California Institute of Technology

Report of the Visiting Committee for the Division of Physics, Mathematics & Astronomy

November 13-15, 2018

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PMA Visiting Committee Report
March 1, 2019

Executive Summary

Caltech's Division of Physics, Mathematics and Astronomy is justly recognized as one of the very top in the world in each of these fields. The visiting committee was impressed by the many strengths of the division, with highlights including the impressive talent, energy and enthusiasm of the junior members of the division, the innovations in the undergraduate physics curriculum, and the positive impact of the new student program director on the graduate student experience, especially in physics and mathematics.

The committee found three critical areas in which its assessments and recommendations are most essential:

Lack of **diversity** was identified as the primary concern in the previous committee report and continues to be a central concern. Practices, deliberate or not, that tend to exclude women and other underrepresented groups impede the achievement of excellence by leaving outstanding talent unrecognized and by creating an unhealthy environment in which it appears that the roles and contributions of different groups are not equally valued. Efforts across the Division instituted since the previous report have resulted in visible improvements in the awareness of the importance of diversity, and improvements in the overall climate. We commend the Division for its efforts to increase diversity at all levels, the greatest challenge being at the faculty level, but note that success has been limited and these are just first steps. We urge enhanced effort at all levels in the Division and ongoing oversight and support from the administration to establish the principle that excellence and diversity are not competing priorities, but rather that excellence at the highest level can only be achieved through diversity of all kinds.

Issues of **graduate student funding** are of top concern across the faculty, and reforms in physics and mathematics will greatly strengthen the research effort. We strongly recommend that the Division find resources to offer fellowship support at least to all first-year graduate students in the Division, as is currently done in astronomy, and ideally to make available additional fellowship support to be used in targeted ways for more advanced and final year students.

Finally, we want to make it clear that appropriate work space and laboratory **facilities** are an increasingly urgent priority. The transformation of Sloan to Linde is a model for how investment in a well-designed space can invigorate a department and promote interaction between faculty and students. For the current experimental research strengths in physics and astronomy to thrive and stay at the forefront, including attracting and retaining the best talent, the Division and Institute need to prioritize investment in new on-campus laboratory space, particularly in the old Kellogg Laboratories and Bridge, and to continue support for crucial off-campus astronomical facilities such as Palomar and OVRO.

Response to the Charge to the Committee

We now address in detail each of the five questions that were posed in the charge to the committee.

1. The physics, astronomy and mathematics faculties have identified priority research areas for future faculty hires. We would like your feedback on these plans. Are the target areas the right ones, given our size and current faculty composition? Are there opportunities that we are missing, either because they are interdisciplinary or are not currently represented at Caltech?

Overall, we affirm the principle of a broad search for excellence in hiring, with breadth opening new research directions and allowing flexibility in consideration of candidates who increase the diversity of the Division. At the same time, Caltech, as a small institution, needs to strategically focus on specific areas in which to excel and needs actively to promote collaboration within the Division and with other parts of the Institute, as outstanding candidates are more likely to choose Caltech over other options if presented with exceptional collaborative opportunities. While the committee was not fully expert in all the research areas identified as priorities for hiring, we offer the following observations on the PMA plans.

Physics has identified the following priority research areas for future faculty hires: biophysics, cosmology/astro-particle theory, gravity-wave physics, particle and nuclear experiment, and quantum matter experiment. These priorities aim to develop or maintain existing research strengths rather than to move into new areas, which seems appropriate given the modest number of hires likely in the next five years.

> **Biophysics**: Given the small size of the current group and the rapidly evolving and rather loose definition of biophysics, we do not support a near-term new hire in the physics department unless an exceptional hiring target of opportunity is identified and coupled with a well-defined research focus that complements other efforts at Caltech. More generally, the Institute should remain open to future developments and opportunities, especially in areas that bridge existing expertise in physics and biology that could stimulate collaboration by the two divisions.
>
> **Cosmology**: Given the departures in theoretical and experimental cosmology and the continuing vitality of the field, we recommend additional hiring to maintain presence in this area. Any such hiring should be in coordination with Astronomy.
>
> **Gravity-wave physics**: given the dramatic recent successes of LIGO, additional strategic hires to strengthen LIGO-related physics should be considered.
>
> **Particle and nuclear**: These fields have evolved considerably and experiments at the intersection of nuclear/particle and astrophysics offer outstanding potential for discovery of new physics while providing opportunities for

collaboration and synergistic efforts with AMO, condensed matter, and quantum physics. In particular, an additional hire that utilizes techniques from "table top" experiments may leverage AMO precision measurement methods, condensed matter approaches, or quantum sensors, make connections with the leading centers on campus, and seems well suited to the research landscape at Caltech.

Quantum matter experiment: The department argued that the current group is below critical mass needed to attract the best students in condensed matter experiment. More important, there are very lively areas not covered by current faculty interests. We support a search in this area, with careful consideration to complementing not only current research in the physics department but also in the context of related work in the applied physics department and other related departments, with a possible joint appointment.

Mathematics has pursued an aggressive hiring plan in recent years and gained momentum in stabilizing and developing a world-class small department. We agree that the next search(es) should be in topology and geometry as additional faculty are clearly needed in this area. We recommend that the focus shift from "just- tenured" to more junior candidates, which will give the department a chance to grow its own talent and, based on the department's recent experience, may increase its success in recruiting top women candidates.

Astronomy has made excellent hires in the last 5-6 years as they renewed their faculty to a level near their asymptotic FTE count. These appointments have very well positioned Caltech in the emerging fields of time-domain astrophysics and extra-solar planets while also revitalizing both Palomar and OVRO with faculty who make innovative use of these facilities. With the eventual opening of TMT, and the continued support of Keck, OVRO and Palomar, Caltech is well positioned to maintain its international leadership in astrophysics. The expectation for new hires is of order one in the next five years, so the department is primarily focused on reconnaissance rather than directed searching. Within that constraint, their planning is sound and the fields appropriate. They prioritize the evident immediate needs in high redshift extragalactic astronomy and theory while also being open to any opportunities that may arise. Hires in related physics fields (cosmology, gravity- wave physics, and particle and nuclear physics) will enhance the overall effort in the Division.

2. Caltech has invested significant private resources in the form of endowments for the Burke Center for Theoretical Physics and the Institute for Quantum Information and Matter (IQIM). Are the resources of these centers being applied effectively to enhance both the research and educational missions of the division?

The Walter Burke Institute for Theoretical Physics was established in 2014 as an endowed research institute to support the theoretical physics effort at Caltech, primarily by integrating and expanding the prize postdoctoral fellowship program in theoretical

physics. In less than five years, the Burke Institute appears to be fully achieving this goal by supporting postdoctoral fellows and organizing workshops, seminars and other activities for the Caltech theoretical physics community. It is a unique program at a unique place. The record of appointments and outcomes is very strong and has placed Caltech in a very competitive position for faculty recruitment and retention across all of theoretical physics.

All theory faculty members that the committee met with noted a number of strengths and science opportunities at Caltech enabled by the current size of the Burke Institute postdoctoral fellowship program (6-7 new postdoc appointments per year). These include the ability to make appointments across the broad spectrum of theoretical physics at Caltech and to improve diversity within the cohort. The question was raised regarding whether Burke should support more graduate fellowships at the expense of fewer postdocs. Our view is that this should not be done. The current number of new appointments each year is just above the critical mass for a distinctive impact on the Caltech theoretical physics community. There has been in the past, and should continue to be, a sense that the Burke Institute could exercise some flexibility if other exceptional needs arise related to the theoretical physics effort (e.g. graduate students, research professor support), but sustained support for the postdoctoral program at the current level should be very much the first priority.

A vibrant top-tier postdoc program such as that of the Burke Institute is expected to have a broad impact beyond the researchers directly supported. We encourage the Burke Institute leadership to track how the activities of the Institute, and the work of the postdocs in particular, enable collaborative research across Caltech and involve graduate students. The same holds for its visiting program and seminars. Conscious attention to this aspect of its activity will guide the institute in encouraging collaboration and maximizing its impact on both research and education in theoretical physics at Caltech.

The Institute for Quantum Information and Matter (IQIM) is an NSF-funded center founded in 2011 with a 5+1 year renewal in 2018. Initial five-year funding from the Moore Foundation at an annual level of $1M is being replaced by support from the IQST endowment. Currently, this supports a faculty chair, experimentalist and computer scientist postdocs (theory postdocs being supported by Burke), and some administrative expenses. The IQIM includes summer research opportunities through the QuantumSURF and WAVE programs, the latter targeting women and underrepresented minorities, and a strong outreach program.

One issue of concern about IQIM/IQST that arose in our discussions with IQIM members regards the collaborative environment. Specifically, it appears that on the experimental side, the IQIM predominantly serves as a vehicle to support individual research groups and is not effectively fostering new collaborations on the boundaries of traditional disciplines. One difficulty may be the physical separation of the various groups, with a lack of shared interactive spaces. The regular activities, which include two seminar series and a faculty lunch, may need to be adjusted or augmented to promote more intergroup communication.

Caltech is very well-positioned as a leader in this timely and exciting field, and we find the level of effort and support through IQST to be extremely appropriate. We support maintaining the undergraduate research and outreach components of the Center and urge the Center to more actively encourage collaboration at all levels, from PhD students to faculty and outside team members.

3. PMA is committed to fostering an inclusive environment and improving its diversity. We would appreciate your advice on how we can engage in better outreach to increase the number of applicants from underrepresented populations, and to improve our success rate in recruiting these populations. We are especially interested in how to increase the representation of women at the prize postdoctoral and faculty levels.

The Committee was impressed with the efforts to improve diversity in the division at all levels: faculty, postdoctoral and graduate; there is clear progress in raising awareness of this issue. We specifically commend the PMA Division Head Fiona Harrison for concrete efforts to enhance the overall climate and feeling of inclusion within the Division. The encouragement of family friendly events, WiMPA activities, and the work toward enhancement of graduate life are important steps in the right direction. Now that these first initiatives are showing success, additional efforts can be started with the expectation that there will be wide acceptance across the division. These should be built into processes at all levels and the collective mindset of the Division, and not be reliant on the priorities of individual leadership.

We would like to highlight the FUTURE program, which ran for the first time this fall in physics and clearly has potential to increase the diversity of graduate applicants both at Caltech and elsewhere. We encourage PMA to continue and to expand the program to more participants and to include mathematics, based on the interest expressed by mathematics faculty. PMA should be able to secure future support for this program from within the Institute, in line with the Institute's stated commitment to diversity. The VC recommends inviting Caltech women and minority undergraduates to future FUTURE events, as some conveyed to us that they felt left out of what appeared to be a program with information highly relevant to them and the opportunity to meet with peers from other schools. The chance to meet current Caltech women and minority undergraduates would be positive for the outside FUTURE participants as well. Finally, we encourage the organization of additional programs like FUTURE to increase the pool of diverse candidates by bringing young researchers at other levels, such as PhD students and postdoctoral researchers, to experience Caltech.

Recognizing and addressing unconscious bias in all aspects of the Division's activities should be at the core of the ongoing effort to increase diversity and foster inclusion. Many studies have shown unconscious bias to be ubiquitous among both men and women. While attention to this is especially critical in the faculty hiring process, as we discuss in more detail below, unconscious bias is also a major factor in recruitment and retention of undergraduate majors, graduate students, and postdocs. We note that

faculty members, when asked, were not aware of opportunities for such training on campus. The Division leadership should formulate a common-sense strategy for eliminating unconscious bias in a way that will be seen as worthwhile and not just as yet another bureaucratic time burden.

The faculty hiring procedures in the Division should be carefully examined and revised as appropriate. In discussions with faculty, we saw some express the attitude that diversity was a priority competing with excellence. Addressing this, and other aspects of unconscious bias specific to hiring, through appropriate training should be required for serving on faculty search committees. Also, we recommend that the membership of all search committees should include faculty from underrepresented groups and/or faculty for whom increasing diversity is a particular priority. A review of best practices should be conducted by each search committee at the beginning of its work. We recommend that the transparency of the hiring process within the department be increased, which would result in better appreciation of the efforts to foster diversity. Assessment of the progress of the search should be made at various points to make sure that members of underrepresented groups are being treated fairly. In this connection, we mention a perception, which we identified in discussion with postdocs, that faculty offers are made to men at earlier stages in their careers (postdoctoral level) than women ("just-tenured" level), conveying a message that women are not "good enough" for Caltech unless they have demonstrated their commitment and talent by getting tenure somewhere else. Flexibility in addressing dual-career hires is essential, and will continue to be a challenge in the academic field. Five-year bridging arrangements for partners and spouses do not appear to provide adequate solutions, based on the results of recent failed recruiting efforts, in part because they typecast the trailing partner/spouse. Overall, our view is that Caltech, given its resources, could do more. We are concerned that if PMA continues with only its current strategies in faculty hiring, in spite of their obvious merits, not much will change before the next committee review.

For improving the climate and work conditions for members of the division, greater access to childcare should be a particular focus. In our discussions, we found that this was particularly challenging for postdocs and graduate students, both on the basis of cost and on priority in the waiting list for campus childcare, but it is a concern for new hires and existing faculty as well.

The Committee's visit did not include a discussion of the procedures for handling discrimination and harassment situations in the Division. Our sense is that recent high-profile events have drawn ample attention to the need for improvement in handling such situations and we expect that care will be that to handle any future situations appropriately based on this experience.

Gathering, disseminating and analyzing the information about the results of efforts to increase diversity is vital. Tracking the success of FUTURE by monitoring graduate school applications will be valuable in establishing and improving the program. For postdoctoral researchers, since hiring decisions are made to a significant extent by individual faculty, the collection and sharing of overall demographic information could be used to provide

guidance in hiring, following the example of the Burke Institute's progress in increasing diversity. Overall, progress should be actively monitored, with the realization that different constituencies (undergraduates, graduate students, postdocs, faculty) inherently evolve on different time scales, with particular attention to the critical mass effect. Finally, the Division should consider scheduling a visit by the APS to assess the climate in the physics department. Currently, the Committee on the Status of Women in Physics (CSWP) sponsors site-visit programs, and there is an option to jointly host a site visit with the Committee on Minorities (COM).

4. In the last three years the division has invested in significant efforts aimed at improving the quality of the graduate student experience, particularly in physics and mathematics. We would like feedback on how successful these efforts have been, and whether there are ways that we can improve further.

The committee met with both graduate students and faculty to discuss the curriculum, graduate student funding issues, faculty and peer interactions, and facilities impact on graduate studies. Efforts to extend the positive culture and support structure in astronomy to physics and mathematics have resulted in substantial progress. Across the Division, graduate students were very positive. about the student program director and about social events to meet each other. Significant efforts have been made to improve work and discussion space for graduate students. In mathematics, the impact of renovations in Linde Hall was noted very positively by students. In physics, the efforts to tailor the shared working space in West Bridge to meet student preferences are commendable, though we recommend continuing effort to ensure the new space is used effectively; in particular, it seemed to us that there was a lack of huddle space for smaller groups to interact without disturbing others. The graduate course curriculum, also central to the graduate student experience, will be discussed further in Point #5.

Graduate student funding clearly emerged as the key issue in graduate student experience. The committee identified a critical need for fellowship support for first year students. In Astronomy, this need has been met by pooling scarce resources.
Finding the necessary funding and extending first year fellowship support to Physics and Mathematics would enhance recruitment and avoid inappropriate grant support for most first-year students. It might also facilitate some form of formal or informal rotation of first-year students among the various disciplines before they select a field of research. The experience of advanced students would be improved by having at least some teaching-free period to focus solely on their research.
Additional fellowship support thus should be targeted for non-GA final-year students and considered as a recruitment tool in appropriate cases. Additional ways should be found to incentivize faculty to support 2nd+ year students on grants.

The benefits and challenges of working as a teaching assistant are central to the graduate student experience. We are concerned that the organizational principle of the TA program in the Division seems to be to cover the teaching needs by employing graduate students who do not have fellowship or grant support at a lower level of

status, pay and benefits. There is an opportunity at Caltech to go beyond this to develop a creative model that builds a culture where good teaching matters. Teaching should be established as a critical part of graduate student training for all students in the PhD program. The annual pay and benefits for TAs should be on a par with grant-supported research assistantships. The number, selection and course assignments of TAs should be determined by the teaching needs of the division, and undergraduate TAs and graders should be used for pedagogical, not budgetary, reasons. Within the division, there should be recognition and rewards for excellent TAs, with exceptional performance by a single TA in physics continuing to be recognized by the Stewart Prize.

5. *We would benefit from an assessment of our educational programs across the three disciplines. At the undergraduate level, are there ways that we can better exploit the small student to faculty ratio to provide a unique and enriching educational experience? At the graduate level, what are the most influential ways that we can improve the quality of teaching and mentoring?*

While the Division can be proud of some truly excellent teachers and laudable recent curricular developments, most notably in physics, overall the quality of classroom teaching in the PMA Division appears to be highly variable. The PMA faculty members have made sparse use of CTLO, instead using it mostly for TA training. The select professors who have used CTLO to improve their teaching tend to be the better teachers from the outset.

It appeared to the Committee that the culture in the division is similar to that in many research universities, in which the quality of teaching and innovation in course design has essentially no impact on decisions regarding faculty hiring, tenure and promotions. We feel that Caltech, with its small size and small student-to-faculty ratio, should follow a different path, and work towards a unique culture where the highest levels of research combine with the level of teaching in a top liberal arts college.

Further, we saw that prospective undergraduate majors, especially in Mathematics and Astronomy, are weeded out at an early stage by their experience in introductory courses. In particular, students who come in with strong interest but less preparation than the top of their cohort are being discouraged from continuing rather than being given the chance to get up to speed in the first years of study, which, given the stringent standards of Caltech undergraduate admissions, it seems that many should be capable of doing. This "weeding out" fuels an attitude that an undergraduate major should only be professional training for an academic career in the field. It is likely that this situation contributes significantly to making the student diversity in the division low even relative to Caltech undergraduates as a whole.

Undergraduate physics: The current majors who attended the committee discussion had lively and strong opinions. They spoke with great enthusiasm of certain professors and courses and critically of others. Physics 11 stood out as a really unique and valuable course for certain students, as did Physics 101, the graduate "orders of magnitude" course. They were very positive about having computational material in

the courses, and the structure of the computational physics laboratory course, with an "optional" first quarter followed by a required second quarter, is well designed. Students reported that they rarely went to their professors' office hours, although a couple did interact with professors after class or by appointment. All students indicated that they do summer research at Caltech or elsewhere starting after the first year, which is commendable.

Graduate Physics: The physics curriculum was revised about a decade ago by eliminating a number of required first-year courses to facilitate rapid entry of graduate students into their research disciplines. The Committee recommends formally assessing the effects of these changes at this time. A particular concern we identified is that there are now no courses beyond the "pizza" seminar series that are common to all students in the first year, which weakens the building of a class cohort through early interactions between incoming students. The qual prep class is very valuable and popular but not needed by all students, and so does not serve the purpose. This may be an opportunity to develop a new core course to cover topics relevant to current physics research that are not included in the traditional core curriculum. Also, we suggest consideration of a required course in professional skills such as teaching, scientific writing and presentation, and communication with non-scientists, which could benefit all first-year students and promote interaction through group assignments.

Undergraduate Mathematics: There is pride in the math curriculum being "the most challenging in the country" and the recipients of math degrees are indeed outstanding. However, we are concerned that this attitude as currently implemented may be turning away talented and motivated students who had less rigorous high school math opportunities. The focus of our discussion was on the core sequence. In particular, Math 1a can be characterized as dated and appears to drive a large number of potential math majors into other fields. We recommend that the math department should reconsider the content and the order of the core sequence, with one goal being to be more inclusive of undergraduate students with strong interest in the subject and potential for success but without sufficient high school preparation to place out of Math 1a. Possible changes discussed by the committee would be to start with linear algebra, putting Math 1b in front of Math 1a, or, more radically, to start with a proof-based course on discrete mathematics.

The small size of the Mathematics faculty means that it is stretched to cover the full range of courses offered for the undergraduate and graduate degrees. The planned hires will help with this, but more attention should be given to leveraging the resources of other departments, primarily the Department of Computing and Mathematical Sciences (CMS). A related problem is that Math only accepts ¼ of its SURF applications. While we understand that it may be challenging to find good summer research projects in math suitable for undergraduates that fit with faculty research, summer research experiences are very important for undergraduate math majors. Interdisciplinary projects with CMS could be developed to strengthen the department's ability to support summer undergraduate research and provide a broader career perspective for undergraduate math majors.

Graduate Mathematics: The main issue is the very small size of the department. This makes it inherently difficult to cover the breadth of mathematical disciplines, though the current department is doing its best to meet this challenge. On the positive side, it also means that the concerns of individual students can be identified and addressed, for example through the regular closed town hall meetings. We note here that in mathematics, the work of TAs is essential for the department to cover its undergraduate teaching obligations, in possible conflict with our recommendation for more fellowship support. If that proves to be the case, the department will need to explore options for bridging the gap.

Astronomy: The small size of the program in Astronomy allows a strong interaction between students and faculty in small classes and research experiences, with graduate students in particular reporting a positive experience and appreciation of their access to faculty and world-class research tools. However, as in the mathematics program, there is a reported weed-out effect for undergraduates, in particular with Physics 1 driving prospective undergraduate astronomy majors to GPS. The faculty expressed the attitude that "the world only needs so many astronomers." However, it may be short-sighted to view the undergraduate program solely as professional training for a career in astronomy. A degree in Astronomy sets the stage for success in many technologically and computationally oriented careers; having a cohort of scientifically knowledgeable alumni in industry could strongly benefit the department and the Institute long term. The department should consider ways to be more inclusive of talented undergraduate students with strong interest in the subject but with inadequate high school preparation for Physics 1.

We understand that many of the changes discussed above can happen only on long time scales, but we encourage the members of the division to examine and discuss the existing culture and actively decide whether and how to take things in new directions. Putting a premium on excellent teaching in all styles, from traditional to innovative, is key to promoting student engagement and success. In addition, it can contribute significantly to efforts to increase student diversity.

Other Observations

<u>Space - Lab Needs - Kellogg Renovation</u>
Access to high quality lab space is essential for recruiting the next generation of single-investigator experiments across all fields. Further, the existing dispersed nature of research within PMA is a significant barrier to collaborative research at the bench level and greatly limits the otherwise natural interaction between students and postdocs in related areas. It would be highly desirable to have graduate and postdoc offices in broadly related areas be co-located, and ideally in close proximity with labs and theory.

For the current experimental research strengths in physics and astronomy to thrive and stay at the forefront, including attracting and retaining the best talent, we strongly recommend that the Division and Institute prioritize investment in new on- campus laboratory space. The renovation of old Kellogg Laboratories is at the top of this list, with improvements to the laboratory space in Bridge being a close second. Further, we strongly recommend that the Division and Institute continue support of crucial off-campus astronomical facilities, such as Palomar and OVRO.

Shared Facilities and Administrative Support

The Committee heard inconsistent views regarding the need for more computational resources within the PMA Division. This may be simply the result of different needs among distinct research disciplines, but we did not find enough evidence to support a clear recommendation. Improved machine shop facilities are essential. More support and exploration of sharing of resources with other divisions should be considered.

In the last few years, there has been a dramatic improvement in administrative support with the restructuring to separate administrators and grant managers. We heard a lot of praise, especially from the untenured faculty, for the grant application and grant management help from the PMA grant manager department.

Junior Faculty

The committee was very impressed by the talent, energy and enthusiasm of the junior faculty. They were generally satisfied with the support from their departments and the Division, with the chair meeting at least once a year with each member of the junior faculty. We heard specific praise for help with grant applications and grant management as well as with nomination for appropriate awards. The single largest concern was with getting PhD students. The junior faculty expressed a strong desire to improve recruiting of students to Caltech by offering first-year funding and to increase the diversity of the grad student population. Other concerns included lack of shared facilities and technicians, and a wish for stronger support for off-campus astronomical facilities. There was felt to be a need for better information, especially on first arrival, about available services and resources, such as teaching instruction and support. Better information could also include more details about the tenure evaluation process. We suggest that the division should identify a hands-on practical mentor for each junior faculty member to help him or her to "learn the ropes" on arrival at Caltech, and to provide information about procedures and available resources at each stage leading to the tenure evaluation. To allow for more freedom of interaction, the practical mentor would not serve on the faculty member's tenure review committee.

Postdocs

The experience of postdocs at Caltech is strongly dependent on their type of position and research supervisor. As a group, they were concerned about the lack of uniformity in salary, benefits such as parental leave, prestige, and year-to-year security of postdoctoral positions.

Postdocs highlighted the challenges of practical issues at arrival at Caltech. These include finding housing, especially given high prices and transportation issues in the area, choosing health insurance, establishing credit, and dealing with taxes. This is especially difficult for postdocs coming from other countries, slowing down their work by at least one month and up to a year. It was felt that more guidance and support in this transition at the divisional level would be extremely valuable.

The postdoctoral years are a critical time in the career development of young researchers. At the divisional level, we suggest establishing information sharing and guidelines for research supervisors about postdoctoral salaries and work conditions. In particular, all postdocs should have access to at least some travel money for conferences and some fraction of time for working on independent projects such as completing previous projects or developing new ideas. Postdocs should work with graduate and undergraduate students and have opportunities for more formal training in teaching and mentoring. Ways to increase the inter-group interaction and collaboration of postdocs at Caltech, discussed above in the context of the Burke Institute and IQST/IQIM, should be explored more broadly.

The Visiting Committee Process

The committee appreciated the Division's efforts in preparing materials and supporting documentation in a user-friendly web-based format, as well as the support of various staff members throughout the meeting. The Committee would have benefited from a short overview of the science addressed within the division. With the breadth of work in the division, the Committee could also have used additional time to survey the academic environment. All morning sessions on Wednesday were very rushed; we could have beneficially expanded those sessions into Thursday morning.

Conclusion

The Division has been very responsive to the issues raised in the previous visiting committee report and the more recent report on the mathematics department.

The situation in mathematics is much improved since the previous review. The new building provides excellent space for all activities of the department. In particular, the design of classrooms and common spaces promotes the personal interaction essential to the activity of mathematics. Three new appointments have reinvigorated the faculty in the department. Ongoing support is suggested to increase pride and energy in the department, perhaps closer ties with applied math and computing and more joint events with UCLA/USC math departments.

The Committee was encouraged by the initial steps taken to improve diversity in the Division at all levels: faculty, postdoctoral and graduate. These efforts have resulted in visible improvements in the awareness of the importance of diversity and in the overall climate, and lay a foundation for future progress.

For the future, we hope for further action in response to the recommendations in this report, highlighting the most important priorities as follows:

- We hope to see that enhanced efforts in increasing diversity will over the next few years lead to significant improvements in the numbers at all levels and to further improvements in the climate of the departments.

- We hope that the Division will find resources to offer fellowship support at least to all first-year graduate students in the Division, with a concomitant improvement in graduate student recruiting and experience.

- We hope to see investment in new on-campus laboratory space, particularly in the old Kellogg Laboratories, and continued support for crucial off-campus astronomical facilities such as Palomar and OVRO, essential for the current experimental research strengths in physics and astronomy to thrive and stay at the forefront.

- We recommend that a formal assessment of the effects of the last round of changes in the physics graduate curriculum be conducted, with a particular focus on possible revisions to improve the experience of first year students.

- We recommend that the TA program be reassessed and changes instituted to make the TA experience more central to the professional development of graduate students.

- We hope to see discussion and initiatives to put a greater value on excellent teaching at both the undergraduate and graduate level and to make changes in the introductory course sequences that will make the programs more inclusive for students with strong interest and potential but lesser high school preparation.

Lastly, we emphasize that Caltech's PMA Division needs to make concerted efforts to get the most out of being small. This includes taking maximal advantage of the opportunities that come from the low student/faculty ratio, fostering collaboration and unique capabilities that may emerge by working with other divisions, and providing internal support for developing new and risky ideas.

Caltech's Division of Physics, Mathematics and Astronomy is justly widely recognized as one of the very top in the world in these fields. By being responsive to the issues and recommendations, the division can, we believe, maintain its stellar reputation as academia evolves and adapts into the 21st century.

The 2018 PMA Visiting Committee
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