

Date: June 15, 2018

To: Martha Venn, Deputy Vice Chancellor for Academic Affairs, University System of Georgia

From: Michael Galchinsky, Associate Provost for Institutional Effectiveness, Georgia State University

Cc: Risa Palm, Senior Vice President for Academic Affairs and Provost, Georgia State University

Re: Comprehensive Program Review

This memorandum explains the reporting mechanism used by Georgia State University for the purpose of Comprehensive Program Review in 2018.

The following Georgia State University programs underwent Comprehensive Program Review (CPR) using the System's CPR reporting vehicle in Spring 2017:

- Bachelor of Arts with a major in Applied Linguistics (16010201)
- Bachelor of Arts with a major in Economics (45060100)
- Bachelor of Arts with a major in History (54010100)
- Bachelor of Arts with a major in International Economics and Modern Languages (45060501)
- *Bachelor of Business Administration with a major in Business Economics (52060101)
- Bachelor of Business Administration with a major in Hospitality Administration (52090105)
- Bachelor of Science with a major in Criminal Justice (43010401)
- Bachelor of Science with a major in Economics (45060100)
- Bachelor of Science with a major in Physics (40080101)
- Bachelor of Science in Nursing (51380101)
- Bachelor of Science in Nursing, RN to BSN (51380105)
- Master of Arts with a major in Applied Linguistics (13140101)
- Master of Arts with a major in Economics (45060100)
- Master of Arts with a major in History (54010100)
- Master of Global Hospitality Administration (52090101)
- Master of Heritage Preservation (30999901)
- *Master of Science with a major in Business Economics (52060101)
- Master of Science with a major in Criminal Justice (43010401)
- Master of Science with a major in Nursing (51380105)
- Master of Science with a major in Physics (40080101)
- *Master of Laws (22020101)
- *Juris Doctor (22010100)
- Doctor of Nursing Practice (51380101)
- Executive Doctorate in Business (52029901)
- Doctor of Philosophy with a major in Applied Linguistics (13140101)
- Doctor of Philosophy with a major in Astronomy (40020100)

Doctor of Philosophy with a major in Criminal Justice and Criminology (43010401)
Doctor of Philosophy with a major in Economics (45060100)
Doctor of Philosophy with a major in History (54010100)
Doctor of Philosophy with a major in Nursing (51389901)
Doctor of Philosophy with a major in Physics (40080101)

In all but four cases (those indicated with an asterisk), these CPR reports were used as inputs in the preparation of self-study study reports by units as part of the comprehensive Academic Program Review (APR) process during the past year.

The following units successfully completed the APR process in 2018:

Department of Applied Linguistics and English as a Second Language

Department of Criminal Justice and Criminology

Department of Economics

Department of History

Department of Physics and Astronomy

School of Hospitality Administration

School of Nursing

In addition, the Executive Doctorate in Business program, which is not located within any single department, completed the APR process.

Unlike CPR, APR at Georgia State University involves the entire unit in which the program is based. Thus, in APR, a department's bachelor's, master's, doctoral, and other programs are all reviewed as part of a holistic evaluation of the unit's viability, quality, and productivity. The robust APR process involves data collection, a self-study, an external review by disciplinary specialists, an internal review by the University Senate, an action plan, and a series of implementation reports. The units must demonstrate their contribution to the University's Mission and Strategic Plan, and must articulate a series of goals aimed at continuous quality improvement.

Consequently, in lieu of a CPR reporting vehicle for each program, we are submitting the following documents for those programs housed in units that conducted APR in 2017-2018 on a unit by unit basis:

- 1) For each program in the unit, the signed final page of the CPR vehicle, attesting that the program "meets" the institutional criteria for retention
- 2) The unit's self-study report
- 3) The report of the external reviewers for the unit
- 4) The report of the University Senate's Academic Program Review Committee for the unit
(The action plans will be developed over the summer and are not yet available)

As noted above, four programs were not covered by the APR process. For two of these programs (BBA with a major in Business Economics, MS with a major in Business Economics), we are submitting an updated CPR reporting vehicle. The two other programs (Master of Laws, Juris Doctor) are scheduled to undergo APR in 2020.

Please let me know if you have any questions. Thank you for your consideration.

SENIOR VICE PRESIDENT OF ACADEMIC AFFAIRS AND PROVOST
Office of the Provost

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Atlanta, GA 30302-3999

Phone 404-413-2574
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June 15, 2018

To whom it may concern:

I hereby certify that each of the programs scheduled for Comprehensive Program Review at Georgia State University in 2018 MEETS the institution's criteria for retention. I have designated Michael Galchinsky, the Associate Provost for Institutional Effectiveness, as the signatory for the individual reports.

Sincerely,

A handwritten signature in cursive script that reads "Risa Palm".

Risa Palm
Senior Vice President for Academic Affairs and Provost

**Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions**

Reporting Vehicle

Institution: Georgia State University

Academic Program Name: Bachelor of Science with a major in Physics

CIP Code: 40080101

College or School and Department: College of Arts and Sciences - Physics and Astronomy

Date of Last Internal Review: 2007-2008

Outcome of Previous Program Review (brief narrative statement):

Current Date: June 2018

**Program Reviewed at the Institution for this report: Bachelor of
Science with a major in Physics**

Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

Provost/VPAA Categorical Summation:

Check any of the following to categorically describe action(s) the institution will take concerning this program.

Program MEETS Institution's Criteria

Program is critical to the institutional mission and will be retained.

Program is critical to the institutional mission and is growing or a high demand field and thus will be enhanced.

Program DOES NOT MEET Institution's Criteria

Program will be placed on a monitoring status.

Program will undergo substantive curricular revisions.

Program will be deactivated.

Program will be voluntarily terminated.

Other (identify/add text): _____

Provost/VPAA Signature and Date: _____

----- OR -----

Provost/VPAA's Designee Signature and Date:

 6/14/2018

Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

Reporting Vehicle

Institution: Georgia State University

Academic Program Name: Master of Science with a major in Physics

CIP Code: 40080101

College or School and Department: College of Arts and Sciences - Physics and Astronomy

Date of Last Internal Review: 2007-2008

Outcome of Previous Program Review (brief narrative statement):

Current Date: June 2018

**Program Reviewed at the Institution for this report: Master of Science
with a major in Physics**

Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

Reporting Vehicle

Institution: Georgia State University

Academic Program Name: Doctor of Philosophy with a major in Astronomy

CIP Code: 40020100 College or School and Department: College of Arts and Sciences - Physics & Astronomy

Date of Last Internal Review: 2007-2008

Outcome of Previous Program Review (brief narrative statement):

Current Date: June 2018

Program Reviewed at the Institution for this report: Doctor of Philosophy with a major in Astronomy

Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

Provost/VPAA Categorical Summation:

Check any of the following to categorically describe action(s) the institution will take concerning this program.

Program MEETS Institution's Criteria

Program is critical to the institutional mission and will be retained.

_____ Program is critical to the institutional mission and is growing or a high demand field and thus will be enhanced.

Program DOES NOT MEET Institution's Criteria

_____ Program will be placed on a monitoring status.

_____ Program will undergo substantive curricular revisions.

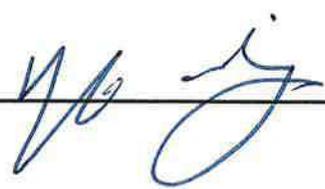
_____ Program will be deactivated.

_____ Program will be voluntarily terminated.

_____ Other (identify/add text): _____

Provost/VPAA Signature and Date: _____

----- OR -----

Provost/VPAA's Designee Signature and Date:  6/14/2018

Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

Reporting Vehicle

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Comprehensive Program Review
Instructions, Reporting Vehicle, and Definitions

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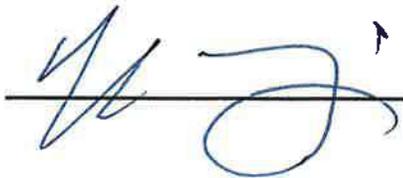
_____ Program will be voluntarily terminated.

_____ Other (identify/add text): _____

Provost/VPAA Signature and Date: _____

----- OR -----

Provost/VPAA's Designee Signature and Date:

 6/14/2018

**Department of Physics and Astronomy
Georgia State University**

2017 Self-Study Report for Academic Program Review

Physics and Astronomy Self-Study Committee

Misty C. Bentz

Megan E. Connors

D. G. Sumith P. Doluweera

Douglas R. Gies, Chair

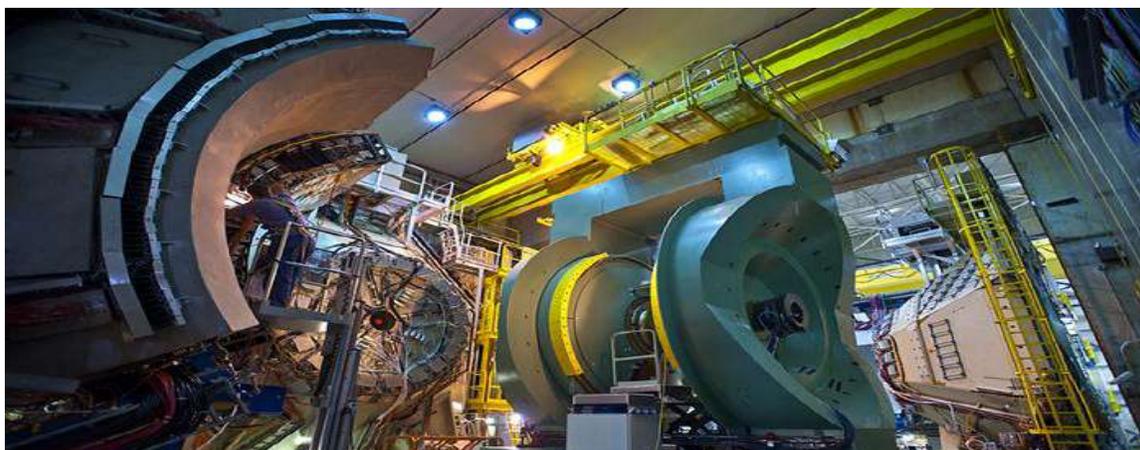
Xiaochun He

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phy-astr.gsu.edu

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APPENDICES (available online at www.astro.gsu.edu/~gies/APR_PA_Appendices.pdf)

Note: In this report, the aspirational peer programs for comparisons are those at the University of California at Riverside, the University of Iowa, and the University of Pittsburgh. Peer programs are those at the University of Alabama at Tuscaloosa, the University of Delaware, the University of Kentucky, the University of New Mexico, the University of Oregon, and the University of Wisconsin - Milwaukee. The criteria for these selections are discussed in Appendix E1 and comparative data are presented in Appendix E2.

Cover photos (clockwise from upper left): In the classroom with Professor Misty Bentz; one of the six domes of the CHARA Array telescopes in California; the PHENIX instrument of the Relativistic Heavy Ion Collider at Brookhaven National Laboratory.

Acronyms used in this report

2CI	GSU Second Century Initiative faculty hiring program (2011-2015)
AAS	American Astronomical Society
AIP	American Institute of Physics
AMEL	GSU Advanced Materials Epitaxy Laboratory
APO	Apache Point Observatory, New Mexico
APR	GSU Academic Program Review
APS	American Physical Society
ARC	Astrophysical Research Consortium
ARCSAT	ARC Small Aperture Telescope, New Mexico
AstroPAL	GSU Astronomy Peer Advising Leaders program
AY	Academic Year (Fall – following Summer semesters)
B&B	GSU Brains and Behavior program
BS	Bachelor of Science degree
CDT	GSU Center for Diagnostics and Therapeutics
CEHD	GSU College of Education and Human Development
CeNO	GSU Center for Nano-Optics
CETL	GSU Center for Excellence in Teaching and Learning
CH	credit hour
CHARA	GSU Center for High Angular Resolution Astronomy
CIOS	University of Hawaii Consortium for Innovative Optical Systems
COAS	GSU College of Arts and Sciences
CS	GSU Department of Computer Science
DOE	U.S. Department of Energy
EPR	two electron paramagnetic resonance
FA	Fall semester
FTIR	Fourier Transform InfraRed
FY	Fiscal Year (July – following June)
GAIN	GSU Georgia AstroInformatics Nexus
GIT	Georgia Institute of Technology (“Georgia Tech”)
GLA	Graduate Laboratory Assistant
GPA	Grade Point Average
GRA	Graduate Research Assistant
GRE	Graduate Record Examination
GSU	Georgia State University
GSURC	GSU Undergraduate Research Conference
GTA	Graduate Teaching Assistant
HBCU	Historically Black College or University
HLCO	GSU Hard Labor Creek Observatory, Rutledge, Georgia
IAU	International Astronomical Union
IEEE	Institute of Electrical and Electronics Engineers
I-V-T	electronic current, voltage, temperature
MBD	GSU Molecular Basis of Disease program
MFM	Magnetic Force Microscopy
MRI	Magnetic Resonance Imaging

MS	Master of Science degree
NASA	U.S. National Aeronautics and Space Administration
NextGen	GSU Next Generation program of faculty hires (2016-2020)
NRC	U.S. National Research Council
NSC	National Student Clearinghouse
NSF	U.S. National Science Foundation
NTT	Non-tenure track faculty
OIR	GSU Office of Institutional Research
OSA	Optical Society of America
P&A	GSU Department of Physics and Astronomy
PER	Physics Education Research
PGSA	GSU Physics Graduate Student Association
PhD	Doctor of Philosophy degree
PHENIX	Pioneering High Energy Nuclear Interaction eXperiment
PhysTEC	APS Physics Teacher Education Coalition
PTI	Part-Time Instructor
REU	NSF Research Experiences for Undergraduates program
RHIC	Relativistic Heavy Ion Collider
SAT	College Board Scholastic Assessment Test
SCALE-UP	Student-Centered Active Learning Environ. with Upside-down Pedagogies
sf	square feet (area)
STM	Scanning Tunneling Microscope
SLO	Student Learning Objective
SMARTS	Small and Moderate Aperture Research Telescope System, Chile
SPIE	Society of Photo-Optical Instrumentation Engineers
SPS	Society of Physics Students
STEM	Science, Technology, Engineering, and Mathematics
SU	Summer semester
TOEFL	Test of English as a Foreign Language
T/TT	tenured or tenure-track faculty
URM	under-represented minority
URSA	Georgia State University Research Services & Administration
USG	University System of Georgia
UV	ultraviolet

Academic Program Review Self-Study

1 Where is Your Unit Now?

Physics is the study of nature at the most fundamental level, exploring entities from the smallest (quarks that make up atoms) to the largest (the universe as a whole) and the forces that drive their interaction. Astronomy is a closely related discipline that investigates planets, stars, and galaxies over vast scales to understand our place in space and time. Advances in basic research in physics have driven technological innovation and transformed our daily lives, and these new technologies have opened up exploration of the universe across the electromagnetic energy spectrum and in new realms of discovery such as detection of gravity waves from distant merging black holes. The mission of the GSU Department of Physics and Astronomy (P&A) is to engage and inspire our students through courses and experiential studies with faculty. We seek to instill scientific literacy at the undergraduate level, to provide training for the next generation of scientists at the graduate level, and to create opportunities for frontier discoveries through a diverse research program that will prepare students for careers in research, technology, data analysis, and teaching. The basic nature of physics leads to strong ties with other departments in the College of Arts and Sciences (COAS) including Biology, Chemistry, Computer Science (CS), Geosciences, Mathematics and Statistics, and Neuroscience, and many students in these areas enroll in classes offered by P&A.

At the time of writing (October 2017), P&A consists of 25 tenured/tenure track (T/TT) faculty, 5 lecturers, 1 academic professional, and 22 support staff (mostly postdoctoral research associates). We offer programs leading to the BS (Physics), MS (Physics), PhD (Physics), and PhD (Astronomy) degrees. We are the only university in Georgia to offer an astronomy PhD, and we are one of just five universities in the southeastern United States with such programs. We have a vibrant and broad research program that includes operation of the CHARA Array, the largest optical interferometer in the world that provides the best views of the stars ever made. Our last APR Self-Study was written in 2007, and we have seen remarkable growth since that time. Here we summarize our activities over the 2014 – 2016 period in the context of the changes made over the last five years. An Appendix to the Self-Study contains more detailed data and analysis, as well as questionnaire results and faculty Curriculum Vitae reports.

1.a Undergraduate Education

In recent years, the Physics BS program has experienced a steady increase in physics majors and a rapid growth in BS degrees, particularly from 2010 to 2015 (Appendix A2). The three-year averages are 18.7 degrees awarded per year, 189 majors enrolled, and 17,210 credit hours (CH) generated per year (Appendix A6). Undergraduate teaching amounted to 669 CH per T/TT per year in AY 2015, much larger than the value of 547 CH per T/TT per year for peer schools (Appendix E2). The increase in degrees is a result of changes in the program, curriculum, and culture over a number of years. One key element of this change was the introduction of a freshman seminar to introduce new physics majors to the program, career paths, and research opportunities. Other elements include the redesign of our advanced laboratory course to emphasize scientific communication and professional skill building, expansion of the required research project to include research

proposal writing, and introduction of a physics teacher concentration. The changes leading to large increases in physics majors and degrees have also impacted under-represented minority (URM) participation in the program. GSU is a diverse, urban research university with a larger minority participation than national averages. Between 2006 and 2016, the fraction of Physics BS degrees awarded to URM increased from 17% to 28%. With the overall growth of the program, this resulted in the number of Physics BS degrees awarded to URM increasing from an average of one per year for AY 2007-2011 to five per year for AY 2012-2015. These efforts are highlighted in the Spring 2015 American Physical Society (APS) Forum on Education Newsletter (Appendix A9).

The development of a concentration leading to high school physics teacher certification within the BS in Physics has both benefited from the growth of the physics program and contributed to it. The concentration began in Fall 2012 with its first graduate in Fall 2013 (Appendix A3). In four years of producing physics teachers, the program achieved national attention, being awarded to the PhysTEC “5+ Club” by APS for 2013-2014 (14 recipients nationally), 2015-2016 (9 recipients nationally), and probably 2016-2017 (pending). The development of this program led to a GSU award of a three-year grant for \$300K from the APS PhysTEC program that along with the “5+ Club” awards has given GSU a national profile in the area of physics teacher preparation.

Development and implementation of innovative teaching has also contributed to the success of the program. P&A has adapted research-based instructional strategies for use in both calculus- and non-calculus-based introductory physics. A “studio” physics course in the SCALE-UP model is used for about half of the non-calculus physics courses. A recent redesign of calculus-based physics labs has implemented a new laboratory curriculum and tutorials led by undergraduate learning assistants. New upper division courses in computational physics and magnetism are being introduced this year.

1.a.1 Quality of undergraduate student attracted to the unit’s program

As shown in Appendix A1, students entering the Physics BS program as freshman in 2016 had an average SAT score of 1213, over 100 points higher than the COAS average and 150 points higher than the GSU average. Freshman physics majors also entered with larger high school GPA resulting in a freshman index considerably higher than the college and university averages. This indicates that the program is attracting high quality students. Comparison with other science majors shows that the physics program is attracting students with higher academic credentials than other STEM disciplines.

1.a.2 Scholarship Support for Undergraduates

P&A offers no internal scholarship support at this time, but physics majors are competitive for GSU and external scholarships. One major recently received a Goldwater Fellowship and another major received the COAS Cooley Scholarship for Sciences.

1.a.3 Student Learning, Success and Satisfaction

1.a.3.1 Assessment of student learning

The Student Learning Objectives (SLOs) and assessment methods are discussed in Appendix A7. The SLOs are based on the themes of (1) developing expertise in the acquisition and analysis of physical data and (2) learning core principles in physics. Over the past three years our assessments have shown that physics majors are achieving competence in area (1) through the junior-level Advanced Physics Lab and subsequent Research Project. Grasping content knowledge in physics (2) requires good problem-solving abilities, and we found that some students needed further grounding in these techniques. For that reason, the department has revised the core requirements over the last three years to now include required courses in Mathematical Methods and Computational Physics (PHYS 3550, 3560). This addition will promote competency in mathematical thinking and problem solving prior to taking advanced courses. Future assessments will help us gauge the effectiveness and improve the content of these courses to meet the needs of majors.

1.a.3.2 Recruitment rates and advisement procedures

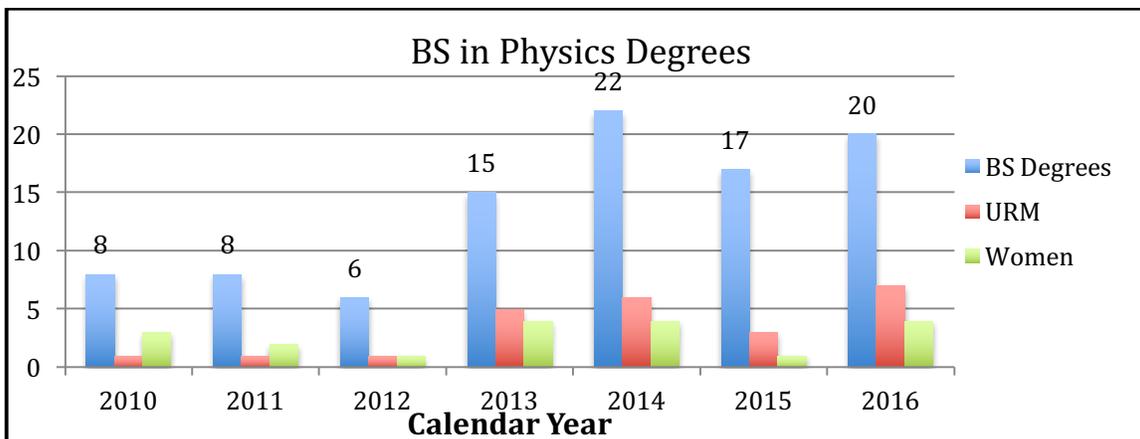
Over recent years the number of incoming freshman declaring physics as a major is quite high (39, 36, and 45 in Fall 2014, 2015, and 2016, respectively); however, this number includes a number of students intending to transfer to other institutions, in particular, to Georgia Tech (GIT) to pursue engineering majors not available at GSU. Internal recruitment occurs in several ways. The Gateway to Physics course, PHYS 1000, offered fall and spring semesters, is aimed primarily at freshman physics majors, but is also intended to be an opportunity for students considering physics and astronomy to find out more about those majors and career paths and to fuel interest in the discipline. P&A works closely with the GSU Advisement Center to advise physics majors and potential majors to take this course and to make progress on the content requirements, particularly in mathematics. The advisement plan within P&A focuses on making connection with students all along their academic path. The undergraduate director connects with students several times in the Gateway to Physics course, once as an introduction and a second time to discuss details of the program and how they match with career opportunities. As students progress through introductory, calculus-based physics courses, the undergraduate director does class visits to introduce himself and encourage students to come for advisement. Physics majors are also tracked by the undergraduate director and contacted when course selection or progress indicates that is needed. Once physics majors get into upper division courses, they are generally well connected to the undergraduate director. The GSU Society of Physics Students (SPS) serves as a faculty contact point and peer-mentoring group for physics and other science majors.

1.a.3.3 Retention rates and graduation rates

Retention and graduation rates for the BS in Physics degree are lower than many other GSU programs. One significant reason for this is the large number of students who attend GSU for one or two years before transferring to other schools to study engineering. The USG encourages transfers within the system by enforcing common course numbering and transferability of core requirements. GIT allows a large number of transfers for students in the system after completing introductory mathematics and physics courses. The

combination of students transferring away and changing majors resulted in 6-year graduation rate of 28% for cohorts beginning in 2002-2010.

P&A recognized these low retention and graduation rates and undertook a series of changes to the program and department practices. The most significant of these are the redesign of upper division laboratory courses and research requirements to create the Advanced Physics Lab (Fall 2009) and Research Project (Spring 2010) and the creation of the Gateway to Physics course (Fall 2010). In addition, P&A revamped advisement practices, adjusted course scheduling to avoid conflicts, and changed requirements to add flexibility especially for students not intending to go to graduate school.



As can be seen by the data in Appendix A2, the number of physics majors doubled from 2009 to 2014 (from 90 to 190) and the number of Physics BS degrees conferred tripled in the same period (from ~7 to ~20 per year). This is a large number for U.S. universities where the typical numbers are below ten (see the APS statistics in Appendix A2). The number of degrees awarded per T/TT per year was 0.68 in AY 2015 that compares favorably with the median of 0.46 for peer schools (Appendix E2). We expect that the 6-year retention and graduation rates will increase in the next few years as these increased student numbers and success rates propagate into the 6-year data. Already it is apparent in 4-year data where the 4-year retention has increased from 36% (2002-2010 cohorts) to 51% (2011-2012 cohorts). Similarly, the 4-year graduation rate for the program has increased from 9% (2002-2010 cohorts) to 17% (2011-2012 cohorts). Appendix A8 presents an analysis of those students who transferred out from the Fall 2010 – 2013 cohorts. These data show that over this four-year period there was a strong trend for students to graduate from GSU rather than elsewhere. Furthermore, the year five graduation and retention data indicate that 78% of these entering classes have completed or are continuing to completion either at GSU or elsewhere. We will continue to track the patterns of students who transfer in or out of the program.

1.a.3.4 Output quality metrics; placement rates into advanced degree programs

Accurate information is difficult to obtain regarding student employment and entrance into graduate programs. We have attempted to gather available information or contact all 63 students who graduated from Fall 2013 to Summer 2016. We were able to verify 8 students going to graduate school (4 in physics or astronomy and 4 in other fields), 13 working at technology companies including at least 3 at General Electric, 11 working as teachers (all

earned certification through the education concentration in the BS in Physics), and one student in the military. Over a longer period of time, GSU physics graduates have gone to physics and astronomy graduate programs at Washington, Wisconsin-Madison, Kentucky, Miami, Massachusetts-Amherst, Mississippi, Georgia Tech, Florida State, Maryland-Baltimore County, and Georgia State University. In addition, students have gone on to law school and graduate school in mathematics, computer science, engineering, and chemistry. This distribution of post-graduation employment is consistent with national trends (Appendix A2).

A goal of the undergraduate program is to better prepare our students for jobs in the technology sector by improving skills such as computing and scientific thinking and communication. We also are working to improve our students' ability to get into high quality graduate programs by improving our teaching methods and our course offerings.

1.a.3.5 Enrollment by program, gender, and race

We have only one undergraduate degree program (BS in Physics) but in addition to the Standard Program we have 7 concentrations (Applied Physics, Astronomy, Biophysics, Computer Science, Geology, Pre-medicine, and Teacher Education). All students that enter as physics majors are in the Standard Program unless and until they complete a change of concentration. Between Fall 2014 and Summer 2017, 19 out of 55 graduating students completed the Standard Program while 10 completed Teacher Education, 9 completed Computer Science, 8 completed Astronomy, 6 completed Applied Physics, and one each completed Pre-medicine, Biophysics, and Geology concentrations. Many students do not declare their concentration until later, so the fraction graduating with each concentration is larger than in the overall population of majors (Appendix A3).

Over the last three years, about 20% of physics majors and 16% of those receiving the BS in Physics were female (Appendix A3), somewhat better than the national average of 10% as reported by American Institute of Physics (AIP). The department is currently looking at ways to increase the number of women physics majors and has recently established the Women in Physics group at GSU, led by some of our women faculty members. The situation in terms of race is very different in that the GSU program attracts and graduates under-represented minorities at a much higher level than national averages. Over the last three years, 11 of 55 graduates identified as African American, 5 as Hispanic and 3 as Native American (Appendix A3). After adjusting for overlap, a total of 18 out of 55 graduates were from under-represented minority groups or 27% of our graduates. Having 20% of our graduates in physics identify as African American and 9% Hispanic and puts us far above national averages (about 4% each according to AIP). As shown in Appendix A3, the number of minority students getting physics degrees has greatly increased from about one per year to over four per year. For context, in 2016-2017 we graduated six African American physics majors, which is more than all but a few programs in the country including most historically black colleges and universities (HBCUs).

1.a.3.6 Level of financial need

According to GSU calculations (Appendix A3), physics majors average a large unmet financial need which has risen in the past three years from about \$6000 to about \$9000.

P&A has increased the available employment in the department through the learning assistant program, and in Fall 2017 we have expanded that program and added paid tutor positions through the support of the USG STEM Initiative. The department hires about 10 paid undergraduate student researchers each summer through faculty grants, and many of these are carried into the academic year. Additional employment and scholarship opportunities are needed to reduce the barriers for students to complete the program. These financial barriers may affect first-generation and minority students more significantly and may limit our ability to increase success rates for these students.

1.a.3.7 Student Surveys

The GSU Office of Institutional Research (OIR) conducted a survey of P&A undergraduates and recent alumni in spring 2017. The results of the undergraduate student survey are given in Appendix F1 and a comparison with other GSU undergraduates is provided in Appendix F2. The survey indicates that students are generally satisfied with the undergraduate program, and the numerical scores are comparable to those for GSU as a whole. In particular, the score on the final question “I would recommend my department to other students like myself” was 5.11 for P&A students versus 4.91 for GSU (where 1 = strongly disagree and 6 = strongly agree), indicating that P&A students have a favorable opinion about their experience at GSU. The highest numerical scores (5.24) were assigned to questions about “integrating new information with past knowledge” and “preparing me for my career or future educational goals.” The lowest score (4.09) was associated with the question about “availability of undergraduate courses in the department.” This may reflect the limited number of sections offered in a highly structured curriculum. The comments expressed a wide range of opinion about the degree of course difficulty, from “expected a high standard” to “below the level of rigor” and “need to enforce a higher standard” of topical proficiency. These comments reflect the wide diversity we encounter in student background and career ambitions that challenges instructors to find a level that will meet the needs of students headed to graduate school as well as those in alternative careers.

The results of the undergraduate alumni are given in Appendix F3 and compared to GSU mean scores in Appendix F4. These also indicate broad satisfaction with the undergraduate program, and the mean of the scores for the three general outcomes questions is 4.82 for P&A alumni compared to 4.69 for GSU alumni in general. The fraction of P&A alumni pursuing graduate work (40%) is much higher than for GSU in general (20.5%), indicating that the P&A curriculum provides a solid basis for advanced studies. Many commented on the excellent advisement and research skills they obtained at GSU. Several mentioned the need to increase our focus on job placement strategies, and P&A faculty are working to increase students’ practical skills and experiences. One respondent related an experience of harassment. We are familiar with this case that took time to resolve, but that ultimately resulted in confronting and disciplining the individuals concerned and led to training sessions for all members of the department.

1.a.3.8 Curriculum Quality, as determined by internal and external benchmarks

1.a.3.8.a Degree requirements and program changes, if any Appendix A4.

1.a.3.8.b List of courses Appendix A5.

1.a.3.9 Contribution to the core curriculum/general education outcomes

The introductory courses in astronomy (ASTR 1010K, 1020K) and physics (PHYS 1111K, 1112K, 2211K, 2212K) form parts of the core curriculum in Area D, Natural and Computational Sciences (for a minimum of 11 CH). These courses accounted for 15,684 credit hours in AY 2017 (Appendix A6).

1.a.4 Signature Experiences

1.a.4.1 Research practica

All majors complete the capstone course PHYS 4950 to develop research expertise. Most students pursue summer research projects with GSU faculty or at other national facilities, and we will continue to make research an essential component of undergraduate work.

1.a.4.2 Urban service learning programs Not applicable.

1.a.4.3 Internships

P&A has teamed with the NASA Jet Propulsion Laboratory to provide summer intern opportunities at this facility. The first GSU student will participate in 2018. P&A is a partner in the University of Hawaii's Consortium for Innovative Optical Systems (CIOS). In 2017, two GSU undergraduate students in physics and a graduate student in astronomy gained signature experiences working on Maui as a part of CIOS.

1.a.4.4 Study abroad Not applicable.

1.a.4.5 Domestic field schools Not applicable.

1.a.5. Honors College

1.a.5.1 Honors courses and Honors add-ons taught by faculty

An average of 36 students enrolled in the honors section of PHYS 2211K (Appendix A6).

1.a.5.2 Honors Faculty Fellows Not applicable.

1.a.5.3 Honors theses produced by students in the major Not applicable.

1.a.5.4 Student participating in the GSU Undergraduate Research Conference

Three students presented their work at GSURC between 2015 and 2017.

1.a.6 Undergraduate programs within the GSU context

1.a.6.1 Programs undertaken jointly with other units, list of cross-listed courses

Cross-listed courses are identified in Appendix A6. These include a few courses in mathematics, neuroscience, and integrated science for teachers (CEHD).

1.a.6.2 Areas of substantial overlap/redundancy with other units Not applicable.

1.b Graduate Education

P&A offers a MS degree in physics (with several concentrations) and PhD degrees in both physics and astronomy. Most students in both PhD programs obtain an MS in Physics on the way to obtaining their PhD. The three-year averages are 9.7 (MS) and 9.0 (PhD) degrees awarded per year, 76 enrolled, and 4,956 credit hours generated per year (Appendices B2, B6). The astronomy PhD degree is the only such program in the state of Georgia and one of only 40 in the U.S. The physics PhD program is ranked 49 of 182 programs in terms of number of degrees granted per year and is ranked number 15 of 182 programs for the number of first-year female graduate students (www.gradschoolshopper.com).

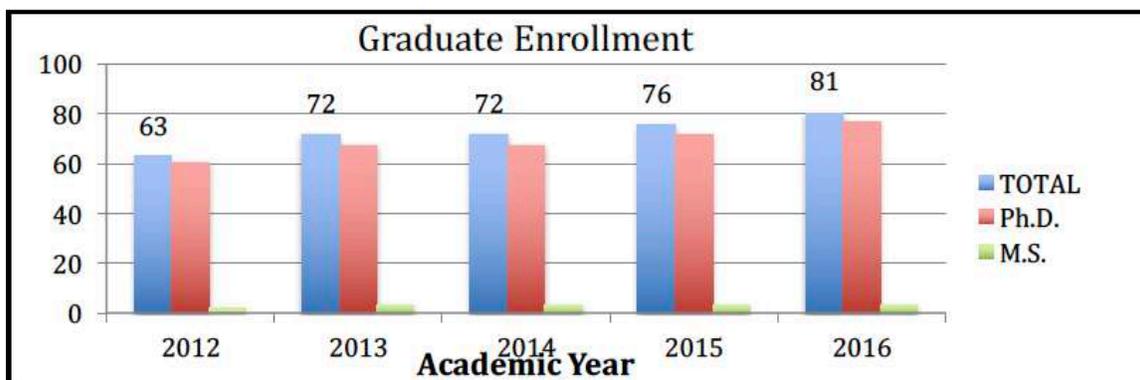
The PhD programs have grown steadily since their inception in 1985, and GSU graduates gain unique experiences in the classroom and laboratory. Most have gone on to careers in higher education, research, and industry. The physics and astronomy PhD programs have different requirements and graduate directors, and both are discussed below.

1.b.1 Quality of graduate students attracted to the unit's programs (average scores on entrance exams, e.g., GRE, GMAT, LSAT)

The number of applicants and GRE scores of enrolled students are shown in Appendix B1. The number of applicants has steadily increased while the number enrolled has grown more slowly (limited by financial support). Consequently, the acceptance ratio has declined to 26% and admission is now much more competitive.

1.b.2 Expanding Support for Graduate Programs

1.b.2.1 Total numbers of graduate students by year, degree program, and concentration in the period of the self-study



Graduate enrollment increased by 29% from 2012 to 2016. Appendix B2 lists the numbers enrolled by concentration and academic year. In FA 2016 there were 28 and 47 graduate students in astronomy and physics, respectively.

1.b.2.2 Percentage of graduate students compared to total number of students in the department

Appendix B2 shows the numbers of graduate and undergraduate majors, and the graduate student group comprises about 29% of the total.

1.b.2.3 Graduate student financial support by type (GTA, GRA, etc.)

Graduate students receive an annual stipend that begins at \$20K and grows to \$21K after certain milestones are met. Additional support is available for graduate students who perform special departmental service and/or are awarded GSU or external fellowships. The stipends are a mix of GTA and GRA (grant funded) dependent on the individual.

1.b.2.4 Ratio of graduate students to TT faculty

The student to faculty ratio is listed in Appendix B2. The average ratio of graduate students to T/TT faculty was 3.3 over the period 2012-2017, which is above the median ratio of 2.7 for peer schools (Appendix E2).

1.b.2.5 Internships, service learning programs, research practica, field placements

Students participate in opportunities at national laboratories as practical within the time constraints of their research work. For example, two PhD astronomy students have participated in the pre-doctoral program at Lowell Observatory in Arizona.

1.b.3 National Reputation in Professional Degree Programs

1.b.3.1 Number of graduate students in professional degree programs by year

Not applicable.

1.b.3.2 Pass rates on national credentialing examinations Not applicable.

1.b.4 Student Success and Satisfaction

1.b.4.1.a Assessment of student learning

The Student Learning Outcomes (SLOs) and assessment methods are discussed in Appendices B9 and B10 for the physics and astronomy programs, respectively. The five, physics program SLOs focus on core knowledge, critical thinking, research skills, communication, and effective collaboration. The outcomes are assessed during three milestones: written and oral qualification exams, MS presentation, and PhD defense. The assessments are uniformly positive. The astronomy SLOs are based on general astronomical knowledge, core principles, development of a research endeavor, communication, and research productivity. There is a four-stage assessment: a first year written exam, a second year written and oral qualification exam, a third-year research prospectus talk, and a dissertation defense. Except in a few cases, the astronomy students have successfully fulfilled all these assessments.

1.b.4.1.b Courses taught Appendix B6.

1.b.4.2 Recruitment rates, admission requirements and procedures and advisement

The GSU graduate program is now recognized nationally and internationally as an outstanding school for launching a career in physics and/or astronomy. The quality of our

graduate student applicants has steadily improved with time, and we now have a cohesive and supportive graduate student community that welcomes new arrivals. We highly recommend GRE Physics subject scores for those physics students seeking an assistantship. We no longer require or recommend GRE physics subject scores for graduate work in astronomy, consistent with the policy adopted by the American Astronomical Society (AAS). Many of our PhD applicants have MS degrees already.

Physics Admissions: Given the small number of physics faculty and the somewhat limited career options for physics MS graduates, the physics graduate program is focused on the training of PhD students, and we admit only a few MS students per year. On average, the program receives 40 applications for PhD studies and less than 10 applications for the MS. Applicants are ranked based on: (1) research interests and faculty preferences, (2) quality of the three letters of reference, (3) previous undergraduate GPA, and (4) GRE/TOEFL scores. Admissions are recommended by individual physics faculty in consultation with graduate director and chair. The average number of the admissions during this report period is 15. The enrollment rate is close to 65%.

Physics PhD/MS Advisement: Students (both in PhD and in MS program) are recruited to specific research groups, so they are actively involved in research projects from the beginning and receive advisement from the faculty advisor. The graduate director periodically discusses academic progress and research involvement with the new students and helps them make decisions for a productive tenure in the graduate program.

Astronomy Admissions: The Astronomy PhD program receives about 60 applications every year. Applicants are ranked based on: (1) previous research and technical experience, (2) research interests, (3) quality of three letters of reference, and (4) previous undergraduate GPA, and (5) GRE scores. Only the general GRE score is required. Top applicants are interviewed via Skype. Applicants are then selected for admission by consensus of all astronomy faculty. Offers are typically extended to about 12 students. We have admitted on average five new students in the program per year.

Astronomy PhD Advisement: New astronomy students are not initially assigned thesis advisors, and in the first year they receive basic academic advisement from the graduate director. Students are encouraged to interact with all astronomy faculty, and must select a dissertation advisor within 12 months.

1.b.4.3 Retention rates, graduation rates, and output quality metrics

Retention rates for the Fall 2009 cohort are given in Appendix B2 as an example. Most students complete the graduate program over a timespan that depends on the subject area. The graduation rate has increased with the size of the graduate population (from 8 to 11 PhD degrees per year from FY 2015 to 2017; see Appendix B2). The number of PhD degrees per year per T/TT faculty is 0.40, which compares well with a median rate of 0.38 PhD degrees per year per T/TT faculty for our peer departments (Appendix E2).

1.b.4.4 Placement rates

Many MS students continue into PhD programs (Appendix B2).

1.b.4.5 Enrollment by program, gender, and race

Appendix B3 lists the enrollment numbers by gender and race. The lower ratio of female to male students (a chronic problem in the physical sciences) has steadily improved to near equality in recent years, and the FA 2016 percentage of enrolled women is 44%, much higher than the national percentages of 37% (astronomy) and 19% (physics). The large fraction of non-U.S. students (mainly Asian) in our physics program is comparable to national trends (49%). The racial mix of the U.S. students is dominated by white students with a small but increasing fraction of African Americans (8% in FA 2016) that is larger than the national average (2%). We will work to increase the URM fraction.

1.b.4.6 Level of financial need

The GSU analysis of unmet financial need is given in Appendix B3, but the actual costs are understated there. The graduate stipends are modest (about \$21K; see Section 1.b.2.3), especially given the annual costs of GSU student fees (\$3.0K) and health insurance (\$1.9K). Although most students receive a tuition waiver, the low effective stipend forces some students to seek student loans. Increasing financial support for graduate students remains a top priority for the near future.

1.b.4.7 Student Surveys

The GSU Office of Institutional Research (OIR) conducted a survey of P&A graduates and recent alumni in spring 2017. The physics and astronomy graduate programs have different requirements and curricula, so the survey results are presented for all P&A graduates (Appendix F5), physics graduates (Appendix F6), astronomy graduates (Appendix F7), and other GSU graduate students (Appendix F8). The mean of all the average scores is 4.53 for physics students and 5.30 for astronomy students (where 1 = strongly disagree and 6 = strongly agree), compared to 4.87 for GSU as a whole. We note, however, that the spread in scores is much larger among the physics sample compared to the astronomy one, which indicates that while many of the physics students are satisfied with the program, there is a fraction that is not. We need to investigate what factors contribute to dissatisfaction among some physics students. The physics group primarily consists of international students, while the astronomy side is dominated by U.S. students, so the opinions may be influenced by the cultural challenges and differences in training that international students face. The highest score on the physics student survey was 5.50 for “my program of study is academically challenging” and this indicates that they found a high level of rigor in the curriculum. The lowest score of 3.78 related to “career preparation and guidance available in the department” and this indicates the crucial need for improved advisement about job opportunities in a competitive environment. The comments of the physics students related mainly to low stipends and the press of teaching and other requirements at the expense of research activities. One respondent complained of a poor relationship with their advisor. We encourage students to bring these problems to the graduate advisor and chair, but some students may feel uncomfortable about doing so. We recognize the need for alternative ways that graduate students can bring their concerns to the faculty; this has begun in the astronomy PhD program through faculty interactions with the student-support group Astronomy Peer Advising Leaders (AstroPAL), and we are creating a similar arrangement in physics through the Physics Graduate Student Association (PGSA). The astronomy graduate students gave highest

scores to questions relating to “the availability of graduate assistantships” (5.78) and “support to attend conferences and publish” (5.74). The lowest grade of 4.37 was associated with “my program requirements are clear to me.” This may be due to recent changes in the curricula and requirements. The astronomy comments were related to qualifier exams, program requirements, and better coordination of course content. One expressed concern that students who choose a non-academic career path are marginalized and offered fewer opportunities. Many students will embark on non-traditional careers and the faculty are making efforts to help students find their way.

The survey of graduate alumni and a comparison to the full GSU sample are given in Appendix F9 and F10, respectively. The opinions are generally positive, but the sample is relatively small, and 3 of the 17 respondents (18%) found the program unsatisfactory. The alumni comments praised their professional development and advisement at GSU. Some suggested a need for greater focus on research activities with fewer teaching obligations. One individual expressed concern for minorities and others from low-income backgrounds and suggested a number of financial incentives to improve the situation. The faculty has taken a proactive stance in recruiting minority students, and we will continue to explore ways to help these students complete their degrees.

1.b.4.8 Student publications and presentations

Our students are encouraged to publish their work as they progress towards a degree, and we summarize their recent publication record in Appendix B7. The columns list the number of refereed papers with a student as primary or co-author by publication year. These numbers correspond to papers reported by individual faculty, and there may be some minor overlap between papers noted by different faculty members. This publication record is impressive (currently over 100 papers per year) and shows that our students are productive at an early stage in their research careers.

1.b.4.9 Student accomplishments: exams, theses, dissertations, projects, grants, prizes, and awards

Our graduate students quickly become active participants in our academic, research, and teaching activities, and they generally excel in all these areas. During the period of this report, a number of students received external and internal research fellowship awards:

- One DOE Graduate Research Fellowship.
- Three NSF Graduate Fellowships.
- Two students are recipients of the university-wide GSU Dissertation Grant Awards.
- Six MBD (Molecular Basis of Disease program) fellowships at GSU.
- Twelve B&B (Brains and Behavior program) fellowships at GSU.
- Twenty-one fellowships in 2CI research initiatives at GSU.
- Two Chambliss Astronomy Achievement Awards at the 229th AAS Meeting.
- One NASA Space Grant Fellowship.
- Many travel grants to attend specialist workshops and scientific meetings.

1.b.4.10 Doctoral student time-to-degree

Appendix B2 lists the time-to-degree for the period FA 2013 to SU 2016. This ranges from 6.2 years (physics) to 7.7 years (astronomy). This duration is high, but not

unusual in these fields where experimental/observational work can be lengthy. The average duration in 2010 and 2011 in the U.S. was 6.3 years in physics (see Appendix B2). The astronomy curriculum was recently revised to allow completion of course work within the first two years of study, so that students may devote more time to research earlier in their program.

1.b.4.11 Student outcomes after graduation: admission into further graduate education, postdoctoral fellowships, employment

There are 14 recent PhD students who graduated from the physics program in recent years. Six of these students took post-doctoral positions, two as physics instructors, three as data scientists, one as an application engineer, one as temporary research staff. One decided to pursue a MS degree in actuarial science at GSU. See details in Appendix B8.

Of the 12 most recent astronomy graduates (dissertations defended since 2015), nine are currently working full time: one is teaching science in high-school, 5 are in post-doctoral research positions in astronomy, 2 are working in government labs (NASA), and one has a full-time teaching position in a community college. This yields a 75% placement rate in the first three years after graduation. Details are listed in Appendix B8.

1.b.5 Graduate programs within the GSU context

1.b.5.1 Programs undertaken jointly with other GSU units, list of cross-listed courses

Appendix B6 lists a few courses that are cross-listed with mathematics and neuroscience.

1.b.5.2 Areas of overlap/redundancy with other GSU units Not applicable.

1.b.6 Number of students enrolled in fully online and hybrid courses Not applicable.

1.b.7 Graduate degrees conferred by fiscal year

Appendix B2 lists the number of degrees by degree, topic, and year. Over the period FY 2013 to 2017, the average number of MS and PhD graduate degrees conferred per year per T/TT faculty member was 0.8.

1.c Research

The faculty direct research investigations over a vast scale of physical sizes and processes. Much of the work is done in relation to two centers, the GSU Center for Nano-Optics (CeNO) and the COAS Center for High Angular Resolution Astronomy (CHARA), as well as the Astroinformatics research cluster. These research initiatives are briefly described in Appendix C1.

The physics side of the department is carrying out research on atomic physics, biophysics, condensed matter, nuclear physics, and physics education. The largest research group is in the area of condensed matter physics and consists of five experimentalists and two theorists along with five postdoctoral researchers and 20 graduate students. The nuclear physics group has three faculty members, one postdoc and six graduate students. In biophysics, one

faculty member concentrates on molecular biophysics and another on neurophysics with four graduate students. An atomic physics theorist with one graduate student and two physics education research (PER) faculty with three graduate students completes the physics research group. Two lecturers are also involved in the PER group. There are seven full professors (two Regents' and two Distinguished University Professors), three associate professors, and four assistant professors. In addition to their individual research, the members are involved in interdisciplinary collaborative research both within GSU (Biology, Chemistry, Neuroscience and CS) and also nationally and internationally. The physics faculty members are not only carrying out externally funded research, but are also internationally recognized experts in their fields with professional society fellowships (three APS Fellows, two SPIE Fellows, one OSA Fellow, and one IEEE Fellow) and major journal editorships (Nature series journals, IEEE, APS, etc.) to their credit.

The astronomy faculty is engaged in a broad spectrum of research topics in four main areas: extragalactic astronomy, stellar astronomy, solar physics, and high angular resolution imaging. The research topics include: black hole masses, active galaxies and quasars, dark matter in galaxies, optical, UV, and X-ray spectroscopy, hot stars and stellar winds, nearby stars, low mass and ancient stars, stellar masses, planet formation, exoplanet surveys, stellar kinematics and galactic structure, solar-stellar connection, seismology of the Sun and giant planets, space weather, image reconstruction and restoration, astronomical instrumentation, large astronomical surveys, astroinformatics and data mining. The work is largely done with telescopes on Earth and in space and through computational astrophysics and plasma physics (see facilities in Appendix D1). The astronomers include a Regents' Professor and two Distinguished University Professors, and all participate in national and international professional organizations.

1.c.1 Success of the Unit's Research Culture

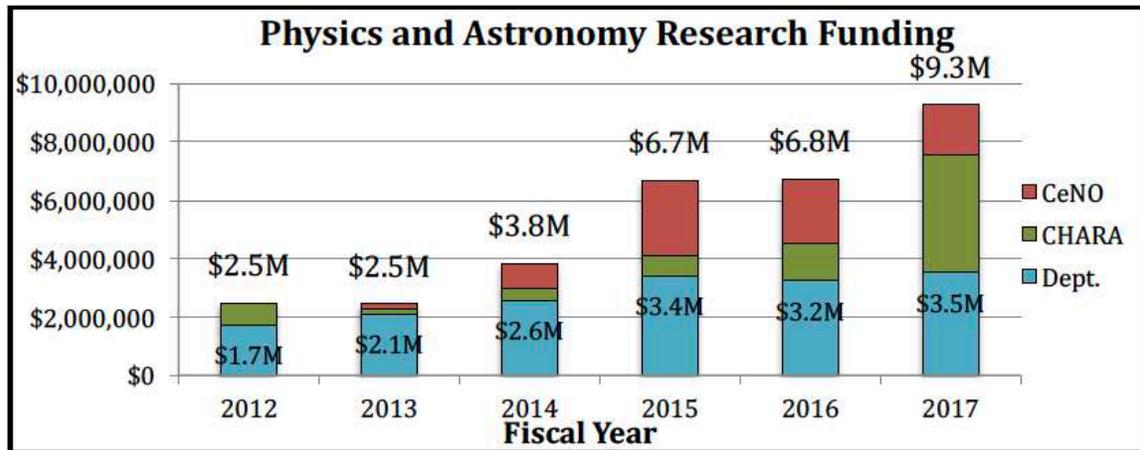
1.c.1.1 2CI and NextGen hires, Regents Professors, Alumni Distinguished Professors, eminent scholars, and endowed professors

- a) 2CI hires through the *Astroinformatics* program
 - Professor: Petrus Martens, Stuart Jefferies (plus Rafal Angryk in CS)
 - Associate Professor: Sebastien Lépine
- b) NextGen hires through the *Solar-Stellar Connection* program
 - Assistant Professor: Jane Pratt (plus Daniel Pimentel-Alarcon, Juan Banda in CS)
- c) Regents Professor: Douglas Gies, Steven Manson, Unil Perera
- d) Distinguished University Professor:
 - Michael Crenshaw, Xiaochun He, Todd Henry, Mark Stockman
- e) Alumni Distinguished Professor: Douglas Gies (2017), Unil Perera (2010).
- f) Eminent scholars: none
- g) Endowed Professors: none

1.c.1.2.a Levels of external and internal funding: grants, fellowships, and awards

External funding has grown by nearly a factor of four since 2012. This is due in part to new awards to CeNO, CHARA, and the Astroinformatics cluster. Appendix C2 lists the yearly levels and sources of funding plus a table of individual grants. The faculty has

received a total of \$29M from 105 external grants since FY 2013. This comes to an average of \$268K in research expenditures per T/TT faculty member per year, which compares favorably with the median value of \$196K per T/TT faculty member per year among peer schools (Appendix E2). Drs. Abate, Bentz, and Dhamala were each awarded a prestigious NSF CAREER grant. The external agencies supporting the P&A faculty research represent a diverse portfolio that includes the National Science Foundation, National Institutes of Health, Department of Energy, Department of Defense, NASA, Space Telescope Science Institute, Illinois Wesleyan University, GIT, National Radio Astronomy Observatory, American Physical Society, and Emory University.



1.c.1.2.b Ratio of proposals submitted to grants awarded

Appendix C2 lists the grants success ratio for the past five years from the APR Dashboard (excludes CeNO grants). The ratio varies from 21% to 52%, indicative of the highly competitive funding environment.

1.c.1.3 National/international rankings of the unit (e.g., by the National Research Council, U.S. News and World Report, professional associations, etc.)

The physics graduate program is placed at number 111 of 142 programs listed in the 2018 U.S. News and World Report rankings. They do not include astronomy. The last NRC ranking of the astronomy graduate program was published in 2010 and was based upon data from 2006, so it is not relevant to the current program. The NRC study placed the GSU astronomy program at that time between 28 and 34 of 34 programs in the U.S.

1.c.1.4 Research productivity that furthers the strategic goals of the university

1.c.1.4.a Quantity and quality of disseminated research

The P&A faculty has been extremely productive during this period, publishing a total of 501 refereed articles and 552 non-refereed articles (mainly conference proceedings) between AY 2012-2013 and AY 2016-2017 as listed in Appendix C3. The data reported for the past year (AY 2016-2017) on the GSU Dashboard is an underestimate because faculty generally update their publication records in January for the preceding calendar year so that the period January – June 2017 is incomplete. The number of refereed articles per T/TT per year is 4.5 for the period AY 2012-2015

and is 3.4 for the period AY 2014-16 (underestimate). This is lower than the median of peer institutions of 8.8 refereed articles per T/TT per year (Appendix E2), but we caution that the peer numbers (an incomplete sample) refer to papers by all authors affiliated with the institution (not just T/TT) and often include papers by large collaborative groups, so the peer publication rate must be higher than the statistic reported by the GSU Dashboard. The number of other articles per P&A T/TT per year is 4.2 for the period AY 2012-2015 and is 3.7 for the period AY 2014-16 (underestimate). The large numbers of papers in the NTT categories in Appendix C3 are authored by our scientific staff (primarily the CHARA staff and other post-doctoral associates). All these publications generally appear in the most prestigious journals in the fields of study, and their impact factors are listed in Appendix C3. Professors Perera, Dietz, and Mani have garnered 11 issued patents with four others pending (Appendix C3).

1.c.1.4.b Impact of research on relevant disciplines, including analyses of citations of the work of individual faculty members

Appendix C3 lists the numbers of citations and *h*-indices for all faculty for their careers and for the 2014 – 2016 calendar period. Most of the faculty members' work has been cited over 1,000 times in the literature, with one faculty member, Professor Stockman, having over 15,000 citations. In addition, 14 of the faculty members have *h*-indices greater than 30 indicating broad interest in their work.

1.c.1.5 Success in recruitment and retention of top faculty in the field

The Department has expanded its research portfolio to include solar physics with the hiring of two senior faculty members under the Second Century initiative (2CI): Professors Petrus Martens (2014) and Stuart Jefferies (2016). Dr. Jane Pratt was recruited and hired in 2017 as an assistant professor under the Next Generation (NextGen) initiative to bring strength in the area of solar and stellar computational modeling. In addition, the Department strengthened its presence in stellar astronomy with the hiring of Professor Sebastien Lépine (2013) under 2CI. In the review period, there have been two transfers out of physics: Professor Richard Briggs retired in 2015 and Professor Yohannes Abate moved to the University of Georgia in 2017. No transfers out occurred among astronomy faculty.

1.c.1.6.a Number of faculty promoted and/or tenured since the last self-study

In 2014, Dr. Sarsour was tenured and promoted to Associate Professor and Dr. Evans was promoted to Senior Lecturer. In 2015, Dr. Apalkov and Dr. Hastings were promoted to Professor. In 2016, Dr. Bentz was tenured and promoted to Associate Professor. There were no unsuccessful promotion or tenure cases during this time period. Dr. McGimsey and Dr. Wang were approved for promotion to Senior Lecturer in Fall 2018. Drs. White and Lépine are currently under review for promotion to full professor, and Dr. Von Korff is under review for tenure and promotion to associate professor.

1.c.1.6.b Average time in rank, recruiting/hiring history

The faculty hiring history is shown in Appendix E4. Beginning in 2013, P&A hired 9 T/TT and 1 NTT faculty members, and lost 2 T/TT faculty members to retirement or another institution. As previously discussed, the growth is primarily due to successful 2CI and

NextGen proposals. P&A is currently searching for two faculty hires (one junior, one senior) in condensed matter and/or nano-optics to begin in Fall 2018. In almost all cases, both T/TT and NTT faculty members have been progressing through the ranks on schedule. The few associate professors that have been at that rank for more than 6 years have retired, recently been promoted, or plan to go up for promotion next year.

1.c.1.7 Faculty participating in exchanges, where applicable to the Unit

Dr. ten Brummelaar (CHARA) won two Fizeau Fellowship Awards for extended collaborative work at the University of Paris and the University of Nice.

1.c.1.8 Faculty surveys

The GSU Office of Institutional Research (OIR) conducted a survey of P&A faculty in spring 2017. The survey results are presented in Appendix F11 and compared to those from other GSU departments in Appendix F12. The faculty has a favorable impression of their mission at GSU with an overall mean of the average scores (from Tables 1, 2, 4, 5, 8 of Appendix F12) of 4.78 compared to 4.44 for other GSU departments (where 1 = strongly disagree and 6 = strongly agree). This sense of job satisfaction is also expressed in the question about “plans for career development at another university” (Table 3, Appendix F12): only 14% of P&A faculty indicated they might seek other employment compared to 30% for those in other GSU departments. P&A has no formal mentoring program for faculty, but the survey responses (Table 7, Appendix F12) indicate that informal mentoring is effective and appreciated. The highest numerical averages and favorable opinion were related to questions about mentoring and the promotion and tenure process, while the lowest score was related to satisfaction with university committee work (presumably due to the associated time burden).

The survey solicited comments specifically about space needs and strategic hiring. Most respondents placed new research laboratory space as the primary critical need given the department’s growth in experimental research. The second and closely related need was for additional graduate student office space to foster better interaction between those involved in similar research activities. The third need is for additional special classrooms that support new innovative approaches to teaching. Most respondents applauded the success of P&A in making new hires especially through the GSU Second Century and Next Generation Faculty programs, but several noted problems associated with this focused hiring approach. For example, the emphasis in the Second Century program on senior faculty left a shortage in our junior ranks and led to the perception among some faculty of a senior tier more focused on their research than the needs of the department. The hiring of junior faculty is being addressed through GSU’s Next Generation Program and other requests for building large collaborative research groups in targeted areas. The recent senior hires at market value have also led to some large differences in faculty salaries, which is being at least partially addressed for full professors through GSU’s recent compression adjustment program. Other comments were positive about the upward trajectory of the department and support for research. Several respondents lamented the lack of collegiality among faculty that is due in part to the physical separation of faculty members (among four buildings on campus).

1.c.2 Faculty Partnerships and Professional Service

1.c.2.1 Faculty participation (direction, affiliation) in research centers and clusters at the Georgia State University

Dr. Stockman is director of CeNO, Dr. Gies is director of CHARA, and Dr. Martens and Dr. Jefferies lead the *Astroinformatics: Solar – Stellar Connection* cluster.

1.c.2.2 National and international research collaborations/partnerships

Most faculty work with collaborators around the globe. Formal partnerships between departmental research groups and national or international collaborators include CHARA (collaborators in the U.S., Australia, France, and UK), Brookhaven National Laboratory and the RIKEN Center (Japan, China, and many others), the Astrophysical Research Consortium (University of Washington, New Mexico State University, and six other research universities), and the SMARTS consortium at Cerro Tololo Interamerican Observatory in Chile (Yale University, The Ohio State University, and others).

1.c.2.3 Evidence of interdisciplinary research

The astrophysics cluster members work closely with colleagues in Computer Science in areas of data mining and image analysis. A new initiative on “Galactic Dynamics” has been proposed that will involve collaborative work with faculty in Computer Science and in Mathematics and Statistics. There is close collaboration between the department’s physicists and individuals in the Departments of Chemistry, Biology, and Neuroscience, as well as the groups on Molecular Basis of Disease (MBD), Brains and Behavior (B&B), the Center for Diagnostics and Therapeutics (CDT), and CEHD.

1.c.2.4 Significant professional service

Faculty members serve on national review panels, grant review panels, editorial boards, and professional organizations, as well as peer review of manuscripts (Appendix C4).

1.c.3 Recognition of Scholarly Excellence

1.c.3.1 Recipients of GSU Faculty Fellowships and other internal awards

The work of the faculty has been honored in ways outlined in Appendix C5.

1.c.3.2 External awards, honors, prizes, and fellowships

The work of the faculty has been acknowledged in ways outlined in Appendix C5.

1.c.4 Unit Infrastructure for Supporting Research

1.c.4.1 Unit-level research and travel grants

The department has a small budget from the college to provide funding for travel or page charges (about \$1100 per faculty member). The principal source of research support is the department’s share of the indirect cost return, which goes toward summer salary (often one month per faculty member), a portion of the startup costs for new faculty hires, laboratory equipment repairs and upgrades, research group initiatives (such as operations costs for the Apache Point Observatory), cost sharing on large proposals, and additional

travel or other research expenses for faculty members (and their students) that are working on obtaining grants to support their research.

1.c.4.2 Grant support: writing, administration

Both the College and the University Research Services & Administration (URSA) offices at Georgia State provide access to pre- and post-award proposal administrative staff support services to P&A faculty. In addition, URSA provides proposal preparation services in the form of providing guidance for finding funding for research projects, basic grant-writing workshops, targeted grant workshops for selective sponsor-specific granting mechanisms, and proposal review for technical corrections prior to submission.

1.c.4.3 Facilities, equipment, technical support and other administrative support

Most work is done with instrumentation developed by individual faculty members, but there are some joint activities that are described in Appendix D1. Examples include the Instrument Shop, high performance computing facilities, and astronomical observing facilities. Faculty are provided with computers, software, and furniture as needed, and one staff member (Ms. Catrice Fraser) aids in financial services related to research.

1.c.4.4 Research information resources

The two P&A information technology staff (Justin Cantrell and Jeremy Simmons) provide essential services in computer hardware, software maintenance and development.

1.c.5 Contributions to Science and Health/Medical Education

The faculty works with the CEHD to train STEM educators.

1.d Contribution to Cities

1.d.1 Activities with the Council for the Progress of Cities Nothing applicable.

1.d.2 Contributions to the arts and media Nothing applicable.

1.d.3 Field-specific contributions to cities

P&A faculty regularly sponsor and participate in K-12 school visits, the Atlanta Science Festival, public astronomy debates, public star gazing events, the Science Olympiad, and special events such as the 2017 solar eclipse. These enrich the community and GSU.

1.e Globalizing the University

1.e.1 Critical issues for global cities: partnerships with other universities on challenges facing cities Nothing applicable.

1.e.2 Funded research on challenges facing emerging nations Nothing applicable.

1.e.3 Establishment of GSU as an international center

1.e.3.1 Faculty international exchanges, speakers, cultural events, visiting scholars

P&A faculty have sponsored international meetings on campus in Atlanta including IAU

Symp. 314 *Young Stars and Planets near the Sun* (2015), AGN STORM collaboration meeting (2017), sPHENIX collaboration meeting (2016), and *Brain Modes* (2015).

1.e.3.2 International fora Nothing applicable.

1.e.3.3 Programs for foreign students

Two GSU astronomy PhD students have obtained dual degrees from universities in France, and a dozen French engineering students have participated in work study programs at the GSU CHARA Array. P&A and GSU are working with the University of Rome Tor Vergata, Italy, to establish a dual PhD program. Students will earn a doctoral degree in Astronomy, Astrophysics and Space Science (“Dottorato in Astronomia, Astrofisica e Scienze Spaziali”) from Tor Vergata and a PhD in astronomy from GSU.

1.e.3.4 Programs coordinated with the university’s international initiatives

Nothing applicable.

1.e.4 Enhancement of global competency

1.e.4.1 Contribution to international studies Nothing applicable.

1.e.4.2 Number of students enrolled in study abroad programs Nothing applicable.

1.e.4.3 Global leadership certificate programs for undergraduates

Nothing applicable.

1.e.4.4 Language programs with learning outcomes and success measures

Nothing applicable.

1.e.4.5 Courses/programs with learning outcomes and success measures

Nothing applicable.

1.e.4.6 Contribution of global/multicultural perspectives to core and other major courses

Nothing applicable.

1.e.4.7 Contribution to global competency for staff Nothing applicable.

1.e.4.8 Success in recruiting top international faculty and students

Nothing applicable.

1.f Overall assessment of the unit

P&A has made remarkable strides in teaching and research in recent years, and the faculty are leading new initiatives that promise further growth. The undergraduate program is more vigorous than ever, and with the merger of GSU and Georgia Perimeter College there is now the opportunity to promote the transfer of Perimeter students to the downtown campus to pursue upper level courses. The undergraduate program will help students launch careers in STEM areas of education and industry.

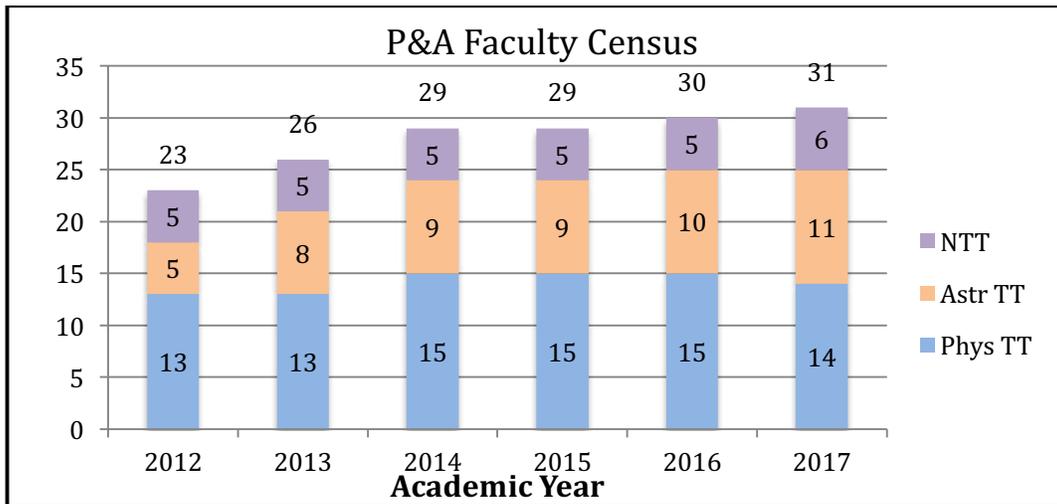
The graduate program is larger than ever, and our graduate students are going on to exciting careers in science. For example, Dr. Tabetha Boyajian (now an assistant professor at LSU) is widely recognized from her TED talks about the discovery of a star with unusual light dips, and Dr. Michelle Thaller is a nationally known NASA scientist who leads public outreach activities. Continuing to grow the graduate program will require both space and financial resources to recruit the most talented students.

The vibrant research programs of the department are admired around the globe and provide unique opportunities for young scientists at GSU. The faculty has successfully sought funding to support advancements in research, and these efforts must continue to be augmented through GSU funding of support staff and through assignment of new laboratory space on campus. Several new multidisciplinary initiatives are underway or planned, and they will open the department as never before in broader collaborations, student training, and access to large grant funding on major scientific problems.

2 How Adequate Are Your Unit’s Resources?

2.a Faculty Resources

2.a.1 Faculty composition



The faculty has grown steadily over the last few years, particularly in astronomy where there were five retirements and transfers out between 2009 and 2012. A history of faculty changes is given in Appendix E4. As of FA17, P&A has 31 full time faculty, 5 PTIs, 6 adjunct professors, 3 joint-appointment professors, and 6 emeritus professors. The full-time faculty were composed of 13 professors, 6 associate professors, 6 assistant professors, 3 lecturers, 2 senior lecturers, and 1 academic professional. There is little diversity among the full-time faculty, with 83% being male and 83% white (see distribution given in Appendix E4). While these numbers are similar to the reported averages across U.S. PhD-granting physics and astronomy departments, increasing the diversity of our full-time faculty is a key area of growth for the future. As a Minority Serving Institution, we

recognize the importance of providing our diverse student body with diverse role models and mentors.

2.a.2 Student/faculty ratio data

Undergraduate Program - The number of undergraduate majors in the program has held steady over the 2014-2016 timeframe with about 190 majors (Appendix A2). The full-time faculty increased from 28 to 30, leading to a slight reduction in the student to faculty ratio from 6.8:1 to 6.2:1.

Graduate Program - The number of graduate students has steadily increased from 72 (Fall 2014) to 76 (Fall 2015) to 79 (Fall 2016) (Appendix B2). With the number of T/TT faculty of 24, 24, and 25 over this period, the graduate student to T/TT faculty ratio has remained steady at 3.1:1.

2.a.3 Credit hour generation data, by faculty by fiscal year

The number of credit hours taught by the faculty has increased from 21,795 in FY15, to 22,073 in FY16, to 22,631 in FY17 (Appendices A6, B6). This represents an increase of 4% over a two-year period (FY15-17). However, the full-time faculty generated a 17% increase in credit hours while the generation by PTIs and adjuncts decreased. During this time, the number of full time faculty increased from 28 to 30, leading to an overall increase of 10% in credit hours per person among the full-time faculty.

2.a.4 Role of clinical faculty, if present, in teaching, research, and service

Not applicable.

2.b Administrative Resources

The departmental staff consists of one Business Manager III (Ms. Felicia Watts), one Administrative Coordinator Sr. (Ms. Keneta Wright Brooks), and one Administrative Specialist (Ms. Catrice Fraser). We also have one laboratory coordinator (Ms. Carola Butler). The business manager, administrative coordinator, and administrative specialist support the department-centered functions such as purchasing, preparing personnel documents, accounts management, class scheduling, graduate student recruitment, etc. The level of staffing for departmental business is sufficient for the near future. The laboratory coordinator oversees the scheduling and operations of the physics instructional laboratory programs; during the 2016-2017 academic year, the department taught 165 two-credit equivalent sections of introductory physics labs. The level of staffing in the laboratory coordinator function is sufficient for the near future; the staff member can accommodate increases in lab sections by further reducing their direct lab instructional activities as long as additional GLAs are funded and available to cover those sections.

2.b.1 Staff support per FTE faculty member

With four full-time staff and 30 full-time faculty, the support staff to faculty ratio is 1:7.5.

2.c Technological Resources

All faculty and staff have desktop computers, the graduate students have sufficient access to workstations, the instructional laboratories have a number of computers available for student use, and the department manages a group of centralized server facilities in support

of various functions (file storage, web services, etc.). The department has a growing cluster of small-scale high-performance computers (Appendix D1) available for research use. As well, the department has a machine and electronics shop facility that is well equipped with general purpose electronic test instrumentation and with both manual and computer controlled machines (Appendix D1). The main problem with these is finding the necessary resources for maintaining, updating, or replacing them as necessary.

In support of these functions, the department employs 2.0 FTE for IT support and 2.5 FTE for the shops, with an additional 0.5 FTE provided for the shops by CHARA. We have seen a steady growth in computer usage by students, staff, and faculty over the past several years, increased complexity in local server and network administration, and the need for increasingly sophisticated hardware and software for research purposes. An added complication is that the department's desktop and research computers use a variety of operating systems: Windows, Linux, Unix, and Mac. With the recent addition of 1.0 FTE for IT support, the level of IT staffing support is sufficient for the near future. The shops serve a vital function in supporting the research activities of the department. Increasingly heavy demand from new projects and new faculty, continued development of the CHARA Array, and our effort to provide service to other members of the COAS research community, mean that the shop staff are working at full capacity to provide work within a reasonable length of time.

2.d Space Resources

The department has acquired sufficient office space to accommodate its growth over the last few years, including faculty, staff, and postdoctoral offices on the 4th and 5th floors of Science Annex (SA) for most of the physicists involved with CeNO, 6th floor of 25 Park Place (25PP) for the astronomers and office staff, 4th floor of One Park Place (1PP) for the remaining physicists and the non-tenure track faculty members (lecturers and academic professional), and recently the 7th floor of 1PP for the growing astroinformatics cluster with CS. Spreading P&A faculty and staff offices over 3 buildings and 5 floors is not conducive to communication, establishing collaborative ventures, mentoring, or socializing, and it is expensive to maintain several copy machines, water coolers, supply cabinets, etc. The department copes by grouping research clusters together and holding frequent faculty, committee, and other meetings. Future growth is anticipated, and a commitment to consolidating the department's office space is a high priority.

Current instructional space for introductory physics laboratories includes three physics labs in the Natural Science Center (NSC 210, 222, and 226; ~1200 sq. ft. each) with an associated storeroom (NSC 224) and one integrated lecture and laboratory space in Classroom South (CS 500, ~1500 sq. ft.). NSC 222 was recently renovated in partnership with GSU's Center for Excellence in Teaching & Learning to replace long benches with small workstations and wall monitors to facilitate student collaboration and interaction with learning assistants. We plan to secure funds to renovate the remaining two introductory physics labs in NSC to also support more effective, collaborative instruction. While technology and instructional lab equipment are maintained through tech and lab fees, the two unrenovated NSC labs and the integrated lecture/lab in CS are showing considerable wear and tear to furniture and classroom infrastructure. Two advanced physics labs (NSC

160, NSC 256; ~900 sq. ft. total) were renovated with department, lab fee, and student tech fee funds. These renovations provide our growing numbers of majors with increased space as well as modern computers and lab equipment.

Introductory astronomy labs are located in Kell Hall (K516 and K528; ~1100 sq. ft. each) with an associated storeroom (K527). These rooms are heavily scheduled, averaging 36 hrs/week/room. Kell Hall is planned for demolition, and new lab space for introductory astronomy must be found by Fall 2018, with enough advanced warning to allow time for departmental participation in the redesign (as done for the physics lab in NSC 222).

2.e Laboratory Resources (both research and non-instruction laboratory space)

The department is fortunate to have a suite of capabilities available for research in physics and astronomy that are listed in Appendix D1. Foremost among these is the CHARA Array of telescopes on Mount Wilson, California. This state-of-the-art facility, used by P&A faculty and by visiting researchers from other institutions, is rapidly providing scientific results impossible with previous instrumentation. It is continuously undergoing enhancements, an activity that requires a large amount of the machine shop's effort. In 2015, GSU became a 1/16 member in the Astrophysical Research Consortium's Apache Point Observatory 3.5-m telescope. The large collecting area of the telescope provides crucial support for the department's extragalactic astronomers especially, who have science targets that are much too faint for CHARA. ARC membership also provides access to the ARCSAT 0.5-m telescope at APO at a very modest cost, which has been useful for monitoring projects for student dissertations. The department is also a founding partner of the Small and Moderate Aperture Research Telescope System (SMARTS), and GSU operates the 0.9-m telescope, one of the four SMARTS telescopes at the Cerro Tololo Interamerican Observatory in Chile. Finally, the department operates an observatory at Hard Labor Creek State Park, located 50 miles east of the GSU downtown Atlanta campus. Significant upgrades and enhancements over the past five years have modernized the instrumentation, thereby providing an excellent training environment for graduate and undergraduate students. It is now possible to obtain research-quality data, and the observatory is regularly being used for science as well as for outreach to the public through free monthly stargazing events.

On the physics side of the Department, the condensed matter area has available a versatile system for optical characterization of materials, including a recently renovated chemical vapor deposition (CVD) system capable of growing epitaxial films of materials designed to have optical properties useful for optoelectronic devices. In addition, another chemical vapor deposition system is available consisting of a 1100°C, 1" tube furnace with a quartz growth tube, a programmable temperature controller, a pumping system for low pressure operation, and programmable mass flow. A nanoscience, low temperature, and high magnetic field laboratory exists for (a) the cryogenic transport study of microwave-photoexcited- and dark- systems from low to high magnetic fields, (b) the nanoscale imaging of low-dimensional systems, and (c) sample fabrication using semiconductor lithography techniques. Several scanning tunneling microscope (STM) systems, an electron beam writer attachment, a mask-aligner and a spin coater are available for electron beam lithography. Another well-equipped laboratory hosts monochromators, FTIR spectrometers, noise analyzers, I-V-T measurement setups, closed cycle and continuous

flow cryostats, Hall measurement systems, variable temperature dewars, etc., for optical and electronic characterization of UV to far infrared (Terahertz) detectors. A spintronics laboratory is equipped with variable temperature magneto-optic Kerr effect microscopy and magnetometry systems, a magnetic force microscopy (MFM), microwave probe station and two electron paramagnetic resonance (EPR) systems. The biophysical spectroscopy lab contains several complete visible and infrared spectroscopy instruments including four FTIR spectrometers with attachments for infrared microscopy and time resolved spectroscopy. Two visible, high time-resolution spectrometers are also available. For time-resolved spectroscopy down to nanosecond timescales, three pulsed Nd:YAG lasers are available, along with three cryostats for measurements at temperatures down to 10 K.

A facility dedicated to the design, assembly, and testing of particle detectors is available in-house. The Nuclear Physics group is active at national labs (including Brookhaven National Lab, Fermi National Accelerator Lab, Los Alamos National Lab, Oak Ridge National Lab, and the National Institute of Standards and Technology). GSU is also a member of the joint Center for Advanced Brain Imaging (<http://www.cabiatl.com/CABI/>) with a 3 Tesla Siemens Trio MRI machine dedicated for neuroscience research. Resources for high performance computing are also available at GSU through the Orion computer system (<http://ursa.research.gsu.edu/high-performance-computing>).

Most of the above-mentioned physics laboratory facilities were developed by individual PIs, and therefore they are not truly multi-user in nature. Nevertheless, as the research in these areas has matured, faculty members increasingly collaborate on projects making use of the full suite of capabilities. It is now time to seek establishment of multi-user facilities incorporating a more extensive variety of equipment for materials and device characterizations, and possibly for device fabrication. Examples of these facilities/capabilities include the following: optical and electron-beam lithography, dry- and wet-etching, deposition and synthesizing chambers, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, optical near-field microscopy, and X-ray characterization. These will function similar to the core facilities successfully set up by Biology and Chemistry as a result of the Georgia Research Alliance's support for biotechnology and drug design.

A problem rapidly reaching crisis proportions is overcrowding of the available laboratory space in the Natural Science Center. NSC opened during a period of rapid retirements (ca. 1993-1998) in P&A, and only in the last five years have we caught up in replacing those experimental physicists. Critical needs at present are: space for the shared characterization activities described above (~3,000 sf); space for molecular biophysics research / photosynthesis (~ 250 sf + 500 sf = 750 sf); space for new activities (1,000 sf); space for neuroscience experiments (~250 sf). A total of 5,000 sf of new space is needed.

2.f GSU Foundation Resources and other gifts the unit has received

Prior to 2013, the department had no endowments. This changed with the establishment of the W. H. Nelson Endowment in 2013 for distinguished lecturers and the R. H. Hankla Endowment in 2014 for the outstanding senior physics major, each at an initial level of \$25K. To encourage further donations and spread the news of our accomplishments, we

created the annual GSU Physics and Astronomy Newsletter in Spring 2014, distributed electronically and by color brochure (<http://phy-astr.gsu.edu/newsletters/>). We have also sponsored a number of local events for the public, university, and alumni.

2.g Library resources

The GSU library effectively supports the curriculum and research areas of our faculty and students. In addition, our subject librarian is available to consult with our students and faculty and to give presentations on the GSU library to both undergraduate and graduate students. In physics, we subscribe to 15 of the top 20 journals and in astronomy we subscribe to 19 of the top 20 journals (as ranked by impact factors). For those journals to which the GSU Library does not provide direct access, Interlibrary Loan service is available to fill quickly requests for articles. In comparison to peer institutions, the GSU Library provides a collection of databases that is both comparable and includes key titles. Beyond subscribed databases, the library links to well established and respected open access resources, such as arXiv.org and the Astrophysics Data System, to assist student researchers with identifying additional resources. A comparison with peer institutions shows that the GSU Library acquired the second highest number of monograph titles in the last three years in the areas of both physics and astronomy. Faculty and students have access to three interstate book-share programs and our Interlibrary Loan service.

3 Where Does Your Unit Want to Go?

3.a.1 Goal: Make the graduate program more attractive and competitive with other high-profile physics and astronomy programs. This is directly related to GSU strategic goal #2: *Significantly strengthen and grow the base of distinctive graduate and professional programs that assure development of the next generation of researchers and societal leaders.*

3.b.1.1 *Objective: Increase graduate student stipends and scholarships.* Graduate support from stipends and scholarships have not kept up with the increased costs of living, and they are no longer competitive, given the high student fees and relatively high cost of living in Atlanta. Stipends in the Georgia Tech and Emory Physics Departments start at \$25K, compared to our \$20K. We will seek additional resources to increase the base stipends by at least 5% over the next two years. This initiative aligns with the GSU strategic objective: *Expand support for doctoral programs.*

3.b.1.2 *Objective: Increase efforts to support graduate students in career development.* In the competitive environment for academic positions, we need to provide students with the best means to advance their career prospects, particularly in alternative jobs such as data science. We will pursue programs of career advisement, training opportunities, travel opportunities, and networking. P&A will encourage peer support through the student organizations AstroPAL, SPS, and PGSA.

3.b.1.3 *Objective: Increase recruitment efforts.* Most of the entering graduate students applied to GSU on the advice of their undergraduate mentors. We need to increase our visibility among potential graduate students through activities at professional meetings and on social media, in order to attract more talented applicants. We will increase the diversity

of the racial mix to better match the national fabric through work with the APS Bridge Program (<http://www.apsbridgeprogram.org>) and by outreach to local HBCUs.

3.a.2 Goal: Build on the steady growth of the undergraduate program. This supports GSU strategic goal #1: *Become a national model for undergraduate education by demonstrating that students from all backgrounds can achieve academic and career success at high rates.*

3.b.2.1 Objective: Increase scientific literacy and immersive learning in our service courses. Astronomical concepts are best visualized through three-dimensional models and direct observing of the night sky (as can be presented through projection in an astronomical planetarium). On the physics side, we can increase experiential learning in the introductory laboratories (NSC 210, 226, CS 500) by refurbishing them in the style of NSC 222 and growing our PER program to investigate further new and effective methods of teaching (see 3.b.3.1, bullet 5).

3.b.2.2 Objective: Increase research and training opportunities on campus and around the world, especially for physics majors. Research experiences for undergraduates are often formative in their career plans, and we will increase access to research activities both on campus and at research facilities around the globe. This objective supports the GSU strategic initiative: *implement an undergraduate signature experience.*

3.b.2.3 Objective: Increase retention rates of our physics majors and smooth the transition from Georgia Perimeter and other two-year colleges. We will improve ties with Georgia Perimeter faculty to facilitate transitions into the GSU program. We will track the progress and obstacles encountered for each student in the physics BS program and provide intervention and advice as needed about physics or other degree options, in order to insure degree completion at GSU or elsewhere.

3.a.3 Goal: Build multi-disciplinary research teams that can compete for large grants and address significant questions. This is related to GSU strategic goal #3: *Become a leading public research university addressing the most challenging issues of the 21st century;* and the associated initiative: *Support a research culture that tackles large and complex problems.*

3.b.3.1 Objective: Grow the faculty in strategic research areas. The current faculty research programs provide outstanding opportunities for new growth in collaborative and interdisciplinary studies. We will explore options to build upon our research faculty in areas of exceptional promise. These will include:

- High resolution and high contrast imaging in astronomy and other experimental sciences: We anticipate proposing to the Next Generation Program for a multi-disciplinary Center for Excellence in Imaging (astronomy, space situational awareness, neuroscience, biology, computer science) with potential funding support from the U.S. Air Force Office of Scientific Research.
- Galactic dynamics and high-performance computing: We will pursue hiring new faculty in P&A, Computer Science, and Mathematics and Statistics to take advantage of million-dollar opportunities in computer simulations.

- Characterization of nano-devices and materials: We are looking to build this area (in conjunction with the Center for Nano-Optics) through junior and senior hires.
- Building instrumentation and theoretical models for the future U.S. Electron-Ion Collider (EIC; <http://www.eicug.org/web/>). We will write proposals for faculty fellowships to Brookhaven and other agencies to contribute to this next generation DOE project.
- Physics education research (PER): We are investigating ways (including a Next Generation proposal with CEHD) to hire a highly respected researcher to build our PER group and develop novel teaching methods.

3.b.3.2 *Objective: Maintain and enhance support for research.*

Most of the faculty requires laboratory space on campus to support the specialized equipment needed for their work. There is insufficient lab space for our current needs, and the problem will be exacerbated with the addition of a new junior hire in nanophysics who will also require laboratory space to establish their program. We will explore the development of a condensed matter / nanophysics joint instrumentation core facility that would support the requirements of many investigators. Instrumentation for a joint facility will require at least a part-time (and preferably a full-time) staff member to maintain the equipment and assist faculty and students. We need to maintain and potentially increase support for the P&A Instrument Shop, which plays a key role for all the experimental scientists in the department and many in other departments. It is essential that this talented staff pool (three FTE, two supported by COAS) continue to be retained. We will work on a long-term plan to centralize office space. We have offices and labs spread over four buildings on the downtown campus, and closer quarters will help foster interaction. This overall objective aligns with the GSU strategic initiative: *Enhance supporting infrastructure for the conduct of research.*

3.a.4 **Goal: Develop programs of community engagement and global activities.**

3.b.4.1 *Objective: Increase public learning activities in the Atlanta area.* During the recent solar eclipse, department faculty and staff hosted events on campus and in north Georgia that each attracted well over ten thousand visitors. We need to pursue opportunities like these to engage the broader community in on-the-spot and informal learning.

3.b.4.2 *Objective: Build connections with alumni and the global community.* Many of the departmental alumni have led remarkable careers in science and industry that are models for our current students. We need to foster greater communication with these successful scientists and encourage networking between students and alumni. The research and scholarly activity of the department needs greater recognition in the community, and we will expand our efforts to publicize these achievements. By building excitement in the wider community, we will foster new avenues for private funding and development.

4 What Do You Need to Do or Change to Get There?

4.a New resources required for the goals and objectives

In a budget-neutral environment where funds are limited, we will continue to work on creative ways to increase our resources to support the current and planned missions of the department, college, and university. Higher stipends and new training opportunities for

graduate students will need to come primarily from grants, applications for external fellowships, and partnerships with other institutions. New facilities for immersive learning will come from student fees, fund raising, and partnerships with the GSU Center for Excellence in Teaching and Learning (CETL) and other university offices. New faculty hires in interdisciplinary clusters will come from a combination of Next Generation (or successor) proposals, retirements, and more creative ventures such as sponsored faculty fellowship or endowed positions. Support for research will come from judicious use of departmental indirect cost return and making strong cases for startup funds and entrepreneurial ventures to the college and university. Community engagement will require a small financial investment from the department foundation and other funds and could lead to a much larger return. Initiation of these new initiatives will require course release time for participating faculty. All the initiatives below will be developed over a five-year period (FY20 – FY25).

4.b Implementation plan for achieving each goal by the next scheduled self-study

4.b.1. Make the graduate programs more attractive and competitive.

4.b.1.1 Find additional sources of income for increasing the base stipend of each student by at least \$1000 in the next two years, such as more faculty grant support, working with the college and university to increase support for teaching labs (currently \$2000/lab), and developing community-supported educational programs. Provide students with guidance to seek external fellowships from federal agencies and other organizations, including mentoring sessions by faculty and our successful NSF graduate fellowship winners. Identify other means to help offset student financial burdens, such as the current practice of the purchase of a new laptop for each incoming student, and find ways to offset the costs of student fees for the first and second year graduate students.

4.b.1.2 Develop ways to improve graduate student mentoring with the participation of the student's supervisor, PhD committee, and student peer organizations. This broad community will help students seek opportunities for professional growth, travel, and making connections with researchers around the globe. We will bring in successful alumni for career day events to discuss career opportunities in research, education, and industry.

4.b.1.3 Increase the visibility of the program by renting display space at undergraduate receptions at professional meetings, advertising when giving talks at other institutions, making professional contacts, and utilizing social media. We will plan to apply for a NSF Research Experiences for Undergraduates (REU) program to bring promising undergraduates to GSU for the summer and acquaint them with our graduate program.

4.b.2 Continue to grow the undergraduate program.

4.b.2.1 Build new facilities for immersive and experiential learning by combining tech fees, student lab fees, and CETL support to redesign our remaining physics labs (NSC 210, NSC 226) in the style of NSC 222 and to refurbish the studio physics room (CS 500). We will

explore the use of virtual reality headsets for the introductory astronomy laboratories as a first step towards assessing the benefits of a campus astronomical planetarium.

4.b.2.2 Take advantage of our national and international partnerships, including those at large observatories such as CHARA and APO and research labs such as Brookhaven, to provide our undergraduate students with research experiences on a global scale. This will be accomplished mainly through summer research associateships sponsored by faculty grants and other travel resources from GSU and elsewhere.

4.b.2.3 Increase retention by tracking each major beginning with the PHYS 1000 *Gateway to Physics* course to identify their needs or stumbling blocks so that we can intervene. This will be done in conjunction with GSU and COAS student advisors. We will build connections with the GSU Perimeter College faculty through community wide meetings and electronic mailing lists to identify promising students and facilitate their paths into our physics major program. We will explore the development of PHYS 1000 courses at the Perimeter campuses to encourage enrollment in physics.

4.b.3 Continue to build multi-disciplinary research teams.

4.b.3.1 Continue working with other departments over the next five years to submit successful GSU Next Generation proposals as outlined above. We will conduct energetic searches to fill pending positions in nano-optics at the junior and senior level. We will pursue faculty fellowships that support the majority of an assistant professor's salary such as the current agreement with the RIKEN center at Brookhaven. We will work with the COAS development office on creating endowed faculty positions in one or more critical areas.

4.b.3.2 Work with the college and university to identify research laboratory space for new faculty and for existing faculty members with new large research grants. We will pool resources and submit proposals to federal agencies for new instrumentation to build a core facility in nanophysics and to shore up support for the Instrument Shop. We will work with the college and university on a decadal plan for contiguous office space for the department.

4.b.4 Increase community and global engagement.

4.b.4.1 Expand our community outreach using star gazing parties at the GSU Hard Labor Creek Observatory and other locations around Atlanta. We will continue to participate in the Science Olympiad events for middle-school students and will look for other such opportunities at the elementary and high-school levels. We will develop a formal program for faculty and graduate student outreach in Atlanta area K-12 schools through class presentations, career days, and judging science fairs.

4.b.4.2 Expand connections to alumni and other potential donors through continued publication of a newsletter and hosting events such as star parties at HLCO and visits to our observing sites (such as CHARA) and physics laboratories. We will establish a Board of Visitors from the high-profile and supportive members of these groups to provide advice to the department and assistance in fund raising. We will further develop communication through social media about P&A research and teaching activities and public events.

Academic Program Review

Department of Physics and Astronomy

Georgia State University

February 25-27, 2018

Alison Baski (California State Polytechnic University, Pomona)

Caty Pilachowski (Indiana University)

Joseph Shields (Ohio University)

Soren Sorensen (University of Tennessee)

The Academic Program Review Committee very much appreciates the Department's hospitality during our visit, and as well as the effort in advance to organize a very busy schedule. We are especially grateful to Department Chair Michael Crenshaw and Professor Douglas Gies, who chaired the Department's Academic Program Review Committee preparing for our visit, as well as appreciating the tremendous effort of each of the members of this committee in preparing the very comprehensive self-study report. Each of our interactions gave us useful and interesting perspectives on the department, and all of our meetings with faculty and students were both productive and enjoyable. It was a particular pleasure to observe the high level of engagement of all faculty and students in the department and its future.

1 Executive Summary

During our visit to the Department of Physics and Astronomy at Georgia State University, we had the opportunity to meet with faculty, graduate students, and undergraduate students to evaluate the successes of the department and to identify new opportunities to strengthen the department.

- We found the faculty as a whole to be engaged in significant scholarly research, making important contributions in both astronomy and physics and competing effectively for external and internal funding. Several of the department's active research programs are recognized internationally. This is particularly true for the core collaborative research groups in the department, and these groups provide a model for strengthening other research areas in the department.
- The department has made remarkable progress in its undergraduate program through its initiatives to create a multi-faceted educational experience for students, including career preparation, opportunities for specialization, and a research experience. These initiatives have led to a significant growth in the number of undergraduate majors. Particularly notable is the department's success in increasing the diversity of its undergraduate majors, a change which, in the future, should hopefully also be reflected in its faculty and graduate students. In addition, we recommend that the department rotate faculty teaching courses for majors so that multiple faculty are available for each course, and that the department implement a peer-observation program in service and majors courses to provide feedback to instructors for continuous improvement in instruction.

- At the graduate level, both the astronomy and the physics graduate programs are strong, but can be improved through increasing graduate student stipends, establishing formal, clear, and shared expectations through graduate student handbooks, reducing time to degree for PhD students, and establishing a more robust advising system for graduate students. We recommend that the department limit further growth in its graduate programs until these issues can be addressed.

Critical to maintaining the department's notable rise in national and international stature in physics and astronomy will be a shared consensus on a comprehensive strategic plan that can guide future department chairs as opportunities appear. We urge the department to undertake this activity.

2 Contributions to the Discipline

2.1 To which subfields of the discipline does the department make the most significant scholarly, creative, or clinical contributions (as appropriate)?

2.1.1 Astronomy

The department continues to make significant scholarly contributions in astronomy, particularly in the areas of extragalactic astronomy, stellar astronomy, solar physics, and high angular resolution imaging.

Professors Bentz, Crenshaw, and Kuzio de Naray, along with emeritus professor Miller, study the properties of galaxies, including the supermassive black holes at their centers and the dark matter and intergalactic medium in which they are embedded. Interactions among the galaxies, the black holes, and the gas and dark matter surrounding them drive the formation and evolution of the galaxies.

Professors Baron Gies, Henry, Lepine, White, and emeritus professor Harold McAlister are each carrying out internationally recognized research in stellar astrophysics, including work on binary stars, nearby stars, stellar properties, and exoplanets. Research with GSU's Center for High Angular Resolution Astronomy has established world leadership in this area, including work on image reconstruction from interferometric observations.

GSU investments in solar physics and astroinformatics are particularly strategic with the 2CI and NextGen initiatives in the area of solar and stellar computational modelling, including Professors Martens, Jefferies, Pratt, and Lepine along with colleagues in Computer Science. GSU is well positioned to take advantage of new space and ground-based facilities in these fields (and the massive datasets they will produce) and has established programs putting GSU in a position of leadership in solar physics and space weather.

2.1.2 Physics

The condensed matter physics program comprises six faculty who study a range of topics that include: theoretical nanoplasmonics and nanophotonics (Apalkov and Stockman, CENO), nanoscience at low temperatures and high magnetic fields (Mani), MOCVD/CVD-grown materials systems (Dietz), magnetism and spintronics (Kozhanov), and optoelectronics (Perera). This group of faculty presently mentors 19 graduate students and produced 10 PhD students over a three-year time period (2013-16). All faculty appear to have well-established research programs with

sustainable funding and do not seem to interact much, except those involved in CENO (Center for Nano-optics). Given that new faculty hires at GSU are linked to strategic clusters, it would be beneficial to build some connections among these faculty so that they were more successful in future hiring and possibly multi-PI research funding.

The nuclear physics program (Connors, He, Sarsour) focusses on studies of nuclear matter at high densities and temperatures and on the parton structure of nucleons. The three faculty members have developed a coherent program, where they supplement each other well. This enables them to take on responsibilities for both data analysis and instrumental development. The group has a stable DOE grant, but with the recent addition of Connors the external funding level should be expected to increase.

2.2 To what extent are the faculty number and composition sufficient to support the research and educational missions of the department?

2.2.1 Astronomy

Each of the Astronomy groups is of sufficient size to form a strong research cluster, and the members of each group share overlapping research interests. Each of these cohesive groups contributes strongly to the research and educational missions of the department, and each group is able to contribute more than the sum of its individual members. The Astronomy faculty have carved out clear and distinctive areas of leadership in the field that are recognized nationally and internationally.

The department's astronomy faculty have also taken great advantage of GSU investments in facilities including CHARA, ARC, and SMARTS. CHARA is a gem and GSU's leadership in high angular resolution astronomy has paid off well. CHARA is a strong, productive facility at the leading edge of this emerging field. The implementation of adaptive optics at CHARA will extend the productivity and reach of this facility greatly. SMARTS and ARC support observational programs for both stellar and extragalactic programs at GSU. All three facilities are well matched to support the research needs for all members of the Astronomy group. The financial model to support these facilities, combining institutional support, F&A return, and grants, appears to be working but will need to be monitored to ensure continued success.

The future of the Hard Labor Creek Observatory is less clear. The return on continued investments at HLCO may not be warranted for research and the facility may be a distraction for faculty. HLCO may have a role in developing new instrumentation for the department's other facilities, however the priority of that use is unclear. Its value for training graduate students in today's world is limited, and students will benefit more from a focus on CHARA, SMARTS, and ARC. The astronomy group should develop a strategic plan for HLCO, perhaps focusing on education and outreach, and consider partnering with other institutions with an interest in using the facility to leverage resources.

2.2.2 Physics

With six researchers in condensed matter physics and three in nuclear physics the department has a sufficient number of researchers in these two fields to sustain a strong research program. The condensed matter group seem to have less coherence and internal collaboration than many

comparable programs and any future hires should augment the current program directions. In the other research areas of biophysics, atomic physics and physics education research (PER) the number of people is sub-critical and the department should decide (through a strategic planning process) if further hires in these areas are needed or if other areas should be enhanced.

From an educational perspective, however, there are concerns about the composition of the physics faculty. The PER group has provided important improvements to parts of the physics lower division curriculum, but the staffing to support this effort is limited and has an uncertain future. Oversight of the undergraduate program and advising is carried out to a very significant degree by one motivated faculty member, which leaves the program at risk of a “single point failure” if that person steps out of this role.

2.3 Based on your knowledge of similar departments in the discipline, evaluate the overall strength of the department.

2.3.1 Astronomy

Overall the astronomy program within the department is very strong in its chosen areas of expertise. The faculty have chosen wisely to focus on specific areas, including solar physics, stellar astronomy, astroinformatics, and extragalactic astronomy. In most of these areas the department has achieved international leadership. While astronomy programs are not ranked by U.S. News and World Report, the GSU Astronomy program competes very well with its aspirational and peer programs, and with many of the stand-alone astronomy programs in the U.S.

2.3.2 Physics

The most recent ranking of graduate physics programs by the National Research Council places the department in the group from 75 to 127. The U.S. News and World Report places it as 111 out of 142 programs. These rankings seem reasonable given the current size, publication rates, graduation rates and funding rates of the physics program. Given the general upward trajectory of GSU a ranking in the top 100 at the next academic review is realistic, but any more dramatic increases of the ranking are not likely unless there will be substantial increases in the number of physics faculty and their external funding levels.

3 Quality of the Department’s Undergraduate and Graduate Programs

3.1 Quality of the Undergraduate Programs in Physics and Astronomy

The Physics BS program has grown recently and now enrolls nearly 190 majors and awards approximately 18 degrees per year, with under-represented minority (URM) students receiving more than four per year (2012-2015)—a notable increase from about one per year (2007-2011). The department attributes their undergraduate enrollment growth in part to curriculum changes such as the introduction of a “Gateway to Physics” course, redesign of the advanced laboratory course, expansion of the research capstone project, and introduction of a physics teacher concentration. It is noteworthy that this new concentration (begun 2012) provides teacher certification and was recognized with the PhysTEC “5+ Club” by the American Physical Society.

3.1.1 Evaluate the quality of the undergraduate curriculum in terms of disciplinary standards and trends.

The physics curriculum has a relatively standard core and provides flexibility with the choice of the Standard Program or seven concentrations (Applied Physics, Astronomy, Biophysics, Computer Science, Geology, Pre-medicine, and Teacher Education). The largest number of students have graduated in the Standard Program (19 of 55 graduates over past 3 years); a reasonable number chose the four concentrations of Teacher Education (10), Computer Science (9), Astronomy (8), and Applied Physics (6); and only a few selected Pre-medicine (1), Biophysics (1) and Geology (1). Although many physics programs across the nation require more upper-division courses in their curricula as compared to GSU, e.g., (6 credit hours in classical mechanics, electricity and magnetism, and quantum mechanics and 3 credit hours in thermal physics and statistical mechanics), the flexibility of the GSU curriculum is well-suited to its diverse student body with a range of career objectives. All concentrations and the Standard Program emphasize student learning outcomes that include core physics principles and gaining expertise in the acquisition and analysis of physical data. Recent assessments show that majors achieve competency in data acquisition and analysis via the Advanced Physics Lab (PHYS 3300) and Research Project/ Advanced Research (PHYS 4900/4950). Some students, however, appear to need more core physics training and the department consequently changed the curriculum to include required courses in Mathematical Methods and Computational Physics I/II (PHYS 3550/3560). The department also improved instruction by introducing inquiry-based tutorials led by undergraduate “learning assistants” in the lab curriculum for the calculus-based introductory sequence, as well as piloting “studio” physics in some sections of the non-calculus sequence.

Our recommendations with regard to the curriculum include the following:

- Continue to support the Gateway course since it was highlighted by students as impactful in their introduction to the major and effectively communicated possible career pathways.
- Migrate research-based pedagogies to more courses in the curriculum, e.g., expand the use of studio physics to the calculus-based introductory sequence and introduce more active learning in upper-level courses.
- Coordinate course learning outcomes among the several sections offered in the introductory sequence, since students commented about inconsistency in preparation for upper-level courses.
- Continue to emphasize computational and programming training, since it is a critical skill for job opportunities.
- Maintain the flexibility offered by the seven concentrations for the BS degree, since it appears that the courses necessary for the low-enrollment concentrations are provided by other units and do not impact resourcing in the department.
- Continue to develop the teacher education concentration with PhysTEC to help fill the critical need for well-trained physics teachers.
- Explore the possibility of connecting the curriculum to service learning opportunities in the metropolitan area, particularly given the success of the teacher education concentration.

3.1.2 Evaluate the quality of both incoming and graduated undergraduate students. Are the enrollment, retention, and graduation rates appropriate? How to improve?

The enrollment and graduation numbers for the GSU BS physics degree program have increased over the past years due to departmental initiatives and nationwide trends. The number of incoming freshman majors is currently robust (45 in Fall 2016); the total number of physics majors more than doubled over a period of seven years to approximately 180 (Fall 2016); and the number of Physics BS degrees tripled to over 20 (Fall 2016). For comparison, AIP data (2014) indicate that the average and median number of bachelors degrees awarded by departments that have PhD programs was 20.4 and 15, respectively. Therefore, GSU is now on par with other PhD-granting departments.

With respect to the quality of incoming students, the entering freshman class in 2016 had an average SAT score of 1213 (150 points higher than GSU average), indicating that the program continues to attract high quality students as it has grown. Regarding the quality of graduates and their employment outcomes, the 33 BS degree recipients who responded to surveys (of 63 students contacted) provided the following data: 39% reported obtaining employment in technology companies, 24% enrolled in graduate programs, 33% are certified teachers, and one entered the military. Although these data are not comprehensive, the relative proportions appear to be consistent with the flexibility of the bachelors program to provide options other than the national norm of roughly half of graduates going on to graduate school (AIP 2017). In addition, the survey of undergraduates indicates that students are generally satisfied with the program and responded with high scores for “preparing me for my career or future educational goals.” The department therefore appears to be doing well with respect to the quality of both incoming and graduated students.

As stated in the APR report, the 6-year graduation rate for GSU physics majors is only 28% for cohorts beginning in 2002-2010, which is lower than other GSU programs. This low rate has been attributed in part to the number of students transferring to engineering programs outside GSU. The department recognized these low rates and has been addressing them by improving advising, making changes to the curriculum as discussed earlier, and better coordinating the course schedule for timely completion. Regarding advising, the undergraduate director connects with students in the Gateway to Physics course and during the calculus-based sequence, as well as contacts them when necessary. The GSU Society of Physics Students (SPS) also serves as a faculty contact point and peer-mentoring group. As a consequence, the 4-year retention rate has increased from 36% (2002 to 2010 cohorts) to 51% (2011 and 2012 cohorts), and the 4-year graduation rate has increased from 9% (2002 to 2010 cohorts) to 17% (2011 and 2012 cohorts). Such improved rates indicate that the department is making substantial progress on their retention and graduation rates.

Another important aspect of the student body in the bachelor program is its demographic profile, particularly in the less representative discipline of physics. Over the last three years, about 20% of GSU physics majors and 16% of BS degree recipients were female, which is reasonable in comparison to the national average of 20% female degree recipients (AIP, 2014). The department recently established a Women in Physics group to improve its retention rates and female representation. With regard to URM populations, over the last three years 18 of 55 (or 33%) of GSU BS degree recipients identified as under-represented minority groups, including 20% as African American, 9% as Hispanic and 5% as Native American. Such demographic representation is

significantly higher than national averages for physics graduates (~5% for African American and 2% for Hispanic, AIP 2012/2013), although not higher than the GSU undergraduate student body (42% and 10%, respectively). Therefore, there is the possibility of increased representation of URM students in the program with some concerted effort.

Our recommendations in this area include the following:

- Continue to focus on improving gender and URM diversity in the program, so that representation is comparable to or better than national (gender) and GSU (URM) profiles.
- Consider the possibility of mandatory advising for upper-level students, since students may be delayed if they do not anticipate the offering of courses for their concentration.
- Institute a more robust advising effort among faculty in the department given that only one undergraduate advisor currently serves about 190 majors.

3.1.3 Are there appropriate resources and support structures for the department's educational undergraduate programs?

The undergraduate program has grown over the past decade and also generates more than 17,000 credit hours per year due to its service mission. The number of degrees awarded annually per T/TT faculty was 0.68 in AY 2015 and is higher than the median of 0.46 for peer departments.

Our recommendations regarding resources and support structures include the following:

- Explore the possibility of optimizing teaching resources by increasing course section sizes for introductory service courses in an appropriate manner.
- Rotate instructors among the upper-division courses to ensure a robust program with multiple instructors for each course.
- Consider introducing peer observations in service and majors courses to provide feedback to instructors for continuous improvement.
- Maintain the SPS room for undergraduates and consider identifying additional space for enhanced peer interactions outside the classroom.

3.2 Quality of the Graduate Programs in Physics and Astronomy

The Department of Physics and Astronomy at Georgia State University offers three graduate degrees, including an MS in Physics, a PhD in Physics, and a PhD in Astronomy. ~76 graduate students are enrolled, and the Department graduates typically 9-10 MS students (mostly on the way to obtaining a PhD) and 9 PhD students each year. The number of graduate students has grown by 29% since 2012.

3.2.1 Evaluate the quality of the graduate curriculum in terms of disciplinary standards and trends.

The MS program in Physics requires the basic and appropriate courses consistent with disciplinary standards in Physics, including a course in mathematical physics, two courses in classical mechanics, two in quantum mechanics, two in electricity and magnetism, and one in statistical mechanics. Students may take additional courses appropriate to their focused research areas and complete a master's thesis or research paper.

More advanced courses in traditional areas of physics are required for the PhD plus an additional 12 (or more) hours of advanced coursework. Overall the quality and currency of the coursework is consistent with disciplinary standards, but the number of courses students must take is high, and limits students' ability to engage in research early in their graduate careers. The heavy course load also contributes to a long time-to-degree compared to other institutions.

Only a PhD is offered in Astronomy, although MS students can follow an astronomy track in Physics. The course requirements were recently revised to allow completion of coursework in the first two years and is now consistent with disciplinary norms. The curriculum is traditional, with a stronger emphasis on stellar astrophysics than is found in many doctoral programs. This emphasis is consistent with the research interests of the faculty and the students' dissertation research areas.

We do not recommend the implementation of a professional master's program in Physics. Similar initiatives have been tried at other institutions, often without success in attracting students. One option, however, might be to work with local partners in the private sector to provide industry-specific training at the master's level.

3.2.2 Evaluate the quality of both incoming and graduated graduate students. Are the enrollment, retention, and graduation rates appropriate? How to improve?

Since 2012, the number of applicants has increased by about 20% while the percentage of applicants offered admission has declined from 41% to 26%. Of those offered admission, the percentage enrolling has increased from 22% to 64%, suggesting that the department is increasingly able to attract students. The number of students enrolled per year has slightly more than doubled since 2012. The verbal and quantitative GRE scores for enrolled students have declined during this period but remain consistent with discipline-specific national norms with verbal percentiles in the mid-40s and quantitative scores in the low 70s, especially given the large number of international students in the Physics program.

3.2.3 Based on your professional experience, are the enrollment, retention, and graduation rates in the graduate program appropriate? If not, what changes might the department make to improve them?

Graduate enrollments in the PhD programs in Astronomy and Astrophysics have increased from 22 to 28 since 2012, while the number of PhD students in Physics has increased from 33 to 47 during the same period. The current graduation rate of typically 9 PhD students per year is consistent with typical enrollments in the period prior to 2013. Retention shown in B2.4 for the 2009 entering cohort suggests that 7 of 10 entering students have graduated by 2017, with three not retained. In Astronomy, two of the four students in the 2009 cohort had graduated by 2017 while two left the program during the first three years. Given the small sample statistics, enrollment, retention, and graduate rates are appropriate.

However, the ratio of graduate students per tenure/tenure track faculty is relatively high at 3.3, noticeably above the median ratio of 2.7 for peer schools. Of greater concern is the high time-to-degree of 6.2 years for Physics and 7.7 years for Astronomy. The department should consider limiting further growth in the number of PhD students to avoid increasing the student/faculty ratio further.

3.2.4 Are there appropriate resources and support structures for the department's educational graduate programs?

Resources and support structures for the department's graduate programs have not kept up with the growth of the graduate program, and we identified a number of areas that need work.

- Foremost is the need to increase the formality and structure of the graduate program, including a graduate handbook with clear expectations for student milestones and progress and a shared student-faculty understanding of degree and course requirements, rules, the content of the qualifying exam, and opportunities available to students.
- Student advising in Physics should be formalized and shared among the faculty. A departmental graduate student advising committee that advises all students during their first two years should be considered by the department.
- The time-to-degree in both the Astronomy and Physics PhD programs is excessively long and the department should consider practices that encourage students' timely progress. One example is to institute mandatory annual meetings of the students' research committees. The Astronomy Graduate Program Director indicated that steps are being implemented to enhance the ability of students to complete the PhD within a more reasonable timeframe of 5.5 to 6 years.
- A more formal orientation program should be instituted to assist new students joining the department. This function seems to be handled effectively within the Astronomy PhD program, but not within the Physics program. The orientation program should include training for new TAs on how to teach the lab sections, both at the general level and for specific labs. Training for teaching the "studio" labs is especially needed.
- The department should work to improve career information and guidance for graduate students. During the committee's conversations with the graduate students a reoccurring theme was the students' lack of awareness concerning further career options after having obtained their PhD. This was in stark contrast to the undergraduates, who seemed much more knowledgeable about their career options. In particular, better information on career options outside academic research should be provided to students. Connections with companies and laboratories in Atlanta can be important partners in providing career guidance to students. Fortunately, improved graduate career information is part of the department's goals as described in the self-study.
- Graduate student stipends of ~\$20K for 12 months are too low to be competitive, especially at an urban campus with a high cost of living. The suggested increase of 5% over two years seems inadequate. Only 39% of the funding for the graduate program is derived from external grants, whereas the rest comes from GSU internal sources like salaries for GTAs and internal competitions for stipends. In addition, the graduate students seem to be GTAs most or all of their graduate career and are thereby receiving tuition waivers from GSU. So the cost per student for each research group is low compared to most other graduate programs. The department and the research groups should consider increasing the graduate stipends based on increased contributions from external grants. This strategy might lead to a slight decrease in the number of graduate students, but an increase in the quality. The department should decide on the wisdom of such an approach as part the development of a comprehensive strategic plan.

These changes will go a long way toward alleviating many of the concerns and issues that are affecting the morale of graduate students in the Physics program.

3.2.5 The potential for growth of the department's graduate programs

Given the current student faculty ratio we cannot recommend that the graduate program continue to increase at the rate it has been increasing. The department should instead stabilize the program at its current size, increase graduate student stipends, reduce the time to degree, and formalize department practices and policies for the graduate programs.

4 Quality of the Department's Research Culture

4.1 Based on your knowledge of the discipline, what is your assessment of the quality of the department's faculty?

The quality of faculty overall is very good as reflected in publications, success in securing extramural funding, participation in internationally prominent collaborations, and involvement in professional service at the national level. The addition of high profile senior faculty as part of an interdisciplinary cluster hire is a notable and positive development.

4.2 From a disciplinary perspective, what is your assessment of the research areas in which the department is already strong, and areas with the potential for further growth?

Within astronomy the department has built successful groups in stellar, solar, and extragalactic areas, with enabling expertise in high angular resolution observations and analysis of large data sets. The extragalactic group is observational in focus and would potentially benefit from the addition of theoretical expertise. From a strategic perspective, the areas of research connect with major questions in the discipline and can be expected to maintain substantial intellectual vitality for the foreseeable future. GSU's sustained commitment to high angular resolution astronomy through CHARA and new investment in interdisciplinary approaches to big data places the department in a strong position to engage successfully with these increasingly important aspects of the field.

Within physics the department has established research programs in nuclear physics, condensed matter physics, atomic physics, biophysics, neurophysics, and physics education. The nuclear program is based on faculty participation in a large international experimental collaboration, and functions successfully as an interactive and coherent group. The condensed matter faculty individually provide important expertise but appear to engage in only limited collaboration or interaction among themselves. The condensed matter group has an opportunity to achieve greater success if the members can find a basis for greater intellectual exchange and active collaboration; based on examples at other institutions, increasing such interaction could benefit extramural funding and student culture.

The areas of atomic physics, biophysics, and neurophysics are represented by a single faculty member in each case. There appears to be little impetus in the long term for maintaining a presence in atomic physics. The biophysics and neurophysics faculty benefit from collaborations extending beyond the department, and it would be helpful if opportunities could be found to increase interaction with other faculty in Physics & Astronomy. The research areas represented in the department are sufficient to enable engagement with a broad cross section of important topics

in the discipline. The department research culture would benefit from a greater sense of intellectual common purpose among its physics faculty.

Georgia State University is to be commended for supporting physics education research, although with current staffing the program appears to be in a tenuous state. If the department is committed to maintaining this effort, it will likely need to consider additional investment in the future. Differences in the scholarly methods and publication venues for physics research per se versus physics education research can introduce challenges in departments hosting both, but in-house expertise in forefront pedagogical techniques can be valuable for achieving improved student outcomes. The Physics & Astronomy Department has seen some benefit of this type but it appears that significant opportunity remains for the department to incorporate the findings of physics education research in its instructional methods.

4.3 What is your assessment of the support structures for faculty and student research (e.g., grant-writing support, travel grants, laboratories, student funding, administrative support, etc.)?

The Physics & Astronomy Department overall benefits from a healthy system of administrative support structures. Institutional support is particularly impressive for astronomy observational access, via direct funding and F&A allocation. The Physics & Astronomy Instrument Shop provides essential support for experimental programs. While members of the department have expressed concerns about availability of lab space, the committee's impression is that the current space is sufficient and can accommodate more activity if allocation and use of the space is optimized; this could involve sharing of physics lab space for similar or related activities by more than one faculty member.

4.4 Do you have any recommendations for improvements in the department's research culture, productivity, and results?

The department's research culture would benefit from several changes. Graduate student stipends are low relative to those at other institutions and it seems that competitive stipends can be achieved through a restructuring of funding allocations for stipends. A question was raised as to whether computer support was sufficient for observational astronomy researchers, which may bear consideration. Programmatic activities that lead to increased interaction between researchers in condensed matter, as well as within physics more broadly and the department as a whole, could potentially benefit the research culture and diminish the current fragmentation of activity.

5 Goals

5.1 Are the goals the department has outlined in its self-study appropriate for the unit?

As part of the self-study exercise the department has developed four strategic goals which (somewhat simplistic) can be described as:

- 1) make the graduate program better,
- 2) make the undergraduate program better,

- 3) build multi-disciplinary teams to increase external funding,
- 4) increase the engagement with the local, urban community and the global community.

These goals are aligned with the overall strategic goals of GSU. However, they are also somewhat generic and do not differ much from what most other departments at GSU might have as goals.

5.2 Are they in accord with disciplinary trends?

Overall the goals are in accord with disciplinary trends. In particular, the emphasis on multi-disciplinary research teams and stronger engagement with local and global communities are seen in many physics and astronomy programs.

5.3 Are the priorities reasonable?

Overall the priorities are well selected. In particular, the goals of increasing graduate stipends (3.b.1.1), increasing efforts to support graduate students in career development (3.b.1.2), increasing retention rates (3.b.2.3), as well as the goals of increased emphasis on multi-disciplinary research teams (3.a.3) and external engagement (3.a.4), seem very appropriate and well-chosen for this department's particular situation. Conversely, the review committee is not recommending an increase in the graduate program, so the goal of increasing the graduate recruitment efforts (3.b.1.3) might either be de-emphasized or redirected towards attracting higher quality students.

5.4 Are the resource needs realistic?

The self-study does not really provide sufficient information on how the department envisions to implement the various goals and it is therefore difficult to judge if there are sufficient human and financial resources available. Overall, the review team was impressed with the level of central support available to the department, especially for astronomy research and the graduate programs.

5.5 Are any changes or additions warranted?

The review committee would have liked to see a more comprehensive strategic plan for the departments than the 2-1/2 pages in the self-study. Most departmental strategic plans contain specific hiring priorities that guide the departmental leadership in their interactions with the university administration. Currently, it appears that the critical decisions on what positions to pursue are made by the Chair after more or less intense lobbying efforts by the various groups separately.

We encourage the department to develop a comprehensive strategic plan that contains goals like those briefly outlined in the self-study, more detailed implementation plans for these goals, and a description of the hiring and funding priorities resulting from the strategic goals.

6 Additional issues

6.1 Departmental Governance

As discussed in section 5.5, the department has not developed a comprehensive strategic plan.

Typically, such a plan is developed through a process where all people in the department are given an opportunity to voice their opinion and where hopefully a broad-based consensus is developed. According to the information we were given, the department has not had a retreat for the faculty for at least 5 years. Furthermore, nearly all of the faculty members we talked with were not aware of the three-year departmental hiring plan provided to the Dean and, as far as we were informed, the hiring had not been discussed or been approved by the faculty. In contrast, we were informed that decisions of what searches to pursue were done by the Chair after a somewhat informal process where individual faculty members or groups could try to lobby the Chair through individual meetings.

A more open departmental decision process is recommended, where search priorities are developed through open, public discussions and where faculty approval of the final priorities are part of the process.

6.2 Faculty Development

Based on the information in the self-study, the faculty seem to be well adjusted and do not seem to lack development opportunities. Nevertheless, the review committee found it noteworthy that the department does not appear to have a formal mentoring process whereby all new faculty members are allocated one or several more experienced professors to mentor them through to tenure or even further during the associate professor period. Most peer institutions have strong formal mentoring programs and we strongly recommend that the department implement such a program. In particular, as the faculty hopefully will increase its diversity, social science research has shown that URM faculty (gender and well as race) especially benefit from careful mentoring.

The committee is also encouraged to learn that GSU is now developing diversity training for its faculty in connection with faculty searches. Given GSU's very diverse undergraduate population, the P&A faculty seems much less diverse, and a strong emphasis on increasing faculty diversity should be a cornerstone in any strategic plan.

7 Summary and Recommendations

7.1 Summarize the department's major strengths and challenges.

The committee was impressed with the substantial improvements the department has shown in nearly all areas since the last program review. Some of the most important positive findings were:

1. A strong growth of both the undergraduate and graduate programs.
2. A strong focus on retention in the undergraduate program that has resulted in impressive gains.
3. A diverse undergraduate population with respect to ethnicity/race.
4. External as well as internal funding levels are good as compared to peer institutions.
5. Recent curriculum innovations and changes that reflect the needs of incoming students with less formal preparation in math and physics.
6. An impressive provision for all undergraduate majors to participate in a research experience.

7.2 List your recommendations.

The justification for the following recommendations are contained in the main body of this report, so here we only provide a summary of our most important recommendations:

1. Develop a comprehensive strategic plan for the department. It should be created through strong faculty involvement and, in addition to the normal issues addressed in strategic plans, it should also address the following issues:
 - Should the Physics and Astronomy department be one unified department, two separate Physics and Astronomy departments, or have increased formal autonomy for the Astronomy and Physics.
 - Research directions for Physics with a plan for creating more synergy in the condensed matter program.
 - Hiring plan emphasizing long term goals with research focus on a few key areas in both Physics and Astronomy and with groups sharing research goals.
2. Develop a stronger emphasis on diversity for faculty and graduate students.
3. Increase the synergy in the physics research program.
4. Develop a formal mentoring process for faculty.
5. Introduce peer observation of faculty teaching and send all new faculty to the AAPT program for young faculty.
6. Increase the rotation of instructors in the various classes to renew and refresh teaching efforts.
7. Increase the use of research-based teaching methods in the undergraduate program.
8. Develop a Graduate Handbook so the students understand the rules, requirements and opportunities better.
9. Develop better career orientation for the graduate students
10. Develop more faculty advising/mentoring in the undergraduate programs to avoid a “single point of failure” issue with essentially only one faculty member doing the majority of the work.
11. Develop a stronger fundraising process, in collaboration with industrial partners in Atlanta.

**Report of the Academic Program Review Committee (APRC)
For the Department of Physics and Astronomy for FY2015-FY2017
APRC approved May 15, 2018**

Overview. The Department of Physics and Astronomy (P&A) in the College of Arts and Sciences (COAS) offers a BS in Physics, an MS in Physics, and PhDs in Physics and Astronomy. P&A's mission is to engage students through coursework and experiential studies to instill scientific literacy and provide training for the next generation of scientists. It prepares students for careers in research, technology, data analysis, and teaching, integrating P&A studies with other STEM disciplines. In fall 2016, P&A had 25 tenured/tenure track (T/TT) faculty, five lecturers, one academic professional, and 22 support staff (primarily postdoctoral research associates). P&A was admitted to the American Physical Society's PhysTEC 5+ Club by producing at least 5 graduates with high-school physics teaching certifications, addressing a critical need in Georgia STEM education.

Research Quality and Productivity. Faculty conduct research in astronomy and physics, with strengths in extragalactic astronomy, stellar astronomy, solar physics, high angular imaging, condensed matter physics, and nuclear physics. P&A participates in the University Center for Nano-Optics (CeNO) and the COAS Center for High Angular Resolution Astronomy (CHARA), which significantly contribute to funding. For the review period, P&A received \$16.2M in external funding, giving an annual average per T/TT faculty of \$221,692. From the APR Dashboard for FY2015-FY2017, T/TT (NTT) faculty published an annual average per faculty member of 3.48 (1.50) peer-reviewed journal articles, 1.01 (0.94) non-peer reviewed journal articles, 0.05 (0.0) book chapters, 0.041 (0.0) peer-reviewed proceedings papers, and 2.78 (1.94) other contributions.

External reviewers found the faculty as a whole to be engaged in research resulting in significant contributions and international recognition in P&A and were particularly enthusiastic about collaborative efforts with CeNO and CHARA, enhanced through 2CI and Next Generation hires. In Astronomy, the reviewers indicated the performance to be on par with peer and aspirational programs, although they expressed concern about the future of the Hard Labor Creek Observatory and continued investment in this facility beyond outreach activities. In Physics, ranked 111th of 142 by U.S. News & World Report, reviewers noted less cohesion and internal collaboration among the condensed matter group relative to comparable programs. In the areas of biophysics, atomic physics, and physics education research (PER), external reviewers deemed the faculty number sub-critical. For the program to increase in future rankings, the reviewers suggested substantially increasing physics faculty and external funding.

Teaching Quality and Productivity

Undergraduate: An annual average of 18.7 BS Physics degrees were conferred, and the mean annual credit hours of instruction for lower/upper divisions were 16,297/913. The three year annual SAT mean/GPA mean for majors was 1180/3.49. Majors were 20% female, comparable to national averages, with enrollments that were 18% Asian, 22% African American (significantly higher than the national average), 49% White, and 11% Other. Majors completed a capstone research practicum to develop research skills, and the faculty employed active learning strategies including studio physics and flipped course formats. Advising was carried out to a significant degree by one motivated faculty member, leaving this crucial activity at risk.

Student learning objectives (SLOs) for the BS in Physics include nine areas (discussed in summary form in Appendix A7) based on the themes of (1) developing expertise in acquisition and analysis of physical data and (2) learning core principles in physics. Assessments revealed majors achieving competence in area (1) through Advanced Physics Lab (PHYS 3300) and a capstone research project (PHYS 4900). In area (2), assessment revealed students were not achieving target levels in problem-solving skills, which

led to replacing math courses with courses in Mathematical Models and Computational Physics (PHYS 3550/3560).

Graduate: The three year annual average acceptance rate for new admits was 32% with an average enrollment ratio of 61.7% and mean GRE Verbal/Quantitative scores of 44.7%/70%. The mean annual credit hours of graduate instruction were 4,956. An annual average of 7.5 MS Physics, three PhD Astronomy, and five PhD Physics degrees were conferred. Graduate students were 41.85% female on average, with limited diversity: 40% Asian, 2.6% African American, 53% White, and 4.4% Other, consistent with national averages.

The five graduate Physics SLOs focused on core knowledge, critical thinking, research skills, communication, and effective collaboration, with outcomes assessed at three milestones: written and oral qualifying exams, MS presentation and PhD defense. Assessments of these SLOs were uniformly strong, and no changes in the programs or its assessment were proposed. The Astronomy SLOs were based on general astronomical knowledge, core principles, development of a research project, communication, and research productivity with outcomes assessed in a four-stage process including a first-year written exam, a second-year written and oral qualifying exam, a third-year research prospectus talk, and a dissertation defense. With a few exceptions, Astronomy PhD students met target levels. Based on assessment results, Astronomy reduced the number of required lecture classes to allow students more time to prepare for the second-year qualifying exam, prepare and present prospectus talk earlier, and reduce the time to dissertation defense. APR surveys of BS students, P&A graduate students, and alumni revealed a generally high level of satisfaction with the major or graduate degree program.

Viability of BS Physics. Three-year annual average enrollment has been stable with a mean of 189 students. Degrees conferred has tripled to ~20 degrees per year, including an increase in under-represented minorities (URM) student degrees conferred that exceeds national averages. As identified in the self-study, retention and graduation rates are areas for improvement with an average retention rate of 54% and 6-year graduation rate of 46% based on Fall 2011-2017 numbers. Reported efforts to address these deficits centered on revisions to the curriculum and scheduling to increase degree completion flexibility; implementation of capstone research experience for every major; and creation of a Gateway to Physics course to promote retention.

Viability of MS and PhD programs. Three-year annual average graduate enrollments were six MS Physics students; 26.7 Astronomy PhD students; and 43 Physics PhD students. Combined enrollment has increased by 29% in the last five years, with female graduate student composition significantly higher than national averages and a low, but growing URM student population. Areas of concern were uncompetitive stipend levels and long times to graduation. The external reviewers repeated these concerns, noting that the ratio of graduate students to T/TT faculty was high at 3.3 (notably above median ratio of 2.7 for peer institutions) and a high time-to-degree of 6.2 years for Physics and 7.7 years for Astronomy. This is further reflected in the relatively low number of graduate degrees conferred per year per T/TT faculty, reported as 0.8 in the period 2013-2017. The external reviewers recommended capping growth to address these issues. Placement rates were strong (Appendix B8).

Unit Goals (Self-Study pp. 26-28)

1. Enhance the graduate program by increasing stipend/scholarship levels; expand efforts to support career development; increase recruitment efforts including diversity.
2. Enhance the BS Physics by increasing scientific literacy and experiential learning in service courses; increase research/training opportunities on campus and globally; raise retention/degree completion rates by improved advising and streamlining of curricula.
3. Build multi-disciplinary research teams to grow the funding portfolio and address complex questions by faculty growth in strategic areas; maintain and enhance infrastructure for research support.

4. Develop programs of community engagement and global activities by increasing public learning activities and building connections with alumni and the global community.

External reviewer recommendations

In addition to confirming P&A's goals, external reviewers recommended:

1. Faculty: Develop a comprehensive departmental strategic plan; increase diversity; increase synergy in physics research; develop a formal mentoring process; peer evaluate teaching
2. Programs: Enhance diversity (MS/PhD); increase instructional rotation to refresh teaching efforts; increase research-based teaching methods (BS); develop graduate handbook and better career advisement; develop more faculty advising/mentoring capacity in BS program to avoid "single point of failure"; curb further growth of MS/PhD to increase stipend levels and reduce time to degree.
3. Resources: Enhance fundraising in collaboration with industrial partners in Atlanta

Consistency of Goals and Recommendations with University Strategic Plan

APRC believes the goals and recommendations discussed above are consistent with and supportive of the GSU Strategic Plan except as noted below:

1. Assess the BS at more points in the program to address student deficiencies and attrition.
2. Differentiate between MS and PhD SLOs. Although graduate SLOs have been met, identify and implement curricular changes for continuous improvement of the programs.