University of Colorado **Boulder**

2017 Program Review

Department of Astrophysical and Planetary Sciences

Academic Review and Planning Advisory Committee Report

Approved

04/18/2018

Provost and Executive Vice Chancellor for Academic Affairs: Date

Contents

Process Overview

The review of the Department of Astrophysical and Planetary Sciences (APS) was completed in accordance with the 2017 review guidelines. The Academic Review and Planning Advisory Committee (ARPAC) conducts and writes the final reviews of all Boulder campus academic units. The unit prepared a self-study during 2016, which was checked in January 2017 by an internal review committee of two CU Boulder faculty members from outside of APS. The internal reviewers found the report to be "comprehensive [and] accurate," and noted that it "identifies strategies and needs for continued success of the department." The external review committee, consisting of three experts within the discipline from outside of the University of Colorado, visited the unit on April 20-21, 2017, reviewed relevant documents, and met with faculty, students, staff, and university administrators. Both the internal and external reviewers' comments and recommendations are cited at appropriate points throughout this report. This public document reflects the assessment of and recommendations for APS as approved by ARPAC.

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Unit Overview

The campus's standardized unit description may be found on the website of the Office of Data Analytics at https://www.colorado.edu/oda/institutional-research/institutional-level-data/information-department/academic-review-and-planning. This report cites Office of Data Analytics statistics posted on October 20, 2016, reflecting the state of the department during the academic year (AY) 2015-16.

The Department of Astrophysical and Planetary Sciences performs teaching and research in the areas of astrophysics, planetary science, and space physics. It offers a Bachelor of Arts degree in astronomy, and Master of Science and Doctor of Philosophy degrees in astrophysical and planetary science. Additionally, it offers an undergraduate minor in astronomy. APS operates the Fiske Planetarium and the Sommers Bausch Observatory.

In 2010 the National Research Council (NRC) ranked the department fourth nationwide, and the external reviewers judge APS to be a "highly ranked (top 20) department with a world-class faculty." The external reviewers make note of the department's broad research portfolio, encompassing astrophysics theory, observation, instrumentation (ground and space), planetary science, and space plasma physics.

Personnel and Governance

The self-study reports 25.5 rostered tenured and tenure-track faculty as of fall 2016, while the Office of Data Analytics reports 23 as of fall 2015; ongoing growth of the department is responsible for this variance. The Office of Data Analytics reports that APS tenured/tenure-track faculty salaries at all ranks (assistant, associate, and full professor) match the American Association of Universities (AAU) public institution peer average for the discipline. Non-tenured academic staff as

of AY 2015-16 was composed of three instructors or senior instructors, 17 TAs or GPTIs, 21 research staff, and nine research assistants. The Office of Data Analytics reports seven staff and 73 student hourly assistants are assigned to APS.

Several TTT faculty are jointly appointed with either the Laboratory for Atmospheric and Space Physics (LASP) or JILA (formerly known as the Joint Institute for Laboratory Astrophysics). According to the self-study, APS plans further joint hires with LASP in connection with the National Solar Observatory (NSO). Other faculty are involved with the Center for Astrophysics and Space Astronomy (CASA), an affiliated unit within APS.

The external reviewers compliment the senior APS faculty as productive and highly regarded. They also say that recent astrophysics faculty hires are of a high quality, and that their fields (galaxy evolution and exoplanets) are active and exciting. The external reviewers also note the high quality of faculty hires in solar physics, but that the field of solar physics is small and rapid expansion in this direction carries risks.

In fall 2016, the student enrollment constituted 57 graduate students and 276 undergraduate majors. The number of undergraduates has increased substantially; Office of Data Analytics statistics show a 60% increase in APS majors from 2010-2015.

The Department of Astrophysical and Planetary Sciences bylaws were last revised in March 2011. The department chair is elected by the rostered faculty (senior instructors and assistant, associate, and full professors) and serves a three-year term. In the past, there was a single associate chair; the department has now added a second associate chair in

response to undergraduate enrollment growth. The associate chairs' respective duties include graduate and undergraduate education. The executive committee consists of three elected faculty members, plus the chair and associate chairs. The department has evolved its curriculum committee into separate graduate and undergraduate curriculum and concerns committees. In fall 2015, the department formed a new climate committee.

The external reviewers comment on the relationship between APS and CU Boulder research institutes. They note that this relationship appears to bear more strongly on APS than on other campus departments and they see both pros and cons with this situation. As mentioned above, APS-rostered faculty are typically associated with LASP or JILA, or with CASA, an APS-based center. The external reviewers note that these relationships lead to new opportunities and capabilities; however, the overhead return to the department is relatively low, and the institutes develop their own hiring priorities that may not be aligned with APS. In particular, the external reviewers note that LASP led the recent initiative to bring the National Solar Observatory to Boulder; several faculty full-time equivalent (FTE) positions were promised in support of this effort to be rostered in APS. This led to the hiring of excellent faculty in the solar physics area, but this expansion may not have been fully supported by APS faculty. The external reviewers recommend that institute-directed hiring be used sparingly.

The self-study includes an extensive and well-supported strategic hiring plan. The plan impressed the external reviewers, including its emphasis on time-domain astrophysics, exoplanets, and extragalactic astrophysics, areas of research that they note will be benefit from current federal projects,

including the National Aeronautics and Space Administration (NASA) James Webb Space Telescope and the future National Science Foundation (NSF) Large Synoptic Survey Telescope. The external reviewers recommend that APS target future junior hiring in these areas, with attention to diversity and underrepresented groups.

The self-study endorses the formation of a college of natural sciences. Additionally, it requests additional fundraising for the natural sciences to provide for endowed chairs, postdoctoral positions, graduate fellowships, and undergraduate scholarships.

Research and Scholarship

The department and its faculty maintain close ties to LASP and to JILA, as well as to other space-focused and Boulder-based research enterprises. CASA is a center that operates within APS. Many institute faculty, including the LASP director, are rostered in APS. Department faculty's research directions include astrophysical theory, astrophysical observation, ground-based instrumentation, space-based instrumentation, space plasma physics and instrumentation, planetary science, solar physics, and astrophysics and planetary science education.

As said earlier, in 2010 the NRC ranked the Department of Astrophysical and Planetary Sciences fourth nationwide and the external reviewers last year placed the unit "in the top 20." APS faculty include a CU distinguished professor, a member of the National Academy of Sciences, a Hazel Barnes Prize winner, and two College of Arts and Sciences professors of distinction. Office of Data Analytics statistics indicate that the APS share of research expenditures (including allocations from institutes to tenure-home department) averaged $29.6M per year over the five years ending fiscal year (FY) 2016, of which an average of

$5.6M was run directly through APS and the remainder run through institutes and other units. For FY 2016, APS grant expenditures totaled $38.5M, ranking the department first among nine units being reviewed in the current cycle. Department research efforts in solar physics were expanded through 2.5 full-time equivalent tenured/tenure-track faculty hires, in connection with the National Solar Observatory (NSO) headquarters move to Boulder. Research efforts in astrophysics and exoplanets are facilitated by ties to observatories and NASA programs; CU Boulder is a member of the Astrophysics Research Consortium (ARC) for their 3.5 meter telescope, the Sloan Digital Sky Survey (SDSS IV) collaboration, and the Dunn Solar Telescope consortium.

The Office of Data Analytics ranks APS as first among seven relevant units in this review cycle in refereed books and monographs per tenured/tenure-track faculty, third of eight in refereed articles and chapters, sixth of eight in conference papers and presentations, second of three in textbooks, and sixth of seven in edited books.

Undergraduate Education

The astronomy major operated by APS has shown remarkable growth. The self-study reports 276 majors in fall 2016. A 2015 survey by the American Institute of Physics notes that in AY 2014-15 APS awarded 39 bachelor's degrees, first among 29 astronomy departments. This survey also noted that nationwide, astronomy bachelor's degrees increased 34% over a ten-year period. Additionally, the department is an important part of the new minor in space associated with the CU Boulder Grand Challenge. The self-study suggests that astronomy graduates go into a broad range of jobs including education, teaching, outreach, business (including companies involved in data analysis and information technology), and the military. The external reviewers recommend an increased effort to track

former undergraduate majors to learn their career paths, and to ascertain how well the undergraduate curriculum serves APS graduates.

The undergraduate astronomy major includes two tracks: an astrophysics/physics track taught at a higher mathematical level and intended to prepare students for astronomy graduate study or for work in technical fields, and a general astronomy track intended for students who plan careers in K-12 teaching, policy, science writing, or planetarium and museum work. The self-study states that 60% of graduates completed the astrophysics/physics track, while 40% completed the general astronomy track. The number of enrolled majors increased by roughly 25% over the previous two years according to the self-study; this development has prompted discussions within APS regarding departmental goals (major counts, course offerings, and technical level) and the purpose of the undergraduate general astronomy track. The self-study reports that only 4% of astronomy graduates go on to K-12 teaching.

Office of Data Analytics statistics for AY 2015-16 indicate that APS taught 10,613 student credit hours, ranking APS fifth of six units in this review cycle. Student credit hours increased 35% over the previous five years. Tenured and tenure-track faculty taught 60% of these student credit hours, while instructors and senior instructors taught 38%. Non-majors accounted for 82% of these student credit hours, as 1000- and 2000-level courses targeted at non-majors constitute the bulk of APS's teaching. FCQ course and instructor ratings were the highest among six relevant units in this cycle. The median time to degree for undergraduate students is 4.33 years.

The internal reviewers note that the department achieved significant growth in the undergraduate major without additional

staff or infrastructure support, and that additional growth within the space minor will support this trend. The internal reviewers recommend increasing undergraduate support staff by at least two full-time positions, as well as increasing undergraduate infrastructure support funding. The external reviewers recommend increasing the undergraduate program assistant's position to full-time.

The external reviewers commend the Fiske Planetarium and the Sommers-Bausch Observatory, the teaching faculty associated with these facilities, and the breadth and depth of the courses that these facilities make available, especially at the introductory level. The Sommers-Bausch Observatory includes a 24-inch telescope used for two APS upper-division courses. The external reviewers suggest that these facilities could be integrated into additional courses, particularly beyond the introductory level, and notes that this may require additional staff and support.

A large share of students who declare astronomy as their first major do not graduate with this degree. Office of Data Analytics statistics for the undergraduate cohorts entering CU Boulder between 2007 and 2010 show that, of students declaring Astronomy as their first major, 32% graduated with an Astronomy major within six years. The comparable figure for all natural sciences majors in the same period was 48% of students graduating within six years in the major that they first declared. Of those declaring astronomy as their first major, 53% graduated with a College of Arts and Sciences degree (any major) within six years and 60% graduated from CU Boulder overall (any college). Campus-wide, the six-year graduation rate for these cohorts was 70%.

The internal reviewers' student survey was completed by 62 undergraduates, of whom 59 were majors. Of the 62 respondents, five were first-year students, 14 were sophomores, 15 were juniors, and 28 were seniors. Students were generally satisfied with the department; however, they expressed dissatisfaction for "availability of required courses" at a rate of 12.9% and "scholarship support" (27.4%). Overall, 84% of surveyed students were "satisfied" or "very satisfied" with the department, while 10% (n=6) were "dissatisfied" or "very dissatisfied." A significant number of students commented positively about opportunities to participate in research and complimented the faculty; these results parallel opportunities that the APS self-study describes for majors to participate in research, teaching, and outreach.

Graduate Education

The self-study reports 58 graduate students enrolled in fall 2016, with a roughly stable head count over the past ten years. The self-study also reports that "APS admits around 8 graduate [students] per year, in line with the funding that APS faculty are able to generate." APS graduates about six Ph.D. recipients per year, a number comparable to the fourteen largest graduate programs in the discipline nationwide. The external reviewers comment that the graduate students are an impressive cohort who are doing first-rate research and generally have a positive view of APS. The self-study explains the opportunities for graduate students to participate in the APS teaching programs, the need for graduate students to gain access to major ground-based telescopes, and the current state of the various TA, RA, and fellowship funding paths open to graduate students; APS requests additional funding for the endowment for graduate student activities. The self-study also requests that TAs and RAs be paid the same stipend rate, as well as an increase in funding for graduate fellowship programs. Office of Data Analytics statistics for AY 2015-16 indicates the median time to

degree in the Ph.D. program is 5.97 years, which ranks APS fifth-longest in terms of time to Ph.D. among the six relevant units in this review cycle.

The internal reviewers' graduate student survey was completed by 23 doctoral students and no master's students. Respondents generally expressed satisfaction with the program and with specific program aspects; only "clarity about program requirements" received more than 10% responses in the "dissatisfied" or "very dissatisfied" categories (13.4% [n=3] indicated they were "dissatisfied" with the clarity of program requirements). Overall, 87% of respondents were "satisfied" or "very satisfied" with the APS graduate program. In graduate students' comments, common themes included (a) developing more diverse faculty, (b) better advising for first- and second-year graduate students, and (c) improvements to the comprehensive exams system.

The external reviewers note some graduate student concerns related to the APS system for comprehensive exams and related milestones. The external reviewers suggest that the department re-examine the current exam implementation, including to better explain to students how ideas and objectives within the current student milestone system relate to the comprehensive exam system.

The internal reviewers point out the disparity between TA and RA stipends and recommends that these pay rates be normalized.

Postdoctoral Program

The external reviewers met with a few of the APS postdoctoral fellows, primarily associated with CASA. The external reviewers note that the postdoctoral fellows did not feature in the APS self-study documents, and it feels that postdoctoral fellows are

underutilized as a department resource. The external reviewers praise the high quality of the postdoctoral fellows they interviewed and notes some quality-of-life issues that would improve the postdoctoral experience, including spousal employment, child care, and socializing events and opportunities.

Space and Infrastructure

The self-study identifies limited ground-based telescope access as a major unit weakness. Consequently, the external reviewers' report also focuses on access to large telescopes and incorporates a substantial discussion regarding needs and options. The internal reviewers also note the need for support for telescope facilities necessary to maintain APS's reputation at all levels.

The LASP-led effort to bring the National Solar Observatory (NSO) to the Boulder campus resulted in new APS-assigned faculty lines. The NSO is scheduled to build and operate the $350M Daniel K. Inouye Solar Telescope in Maui, Hawaii, which will be the world's largest solar telescope. The external reviewers view this as a major opportunity for APS. The external reviewers also note the recently negotiated partnership for access to the Sacramento Peak, New Mexico-based Dunn Solar Telescope, as well as possibilities for accessing multiple non-solar telescopes, both large (and expensive) and more modest. The external reviewers recommend that APS identify paths that would allow faculty to participate in telescope projects ranging from large (the Giant Magellan and Thirty Meter telescopes) to more modest (the Large Millimeter Telescope and the Caltech Submillimeter Observatory). "Undoubtedly these would involve a significant fund-raising effort," the external reviewers add.

The internal and external reviewers note increased demand for space and resources resulting from recent faculty hires, and that the dispersal of faculty between the Main and East campuses, including to spaces in JILA, CASA, LASP, and APS, may produce concerns about the sustainability, continuity, and other responsibilities of APS. Nonetheless, the internal reviewers state that the existing collaborations with the institutes and centers produces a very stimulating research and teaching environment. Additionally, the self-study encourages construction of the long-proposed Duane Physics H-wing extension.

Inclusive Excellence

Office of Data Analytics statistics as of fall 2015 shows that, of the 23 tenured/tenure-track faculty, two were women and none were members of underrepresented minorities. The self-study reports that as of fall 2016, APS tenured/tenure-track faculty included two female assistant professors and one female associate professor, out of a total of 27 persons (25.5 full-time equivalent positions). The external reviewers note the recent additions of two women to the tenured/tenure-track faculty, but also remark that significant work remains regarding gender balance. The external reviewers recommend that future hiring efforts pay special attention to addressing existing demographic and diversity imbalances. The self-study notes that a 2015 NSF report showed that 32% of nationwide astronomy PhD recipients were female while 10% were members of ethnic minorities.

According to Office of Data Analytics statistics, undergraduate majors are approximately two-thirds male and one-third female, and the self-study reports that this ratio has held constant for over ten years. The Office of Data Analytics reports that the fraction of students of color in AY 2015-16 (23%) had increased by 26% over the previous five years, and that the fraction of

students from underrepresented minorities (16%) had increased by 8% in that same time.

At the undergraduate level, APS operates the Science, Technology and Astronomy Recruits (STAR) program, which attempts to recruit and retain undergraduate science majors, especially through outreach to underserved Colorado high schools.

The graduate student population gender balance as of AY 2015-16 was 30.4% women and 69.6% men, like that of the undergraduate population. The external reviewers note that this ratio is unbalanced relative to peer institutions and should be corrected. The APS women-to-men ratio does, however, appear to be consistent with discipline-wide statistics; 32% of recent Ph.D. recipients are women, as mentioned above. The external reviewers also indicate that at peer institutions, more diverse faculty hires often welcome a more diverse student population; APS should fully pursue such opportunities.

The internal reviewers' surveys asked both undergraduate and graduate students to respond to the statement, "APS encourages a climate that is tolerant and respectful of diversity." Among the undergraduate respondents, 82% "agreed" or "strongly agreed," while 11% (n=7) "disagreed" or "strongly disagreed." Among the graduate student respondents, 74% "agreed" or "strongly agreed," while 8.7% (n=2) "disagreed" or "strongly disagreed." The written comments on several of the undergraduate internal review surveys include requests for additional help to overcome a poor high school background in math and science and gender-related problems with faculty mentors. As mentioned above, written comments in response to the graduate student internal review survey mentioned a need for faculty diversity.

In the self-study and in the APS external review response, the department states its intention to continue pursuing inclusive excellence. Towards this end, APS requests the following: faculty lines designated to support diversity, increased support for the Chancellor's Postdoctoral Fellow program with a path to a faculty position, a dedicated career assistance office to serve spouses and partners of faculty and prospective faculty, subsidized child care for faculty, staff, and students, and increased resources for the Strategic, Targeted, and Accelerated Recruitment (STAR) program.

Climate

In 2015, the Department of Astrophysical and Planetary Sciences formed a standing climate committee. This group has initiated training for key APS committees and has discussed strategies for improving department climate and pursuing inclusive excellence in hiring. The APS department website now devotes a page exclusively to diversity and collegiality, at https://www.colorado.edu/aps/our-department/diversity-and-collegiality. This page includes statements regarding campus policy and procedures. Additionally, it includes a form to communicate issues or concerns anonymously to the APS climate committee.

The external reviewers confirm climate issues within the department, including "strained relations among some senior astrophysics faculty and senior members of LASP." They state that they were "troubled by reports from junior faculty and even students that these interactions have negatively affected the environment." The external reviewers applaud the climate committee's efforts but note that tensions remain. They recommend that department leadership continue to actively address climate concerns. APS agrees with this evaluation and request the provost's support to administer an annual climate survey.

The external reviewers also asked student, staff, and faculty whether APS neglected any discrimination or harassment issues, and responses did not address specific concerns. However, the external reviewers are concerned about the lack of knowledge and training in how to deal with such issues, and about which issues trigger mandatory reporting. The external reviewers recommend additional periodic training for APS staff and faculty. The unit states its intentions to offer refresher training sessions.

Past Reviews

The internal reviewers express concern about female faculty members' survey responses regarding the department's social and professional climate. Additionally, the internal reviewers report some faculty unhappiness with the department's climate. In its response to the internal reviewers, APS points towards the new climate committee and promises to continue to work on this issue.

The last the Department of Astrophysical and Planetary Sciences review took place in 2010. At that time, ARPAC recommended addressing a lack of student population diversity; the self-study in the current review reports little progress but notes that APS numbers are in line with national averages. In response to other recommendations, APS revised its bylaws to give instructors voting rights, and revised the Comps 1 exam. APS also developed a prioritized faculty hiring plan. Four of the eight hires since that time followed from this plan, while the other four hires resulted from special initiatives (Aerospace Ventures [ASV] and solar physics) that operated outside of hiring plan priorities.

ARPAC made recommendations in the 2010 review to resolve space issues. Since then, the Department of Atmospheric and Oceanic Sciences (ATOC) moved to the East Campus, a move that opened Duane offices and labs to CASA. The self-study states that these have been positive changes. Nonetheless, the self-study points out that APS faculty remain widely distributed across several locations including in JILA and offices attached to Folsom Field, as well as the LASP Space Technology Research Center and the Astrophysical Research Lab on East Campus.

Campus Context

The Department of Astrophysical and Planetary Sciences plays an important role in the campus emphasis on space, including the Grand Challenge related to space. APS serves as the tenure home for faculty who have leadership responsibilities in LASP, JILA, and CASA. Along with offering undergraduate and graduate astronomy degrees, APS provides the campus a significant amount of service teaching. It operates the Fiske Planetarium and the Sommers-Bausch observatory, which serve many populations and are key components of campus community outreach.

Disciplinary Context

The external reviewers laud APS for their status as a top 20 department, world-class faculty, and high NRC rankings. APS awards more astronomy degrees than any other department nationwide. The department is highly engaged in planetary and astrophysical research funded through NASA and other national sources, and faculty and graduate students perform their research at several nationally and globally recognized observatories.

Analysis

The Department of Astrophysics and Planetary Sciences is an excellent and highly-ranked component of CU Boulder. Not surprisingly, the unit faces challenges in maintaining and improving on its prominence. These include future access to large telescopes, strategic hiring, improving faculty and student diversity, addressing department climate issues, and support and further development of the undergraduate and graduate programs.

Research

ARPAC commends APS for its strong research program and its high level of engagement with the Laboratory for Atmospheric and Space Physics (LASP), JILA, and the Center for Astrophysics and Space Astronomy (CASA). The department has developed a convincing faculty hiring plan that the external reviewers endorse. Keeping in mind that several faculty members intend to retire soon, APS should continue to hire tenured/tenure-track faculty to build its research program and support its degree programs. The unit should use these opportunities to hire diverse faculty.

Bringing the National Solar Observatory (NSO) to Boulder was a substantial win for LASP as well as for APS. However, it appears that this decision was not entirely supported within APS, since it seems possible that hiring solar physics faculty rostered in the department reduces the potential to hire new faculty according to the APS strategic hiring plan. The external reviewers feel that solar physics research is less compelling than the newer areas identified in the APS hiring plan. Ultimately, department faculty can approve or disapprove rostering a LASP tenured/tenure-track faculty hire within APS; nonetheless, APS has benefited greatly from its association with LASP, and resolving LASP/APS differences in strategic directions would benefit both units. Assistance from the College of Arts and Sciences and the Office of the Vice Chancellor for

Research and Innovation might help settle this issue. ARPAC notes that APS has indeed received faculty lines through the college—not solely through institute hires—in each of the recent years, so it is not the case that solar physics has been promoted in faculty hiring to the exclusion of other fields.

The strategic hiring plan includes faculty who would need access to large telescopes and funding this access would be a challenge to the department's hiring plan and strategic directions. The external reviewers discuss alternative ways to address this challenge. A fundraising plan or some other approach to acquire telescope time is called for.

Personnel and Governance

The Department of Astrophysical and Planetary Sciences and several other departments have proposed breaking the College of Arts and Sciences into smaller colleges, including a natural sciences college. The self-study includes a statement to this effect. Support for a break-up among multiple college units suggests the merits of a serious discussion about the details. Discussions should include both the benefits to the college's current units and divisions, as well as the possible future negative impacts. If a meritorious proposal is developed, then it should be given to the provost and acted upon as appropriate.

Undergraduate Education

ARPAC commends APS for developing its undergraduate degree program into the nation's largest. The department provides many notable opportunities for undergraduates to participate in research, teaching, and outreach. Additionally, ARPAC lauds the department's significant efforts to offer courses to non-majors, to operate the Fiske Planetarium and the Sommers-Bausch Observatory, to support the campus space minor, and to operate the Science, Technology and Astronomy Recruits (STAR) program. ARPAC also finds commendable that as of AY 2015-16, tenured/tenure-track

faculty taught 60% of undergraduate credit hours, faculty earn high FCQ ratings, and that the median time to degree of APS's undergraduates is 4.33 years. However, ARPAC is concerned about the relatively low retention rate within the undergraduate major and encourages APS to investigate possible causes.

In the self-study, APS raises questions about the astronomy major's proper size, graduates' jobs and outcomes, whether the degree program serves its students' needs, the correct curriculum balance, and how to serve underrepresented groups. ARPAC believes these are excellent questions to ask, and it encourages the department to find answers as well as to continue improving its undergraduate degree programs. Further, ARPAC finds the dual undergraduate tracks attractive to a variety of students and recommends that APS maintain both the non-astrophysics and astrophysics tracks.

Considering undergraduate enrollment growth, the self-study requests that the APS undergraduate program assistant be increased from a part-time position to full-time. The external reviewers endorse this request while the internal reviewers recommend at least two full-time undergraduate support staff. The self-study also requests increased TA support. Ultimately, these are requests to the college; ARPAC expects that the college will allocate (or reallocate) support for undergraduate programs in a way that is responsive to enrollment.

Graduate Education

The self-study reports that APS admits approximately eight graduate students per year; given the reported annual APS expenditures of $38 million per year, the bulk of funding is not devoted to the graduate program. The external reviewers praise the graduate student body's high-quality work. The program is also well regarded by its students, according to positive responses to the internal review surveys. Specific student

suggestions for improvement include developing more diverse faculty, better first- and second-year advising, and comprehensive exam improvements. ARPAC recommends that the department consider these suggestions. The external reviewers recommend additional efforts to improve the graduate student population's gender balance, as well as to hire more diverse faculty. ARPAC agrees with these recommendations. The comprehensive examination system received attention in the last ARPAC review and was subsequently revised. Apparently, issues remain, and APS is considering further revisions. ARPAC encourages continuing these efforts. ARPAC recommends that APS also take steps to improve the Ph.D. program time-to-degree.

Postdoctoral Program

Like the external reviewers, ARPAC is concerned that the self-study did not address the postdoctoral program. ARPAC encourages APS to work to integrate postdoctoral fellows into department life, to make full use of their expertise, and to track postdoctoral outcomes and placements as a way of documenting postdoctoral fellows' success.

Space and Infrastructure

The Department of Astrophysical and Planetary Sciences faculty face ongoing problems to secure adequate time on ground-based optical and radio telescopes. The external reviewers present a detailed analysis of options and recommend that the department identify paths that would allow APS faculty to participate in a variety of telescope projects. Such facilities are important to the departments' future research capabilities, thus the department should develop a fundraising effort in support of telescope time, as suggested by the external reviewers. Telescope access is central to APS's strategic hiring plan and graduate program quality, as well as the department's aspirations. ARPAC notes that some campus portion of facilities and administrative (F&A) funds generated by APS

could be applied to external infrastructure (the telescopes are located out of state), rather than being confined to on-campus infrastructure.

The Department of Astrophysical and Planetary Sciences observes that its faculty is dispersed among multiple Main and East Campus locations. To a large extent, this dispersal is a natural consequence of faculty associations with LASP, CASA, and JILA. In its self-study, APS advocates for the Duane Physics H-wing extension to eventually facilitate better department consolidation. ARPAC notes the great success that APS has derived from its LASP, CASA, and JILA collaborations, and questions whether there is a single optimal location for its faculty.

Inclusive Excellence

In its self-study, APS acknowledges a lack of faculty diversity. The external reviewers recommend that APS address these issues. ARPAC agrees: the department must make progress in addressing faculty imbalances.

ARPAC is concerned by the degree to which the self-study, as well as APS's response to the external reviewers, hands off action on these counts to the campus administration. In its response to the external reviewers, APS asks that the campus extend its program for hiring postdoctoral fellows from underrepresented groups to include funding towards a tenure-track position and suggests that the campus set aside faculty lines for advancement of faculty diversity. ARPAC notes that the campus already operates the Chancellor's Postdoctoral program and the Strategic, Targeted, and Accelerated Recruitment (STAR) program to diversify faculty, and it urges APS to take full advantage of these efforts. APS can strengthen future hiring requests by explicitly addressing how the department plans to address inclusive excellence on its own.

ARPAC also recommends that the unit familiarize itself with and respond to research showing the impact of including more than one female/underrepresented minority candidate in each finalist pool.[1]

ARPAC agrees with the self-study's suggestion that on-campus child care—which is currently unavailable to CU Boulder personnel—could be a useful recruitment tool. It encourages the campus to look to other University of Colorado campuses (e.g., UCCS) for examples of program facilities and funding. The self-study also suggests that the campus should "provide assistance with finding employment for spouses outside as well as inside the CU system."

Climate

The external reviewers praise the department's recent actions to address climate issues, especially the formation of a department climate committee. Nonetheless, the external reviewers note that climate issues persist, and found evidence that such issues are negatively affecting junior faculty members and graduate students. Hence, the external reviewers recommend that APS continue to give high priority to understanding and addressing climate problems both within the department, and in the department's relationships to LASP, CASA, and JILA. ARPAC concurs with this recommendation.

The external reviewers also recommend that faculty and staff receive regular harassment and discrimination policy training and learn the requirements of Title IX reporting. The department concurs and is addressing this issue. ARPAC likewise encourages APS to implement these changes.

[1] See, for example, "If There's Only One Woman in Your Candidate Pool, There's Statistically No Chance She'll Be Hired." *Harvard Business Review*, April 26, 2016.

Recommendations

The members of the Academic Review and Planning Advisory Committee (ARPAC) address the following recommendations to the Department of Astrophysical and Planetary Sciences, and to the offices of responsible administrators:

To the unit:

1. Follow the department's strategic hiring plan and inclusive excellence narrative when proposing hiring new faculty or replacing retiring faculty. Work with the Laboratory for Atmospheric and Space Physics (LASP), JILA, and the Center for Astrophysics and Space Astronomy (CASA), and possibly with the College of Arts and Sciences and the Office of Vice Chancellor for Research and Information, to resolve differences in these units' strategic hiring plans versus that of APS.

2. Investigate the two tracks of the astronomy major. Evaluate post-graduate job placement outcomes to ascertain whether both tracks serve the needs of APS students, including underrepresented groups, and act on these findings. ARPAC supports continuation of both tracks within the undergraduate degree.

3. Examine the factors affecting student retention in the undergraduate major and determine what changes should be made.

4. Continue to build and offer enhancements to the undergraduate experience, including programs at the Fiske Planetarium and the Sommers-Bausch Observatory, the Science, Technology and Astronomy Recruits (STAR) program, and opportunities for undergraduates to participate in research, teaching, and outreach.

5. Work with the Office of the Senior Vice Provost and the quality initiative leader to develop formal mechanisms for articulating learning outcomes and measuring student success.

6. Continue to revise the graduate comprehensive examination so it meets the department's learning outcomes and is clear to students.

7. Take steps to improve the time to degree in the Ph.D. program.

8. Work with the Office of Data Analytics and internal records to track graduate student outcomes.

9. Incorporate postdoctoral fellows into department activities, and work with the Office of Data Analytics and internal records to track postdoctoral outcomes.

10. Develop a plan to address needs for access to large ground-based telescopes, especially by new faculty and their graduate students and postdoctoral fellows. Work with the campus to develop new ways to fund these needs, including possible use of APS generated facilities-and-administrative funds.

11. Address imbalances in diversity and demographics of existing faculty and new hires. Work with the Office of Diversity, Equity, and Community Engagement (ODECE) and the Office of Faculty Affairs to develop a concrete faculty recruitment plan for women and members of underrepresented minorities, using tools such as the Strategic, Targeted, and Accelerated Recruitment (STAR) program and the Chancellor's Postdoctoral Fellowship

program. Include the makeup of the finalist pools for each faculty recruitment in the reporting progress on this recommendation. Aim for pools that include multiple diverse candidates.

12. Continue to understand and address climate problems both within the department and in the department's relationships with LASP and JILA.

13. Ensure that faculty and staff continue to receive regular training on harassment and discrimination policies and understand the requirements of Title IX reporting.

To the Dean of the College of Arts and Sciences:

14. Ensure that the College of Arts and Sciences allocation of funding for TAs, staff and faculty reflect recent growth in the undergraduate instructional productivity of APS.

To the Dean of the College of Arts and Sciences and to the Provost:

15. Work with APS and the Office of Advancement to assist the department with meeting its fundraising needs as defined in its strategic plan.

To the Vice Chancellor for Research and Innovation:

16. Investigate the financial and programmatic issues associated with allocating faculty positions to institutes rather than via the College of Arts and Sciences. Assist APS in working with institutes to minimize problems and maximize benefits.

To the Provost and to the Vice Chancellor for Research and Innovation:

17. Work with APS to identify new ways to raise funding for ground-based telescope access.

Required Follow-Up

The chair of the Department of Astrophysical and Planetary Sciences shall report annually on the first of April for a period of three years following the year of the receipt of this report (i.e., April 1st of 2019, 2020, and 2021) to the dean of the College of Arts and Sciences and to the provost on the implementation of these recommendations. Likewise, the dean shall report annually on the first of May to the provost on the implementation of recommendations addressed to the college. The provost, as part of the review reforms, has agreed to respond annually to all outstanding matters under their purview arising from this review year. All official responses will be posted online.