Cosmology and AstroParticle Physics (CCAPP) and the Center for Exploration of Novel Complex Materials (ENCOMM), both established by TIE, provide a great investment toward making faculty competitive for external grants and seeking large center funding, such as the Center for Emergent Materials, a National Science Foundation MRSEC.

The department is starting from a position of strength. While the pending wave of faculty retirements represents a serious challenge, it provides an excellent opportunity to act strategically to further improve the research excellence of the department. However, to achieve this, we must find ways to reestablish research infrastructure and resources that have degraded in the past decade. Making a commitment toward this necessary investment in faculty hiring and research support will be a major step forward for advancing the quality of the department.

2.1 Hiring Plan

The hiring plan presented in the Self Study was endorsed by the external review committee. The committee remarked, "The hiring plan exercise is regarded as very impressive – it brought the department together and resulted in the framework for a plan that can be flexible moving forward." The plan consists of 10–15 new hires that will maintain our breadth by stabilizing core areas, grow areas poised to attract additional or new center-like funding, and initiate efforts that will move the department into exciting new areas. This will be an opportunity to improve the diversity of the department, and we have set the goal of doubling (from 5 to 10) the number of Columbus-campus women faculty members in the next five years. A summary of the hiring plan can be found in the appendix of this document. The external committee described the hiring plan as "extensive and well-thought out" and "focused on the right priorities and builds on existing department strengths." The committee strongly endorsed the plan and recommended "that this be done aggressively", stating, "If done well, this will position the department well for the future."

Execution of the hiring plan will require careful planning and establishing processes for year-to-year choices for research areas and effective techniques for recruiting highly qualified diverse candidates. **It will be essential for the department and the College to identify the necessary funds for startup costs. Without these resources, the hiring plan cannot be successful and the department will shrink in stature.** Specific actions to address these issues are discussed below.

- **Action – Establishing Yearly Priorities:** The Personnel Resources Committee (PRC) will establish a procedure for determining priorities for subsequent academic year hiring cycles.
  Status: Discussions are currently taking place in the PRC to formulate this structure. The procedure is coupled with the second action item, which seeks to establish a search process that maximizes our ability to conduct diverse searches.
  Timescale: Approval by the full faculty during the 2019 Spring semester
  Resources: None

- **Action – Establish Search Committee Structures and Processes:** The makeup of search committees should have broad representation from across the department, have a clear charge with specific duties, and a well-defined rubric for evaluating candidates. The processes should maximize attracting an excellent and diverse pool of candidates.
  Status: Recently, changes were made to the membership of search committees to have a broader representation of research disciplines. This will continue. The Chair, in consultation with the PRC, will define a template for a search committee charge. This template will serve as a starting point for specific searches and a final charge will be established when a search committee is formed. Similarly, a template rubric will be defined. A rubric for a specific search will be finalized prior to reviewing any candidate applications. The charge and rubric for each search committee will be shared with the full faculty. The PRC is currently considering a strategies that could help increase our pool of diverse candidates. One strategy consists of conducting broad searches that are open to multiple strategic areas rather than searches focused on a single area.
  Timescale: The template charge and rubric will be defined prior to the next search cycle. These will be voted on by the full faculty. The process of how we conduct the searches (multiple areas or single areas) will be established during 2019 spring semester. This will be linked to the processes of establishing year-to-year priorities (previous action item).
  Resources/Needs: The approach of searching across multiple disciplines will require College buy-in.

- **Action – Identify funding mechanisms for startup costs:** Physics is a laboratory science and thus comes with the requirement of significant startup costs. The source of these funds must be identified and planned for.
  Status: We have created a funding profile for the projected startup costs for our hiring plan. The total cost is estimated at $12M. These funds would be distributed over approximately 9–10 years assuming a phased hiring of faculty and startup costs spread over four years after each hire is made. Peak years would require about $2–2.3M per year. The department's research program currently (FY18) brings in $4.6M per year of indirect costs. However, only $0.46M is returned to the department (FY19), which is insufficient to cover the proposed startup costs. It is unclear whether the College has a sufficient amount of reserved funds to cover these costs. It is essential to develop a financial plan for funding these positions.
  Timescale: Having an agreed plan prior to the start of the next hiring cycle would be beneficial.
  Resources/Needs: Approximately $12M of startup costs and the department must partner with the College to formulate a plan for how these funds will be acquired.

- **Action – Establish a Postdoc Seminar Series:** In order to recruit promising young physicists, the department will establish a Postdoc Seminar series that invites diverse physicists to campus. The department will survey postdocs that will be entering the job market in coming years and the postdocs will learn about the department.
  Status: Currently this is in its early stages, however, the barrier to creating such a program is low. We envision partnering with the Office of Postdoctoral Affairs on strategies.
  Timescale: The program would start in the 2019–2020 academic year.
  Resources/Needs: Inviting six candidates per year would cost about $8–10k and can be accommodated within the current budget.

2.2 Infrastructure and Resources

One of the stated strategic goals in the department's Self Study was to promote research by reestablishing technical expertise, research infrastructure, and flexible financial support for faculty; seek new sources of funding with a five-year goal of achieving $20M in annual research expenditures, which represents a 25% increase. Growing our research effort will require a dedication to providing resources to faculty in order to have a solid foundation for their efforts.

- **Action – Increase cost-share for grants:** Cost-share, where allowable, makes grant proposals more competitive and provides opportunities to build department research infrastructure. The department needs to increase its capacity for offering this support.
  Status: In recent years, very limited resources have been available to provide cost-share for grant proposals, except for several high profile interdisciplinary grants. This is due, in part, to the limited amount of indirect cost returned to the department. This cost-sharing can be used to build up equipment infrastructure, host workshops and conferences, etc.
  Timescale: Ramp up over several years.
  Resources: This will require a higher fraction of indirect costs returned to the department to use for research support. The ability to fund such a program would depend on available indirect costs after accounting for the startup costs for the hiring plan and general support of research infrastructure in the department.

- **Action – Faculty Research Funds:** Research active faculty should be provided with research funds to pay for expenses typically not covered by external grant funds and to pursue speculative new research directions that could lead to new sources of funding.
  Status: In the coming months, the department Chair, in consultation with the Budget Committee, will generate a procedure for determining the amount of funds to provide to each faculty member. This determination will include factors such as: faculty research grant F&A after accounting for cost-share; number of supported graduate students and post-docs; faculty involvement with undergraduate research; and potentially other factors. Such a program would likely have both a cap (maximum) and a minimum.
  Timescale: Ramp up over several years.
  Resources/Needs: This will require a higher fraction of indirect costs returned to the department to use for research support. The ability to fund such a program would depend on available indirect costs after accounting for the startup costs for the hiring plan, cost-share expenses, and general support of research infrastructure in the department.

3 Graduate Program

The graduate program in the department is a strong program with ∼200 students pursuing studies across the broad research disciplines. The department is a top 20 producer of PhDs and the time to degree is just under six years, which is near or below the national average. Graduate students are typically funded their first two years as GTAs or Fellows after which time they are normally funded by faculty research funds. One of the recent challenges has been a reduction of funding for GTAs, which has been reduced from 60 FTE (2013) to 42 FTE (2018). This reduction has required compromises in pedagogy (see Section 5) and restricted the pipeline of students for the research program. This trend must be reversed and action steps are described in Section 5. An MS-to-PhD Bridge program was established in 2013 and has allowed the department to significantly grow the graduate population of underrepresented minorities, which now stands at about 25% of domestic students. However, gender diversity continues at or below national averages (see Section 4 for actions). Through the review process several areas emerged as requiring improvement. The qualification and candidacy processes are being reviewed and considered for reform. In addition, we are conducting a review of the graduate curriculum for content, uniformity, and level.

- **Action – Qualifying Process:** Currently, students qualify for continued graduate studies by obtaining a B+ average in the 6 core graduate courses normally taken in the first two years. This has the negative consequence of potentially creating an adversarial "Gate Keeper" relationship between instructor and student.
  Status: The Graduate Studies Committee has conducted an evaluation of qualifying procedures at peer institutions. Alternate forms of qualifying include written and oral exams (at different levels) separate from the core courses and standardized testing in conjunction with the courses. The Graduate Studies Committee is in the process of synthesizing the ideas gained from this peer survey with those gained from the curriculum review process (see below) into recommended changes to the qualifying process that will best address the concerns.
  Timescale: The Graduate Studies Committee will report their finding to the faculty and students during Spring 2019.
  Resources: The establishment of a qualifying exam would require an additional service load for faculty.

- **Action – Curriculum Review/Reform:** The core graduate curriculum has been unchanged for decades. A problem noted by the external review committee was the lack of year-to-year uniformity in content and grading depending on the instructor.
  Status: The Graduate Studies Committee is evaluating the content, level, and grading norms of these courses and has conducted a survey of comparable course content/level at peer institutions. Potential changes to the level and scope are being considered in coordination with concurrent changes to the qualifying procedure, because if the core courses were no longer used as the qualifying mechanism, the resultant greater freedom in curriculum design could be exploited to enrich the graduate education (e.g., offering fewer required and more elective courses). Other potential recommendations being considered include standardizing syllabi and/or textbooks in order to reduce year-to-year variation while still allowing individual faculty to bring their unique research specialty into the classroom.
  Timescale: The Graduate Studies Committee will report the their findings to the faculty and students during Spring 2019 with additional evaluation moving forwarded.
  Resources: None

- **Action – Candidacy Exam:** The department will work to develop a more clear and uniform set of standards for the graduate candidacy exam.
  Status: The Graduate Studies Committee is in the process of reviewing the current standards and trends based on a historical review of the letters issued to candidates by recent candidacy committees. Based on that review, it will clarify the existing standard, and develop new guidelines where appropriate. These will conform to existing standards of the Graduate School. A template letter that clearly states these standards will be provided to faculty advisors for use in future candidacy exam letters.
  Timescale: The Graduate Studies Committee will provide the template letter to the faculty and students during Spring 2019.
  Resources: None

4 Undergraduate Program

The Physics Department coordinates two separate B.S. degrees, one an ASC Physics degree and one an Engineering Physics degree conferred through the College of Engineering. The number of majors has doubled in the last ten years. The committee found this growth to be impressive and a sign of growing interest in STEM fields and the utility of this highly marketable degree. The department is one of the largest (top 10–20) physics degree producing units in the country, which is beneficial for developing a highly qualified workforce for the state of Ohio and the nation. The current enrollment of ∼500 majors, including >150 entering freshman, has created challenges that must be addressed. Classroom enrollment and laboratory space for upper division majors are not capable of handling the recent large incoming classes. Past graduates have benefited from research experiences in faculty research labs, which provides hands-on experiences and 1-on-1 mentoring that is an essential part of student development and positions the students for successful careers and post-graduate studies. In addition, the diversity of the student population lags behind national averages for physics departments. The department must find ways to address these challenges and to continue providing a high-quality experience for the growing major, over half of whom will directly enter the work force with promising careers after graduation.

- **Action – Recruitment and Retention:** To improve the diversity of our student population we must expand our efforts to recruit and retain underrepresented groups. In addition, the department should partner with undergraduate admissions to develop a more diverse set of incoming students.
  Status: The department currently has a variety of programs that work toward the goal of increasing diversity in the student population. Some of these exist at the graduate program level (see Graduate Program section). The department has coordinated the ASPIRE workshops for high school aged women interested in Physics. Previously a similar program, GRASP, existed for 6–8th grade girls. The department would like to restart this program. Recently, a program (POLARIS), started by a group of graduate students, pairs early program undergraduates with graduate student mentors to help navigate the challenges of a physics major. What has been lacking is a coordination of these efforts. In addition, more can be done to recruit underrepresented students to the program. If the department is to make progress in this area, we need a new staff member that is solely focused on these efforts.
  Timescale: Ideally, a new staff member would be in place by summer. Evolution and coordination of the departmental programs would take place over several years.
  Resources: Create a new departmental staff position of "Diversity Recruitment and Outreach Coordinator" to oversee and coordinate these activities for the department. This would require additional funds for salary plus benefits of $65–75k.

- **Action – Overhaul of Major Lab Sequence:** The laboratories are not providing students with sufficient experience with modern toolsets and too much of the laboratory sequence is taken in junior and senior years. In addition, with the growth in majors, the physical infrastructure for the labs is not capable of accommodating the large influx of students. The department has embarked on an effort to overhaul and modernize the lab sequence for physics majors.
  Status: An ad-hoc committee was formed last fall to consider options for structural changes to the lab sequence. The charge to the committee instructed them to consider standardizing toolsets across all labs, consider an expanded lab sequence in sophomore and junior years that

establishes competency in these toolsets, and revised content for upper division lab courses.
Timescale: The ad-hoc committee will report by the end of spring semester. One pilot course, the first in a four-course sequence, will take place next academic year with the full revised sequence to be piloted in academic year 2020–2021.
Resources: Additional equipment, space, and staffing will be required for the new laboratory sections and an expanded senior-level laboratory. Current estimates are: two new lab rooms, 1–2 additional lecturers, one support staff member, and reassignment of two faculty members whose current instructional role in introductory courses must be backfilled.

- **Action – Additional Student Advising:** As noted by the external review committee report, the doubling of the majors has overloaded the one academic advisor in the department. The single advisor can no longer effectively advise this many students and carry out duties such as assessment and tracking outcomes.
  Status: The Physics Department has a close relationship with the Department of Astronomy. Many students double major in the two disciplines and there is a large overlap of the curriculum for the two majors. The Astronomy Department, whose major has also been growing, does not currently have a staff member that acts as an academic advisor. The two departments are currently formulating a proposal for a joint academic advisor for the two majors. This shared resource would benefit the students in both departments and strength the advising for students that are double majoring.
  Timescale: A proposal will be sent to the College in March. If approved, the new advisor would be in place for the next academic year.
  Resources: This would be a shared expense between the Astronomy and Physics Department, which would be about $65–75k.

- **Action – Improved Instruction for growing Majors:** Large growth has also created problems in our lecture courses, especially the large core classes. The sophomore-level course sequence has grown to over 160 students. Upper division courses have grown to as many as 80 students in sections despite adding additional sections. These large course enrollments have made the development and implementation of modern pedagogical techniques very difficult. The department must manage course sizes and identify classroom spaces that allow and facilitate modern teaching approaches.
  Status: In the past few years additional sections have been created for some upper division courses. More of this will be required in the future. Effective classroom space is a problem with no obvious solution yet. One room in Smith Lab was recently modified for a more active learning space. This has relieved some pressure but additional space is needed.
  Timescale: The exact timescale for resolving these problems is unclear, but our large freshman class necessitates a solution in the next few years.
  Resources: Additional dedicated teaching space is required. We need classrooms suitable for 30–40 students and suitable for 60–80 students, arranged to facilitate group work. There are several contiguous rooms in Smith Lab that could be renovated to fill this need, but courses currently using the space would need to be relocated. Opening additional sections of upper-division major courses will require reassignment of two faculty members whose current instructional role in introductory courses must be backfilled.

5 Introductory Physics Instruction

The department has a large instructional load that serves STEM majors and, in particular, the large enrollment in the College of Engineering. Last year approximately 40% of OSU graduates had taken at least one physics course here at OSU. Our instructional load in the introductory courses, which now approaches seven thousand enrollments, has grown 37% since 2005 with no significant increase in resources. This increase in enrollment in Physics courses "is putting *extreme* pressure on the ability of the department to provide the educational experience required to train students with modern techniques...Pedagogy has suffered because of the required compromises." The external committee recommended a reinvestment in TA support. There is a clear need for expanded use of modern pedagogical techniques with an accompanying improvement of TA training and support. In addition, faculty in the department have been strongly encourage to participate in the UITL Teaching Support Program in order to facilitate these advances in instruction.

- **Action – Reinvention of Introductory Teaching:** The department seeks to introduce proven physics education techniques into the introductory physics course sequences.
  Status: Using $50k of funds provided by OAA, the department has begun introducing new approaches in the recitation sections of both our algebra and calculus based sequences. These new approaches leverage the benefit of group instructional approaches, and include group-work sessions designed to provide the skills needed for tackling each week's homework, and group-based quizzes that capitalize on the high motivation during graded exercises. We are also incorporating a hand-graded homework problem with a focus on methods and procedures to help mitigate shortcomings of the exclusively numerically graded online homework system.
  Timescale: Developing these instructional materials is resource intensive. Our effort this year has involved 45 hours per week of combined TA and faculty effort to generate about a third of the materials needed to expand the approaches to all introductory course recitations. Once recitation activities have been fully modified, we plan to introduce new measures into the laboratory section, followed by lecture sections. Additional improvements in all of these areas will take place as we gain experience.
  Resources: The work necessary to develop new instructional materials lies outside the responsibilities of our traditional instruction assignments, which themselves have been compromised in order to handle the enrollment increases. We do not have the personpower, for example, to grade lab reports or to grade more than a restricted few-per-term partial credit problems on evaluations. Any instructional improvements thus require resources, our multi-year plan for these courses will need at a minimum five or six years of investment at the level provided by OAA this year.

- **Action – Additional GTA support and Training:** The department would like to increase the number of GTAs to support its large educational program. These students would in be integrated into the reinvention of introductory teaching described above. They would be trained in modern teaching approaches and assist with the implementation of the improved instruction.
  Status: Typically, graduate students are supported either as GTAs or Fellows during the first two years in the program and are almost universally supported by faculty research funds as GRAs for the remainder of their academic program. Drastic cuts in the GTA program have taken place over the last five years. Since 2013 the department has reduced its number of GTAs from 60 to just 42 (full year FTE), despite continued high enrollments. This has

resulted in two problems: pedagogical compromises in our teaching and a reduced number of students to supply our growing research effort. Other improvements are desirable, high on our list is implementation of peer instructional evaluations by GTAs; however the most impactful change to the quality of instruction would be to reduce recitation/lab sizes. Constraints involving space prevent small changes, the only option is to use a maximum class size of 21 students as opposed to the current 28. This would require about a 30% increase in the numbers of GTAs, but would solve a wide range of instructional issues.
Timescale: The ramp-up of these increases could be spread over two academic years.
Resources: Funding for 14 additional GTAs to support the large instructional program and provide additional available manpower for the growing research program, which is capable of absorbing this influx.

6 Summary

Past investments in the department have built a solid foundation of research excellence that has contributed significantly to the international reputation of the Department and the university. We are poised to reshape our research portfolio and strengthen the department's ability to purse its mission of developing a new and transformative understanding of the physical universe. We have a vision for developing our student programs to improve teaching and learning, and to educate a large, diverse group of students to obtain a mastery of the subject and the critical skills necessary for solving 21st-century challenges.

External Committee Report:
We see the potential for the department to make another significant step up in the quality and impact of the program now. The members of the department have the vision and leadership and commitment to do that, but it will take a sustained effort and substantial investments from the campus and College for that to happen.

To achieve these aspirations, we seek to partner with the University and the College to find the resources to bring these plans to fruition.

Appendices

A Hiring Plan

The department hiring plan is the outcome of more than two years of effort to identify key areas for future hiring. It is the result of careful deliberations of the Personnel Resources Committee and discussions with the entire faculty. Given the magnitude of the hiring, it will significantly shape the department for the next 25–30 years and is an opportunity that arises only rarely. The department is not seeking to grow in size but instead reorient itself to align with new exciting areas that are emerging in the discipline and propel itself forward in terms of importance and stature. A more complete discussion of the hiring plan can be found in the Self Study while key points are summarized below.

The plan consists of 10–15 new hires in a range of disciplines. Three of these hires are considered "carryovers" from past planning. One of these was a hiring in AMO, which was successfully completed; one was a condensed matter theory search for which a offer is pending; and one is an Ohio Eminent Scholar endowed position for which a search has not yet commenced. The remaining hires are distributed among nine important strategic areas that are grouped into three categories, which are summarized in the Table 1. In some cases more than one hire in a strategic area may be warranted.

Stabilization	**Growth**	**Initiatives**
Nuclear Experiment	Astrophysics Experiment	Neutrino/Dark Matter Experiment
Particle Theory	Atomic Experiment or Theory	Gravitation Theory/Exp
Particle Experiment	Biophysics Theory	Quantum Information Theory/Exp

Table 1: Summary of hiring plan areas. For a more detailed description of these areas please refer to the Self Study document.

• **Stabilization:** Hires in this theme support the continued success of key research efforts. Prior investments established seven research groups, covering much of contemporary physics. This breadth is an important departmental asset, which provides a foundation for the next two themes by leveraging hires with existing strengths. This breadth also serves well the interests of our large, diverse groups of undergraduates and graduates, providing them a complete education and broad research opportunities.

• **Growth:** Hires in this theme support our efforts to attract new center-like funding. The 2010 External Review recommended that we seek to become especially prominent in one or two research areas. In condensed-matter physics and in astrophysics, we now have internationally visible centers, which are key assets to develop further. In condensed-matter physics, we have already made large investments in faculty hires and have obtained NSF MRSEC funding, whereas in astrophysics, we have further to go on both hires and funding. In addition, we want to nurture other efforts that could attract center-like funding.

• **Initiatives:** Hires in this theme support our goal of expanding our research in new directions. Even with single hires, we can attract strong people and reach critical mass by taking advantage of our foundation of breadth and the strengths of our centers. To maximize impact, we have selected directions where we have competitive advantages to establish visible new efforts. In addition, two of these would help CCAPP develop new directions for seeking center-like funding.