

Astro2020 APC White Paper

Primarily Undergraduate Institutions and the Astronomy Community

Thematic Areas: Ground Based Project Space Based Project
 Infrastructure Activity Technological Development Activity
 State of the Profession Consideration

Principal Author:

Name: Joseph Ribaudo
Institution: Providence College, Utica College
Email: jribaudo@providence.edu
Phone: 401.865.2379

Co-Authors: (names, institutions, email)

Rebecca A. Koopmann, Union College, koopmanr@union.edu
Aileen A. O'Donoghue, St. Lawrence University, aodonoghue@stlawu.edu
Aparna Venkatesan, University of San Francisco, avenkatesan@usfca.edu

Co-Signers: (names, institutions, email)

Thomas J. Balonek, Colgate University, tbalonek@colgate.edu
Rachael L. Beaton, Princeton/Carnegie Observatories, rbeaton@princeton.edu
Jillian Bellovary, CUNY - Queensborough Community College, jbellvary@amnh.org
G. Bruce Berriman, Caltech/IPAC-NExScI, gbb@ipac.caltech.edu
John J. Bochanski, Rider University, jbochanski@rider.edu
Derek L. Buzasi, Florida Gulf Coast University, dbuzasi@fgcu.edu
John M. Cannon, Macalester College, jcannon@macalester.edu
Joleen K. Carlberg, Space Telescope Science Institute, jcarlberg@stsci.edu
Jennifer L. Carter, Susquehanna University, carterj@susqu.edu
Charlotte Christensen, Grinnell College, christenc@grinnell.edu
Kim Coble, San Francisco State University, kcoble@sfsu.edu
Kevin R. Covey, Western Washington University, coveyk@wwu.edu
Mary Crone Odekon, Skidmore College, mcrone@skidmore.edu
Kathryn Devine, The College of Idaho, kdevine@collegeofidaho.edu
Chuanfei Dong, Princeton University, dcfy@princeton.edu
Adriana Durbala, University of Wisconsin-Stevens Point, adurbala@uwsp.edu
Paul B. Eskridge, Minnesota State University, Mankato, paul.eskridge@mnsu.edu
Cassandra Fallscheer, Central Washington University, cassandra.fallscheer@cwu.edu
Gregory A. Feiden, University of North Georgia, gregory.feiden@ung.edu
Rose A. Finn, Siena College, rfinn@siena.edu
Josh T. Fuchs, Texas Lutheran University, jfuchs@tlu.edu

Gregory Hallenbeck, Washington & Jefferson College, ghallenbeck@washjeff.edu
Martha Haynes, Cornell University, haynes@astro.cornell.edu
Todd Hillwig, Valparaiso University, Todd.Hillwig@valpo.edu
Cameron Hummels, California Institute of Technology, chummels@caltech.edu
Richard R. Lane, Pontificia Universidad Católica de Chile, rlane@astro.puc.cl
Lauranne Lanz, Dartmouth College/The College of New Jersey,
lauranne.lanz@dartmouth.edu
Nicolas Lehner, University of Notre Dame, nlehner@nd.edu
Lukas Leisman, Valparaiso University, luke.leisman@valpo.edu
Britt Lundgren, University of North Carolina Asheville, blundgre@unca.edu
Karen Masters, Haverford College, klmasters@haverford.edu
John O'Meara, W.M. Keck Observatory, jomeara@keck.hawaii.edu
D.J. Pisano, West Virginia University, djpisano@mail.wvu.edu
Katie Rabidoux, University of Wisconsin-Platteville, rabidouxk@uwplatt.edu
Benjamin Rose, Space Telescope Science Institute, brose@stsci.edu
Jessica Rosenberg, George Mason University, jrosenb4@gmu.edu
Michael J. Rutkowski, Minnesota State University-Minnesota,
michael.rutkowski@mnsu.edu
J. Allyn Smith, Austin Peay State University, smithj@apsu.edu
Ryan Terrien, Carleton College, rterrien@carleton.edu
Todd Tripp, University of Massachusetts-Amherst, tripp@astro.umass.edu
Parker Troischt, Hartwick College, TroischtP@hartwick.edu
Nicholas Troup, Salisbury University, nwtroup@salisbury.edu
Jackie Villadsen, St. Mary's College of Maryland, jrvilladsen@smcm.edu
Anna Williams, Macalester College, awill111@macalester.edu
Jason E. Ybarra, Bridgewater College, jybarra@bridgewater.edu

Executive Summary

This White Paper highlights the role Primarily Undergraduate Institutions (PUIs) play within the astronomy profession, addressing issues related to employment, resources and support, research opportunities and productivity, and educational and societal impacts, among others. Astronomers working at PUIs are passionate about teaching and mentoring undergraduate students through substantive astronomy experiences, all while working to continue research programs that contribute to the advancement of the professional field of astronomy. PUIs are where the majority of undergraduate students pursue post-secondary education, and as such, understanding the unique challenges and opportunities associated with PUIs is critical to fostering an inclusive astronomy community throughout the next decade.

We provide a view of the profession as lived and experienced by faculty and students of PUIs, while highlighting the unique opportunities, challenges, and obstacles routinely faced. A variety of recommendations are outlined to provide the supporting structures and resources needed for astronomy to thrive at PUIs over the next decade and beyond - a critical step for a profession focused on fostering and maintaining an inclusive, supportive, and diverse community.

Recommendations:

- **The Decadal Survey:** Address the significant under-representation of PUI faculty membership on Decadal panels and committees. Funding course releases for PUI-faculty may be one way to improve participation.
- **Teaching and Pedagogy:** Provide greater opportunities for teaching courses and teacher-training/mentoring for graduate students who aspire to faculty positions at PUIs (similar to the research mentoring of a Ph.D. program).
- **Research Support:** Increase the number of targeted grant programs for faculty at PUIs. Consider extending these PUI-awards for up to 5 years, to allow for sustainable projects with undergraduate student research participation. Foster programs that allow PUI faculty to interact with or mentor graduate students and postdoctoral researchers.
- **PUI-focused Collaborations:** Encourage and financially support the development of large-scale, long-duration research collaborations that leverage the contributions of PUI-affiliates (faculty and students). See the White Paper by Koopmann et al. - *Integrating Undergraduate Research and Faculty Development in a Legacy Astronomy Research Project*.
- **Regional Astronomy:** Increase the number of regional astronomy associations and provide financial and logistical support for the establishment of regularly held regional meetings.
- **Scholarship and Career Assessment:** Establish a robust assessment procedure to examine the scholarly research contributions made by PUI-affiliates (publications and conference presentations). Expand current career assessment work to include an analysis of astronomers at PUIs. Create formal AAS committees/working groups to pursue PUI-related assessment.

1 Background

Primarily Undergraduate Institutions (PUIs) are defined by the National Science Foundation (NSF) *by the nature of the institution and not solely on the basis of highest degree offered. Eligible PUIs are accredited colleges and universities (including two-year community colleges) that award Associate's degrees, Bachelor's degrees, and/or Master's degrees in NSF-supported fields, but have awarded 20 or fewer Ph.D./D.Sci. degrees in all NSF-supported fields during the combined previous two academic years.*¹ Simplifying slightly, PUIs can be thought of as teaching-focused institutions that do not offer Ph.D.s in Physics or Astronomy/Astrophysics. We are writing this White Paper primarily from the perspective and experience of faculty at 4-year Bachelor's degree-granting institutions, which is heavily influenced by working in relatively small Physics/Astronomy Departments, where small typically means less than 10 faculty members and often means less than 5.

By a variety of measures PUIs make up the majority of the educational opportunities in post-secondary education in the United States. In 2017, over 90% of the ~4,300 accredited post-secondary institutions were Non-Ph.D. granting institutions and over two-thirds of the nearly 20 million students enrolled in post-secondary education, did so at a non-Ph.D. granting institution.² PUIs serve a broad range of student demographics, with many mission-driven PUIs focused on underserved populations. PUI enrollments are also heavily weighted towards first-generation college students, particularly at 2-year institutions³. Taking all of this together, PUIs offer an opportunity to dramatically influence the next generation of global citizens through the personalized student-faculty interactions that are often the hallmark of PUIs. This is true not only for STEM and astronomy-related careers, but for the general education of society as to the importance of literacy across a variety of intellectual, practical, and creative fields. As the astronomy community considers how to best support educating the next generation of astronomers it is important to appreciate the impact professional astronomers have beyond the astronomy community and how PUIs fit into this narrative.

Considering the current state of the profession, the astronomy community needs to do a better job recognizing PUIs as an integral part of the astronomy profession. This need is evidenced in the lack of PUI representation in the Decadal process itself. An analysis of membership on panels and committees from the 2010 Decadal suggests just 2 members out of 115 (1.4%) were from PUIs, a number which vastly under-represents the contribution to astronomy research from faculty at PUIs.

Recommendation: The Decadal Survey panel and committee membership selection process should be adjusted to allow for greater involvement from faculty at PUIs. Solving this may require funds to enable teaching release for faculty serving on panels.

2 Astronomers and PUIs

At times in the past, and perhaps even continuing to this day, career paths leading to a position at a teaching-focused institution could be viewed by our professional community as a failure to secure a career at a research-focused institution, rather than the successful outcome it is. The reality is many astronomers have intentionally made, and will continue to make, choices throughout their education and early-career years in an effort to realize a career at a PUI. For these astronomers, a

career at a PUI is *the goal*, not the consolation. The primarily teaching-focused job responsibilities of PUIs are not seen as a burden or at the expense of more research oriented careers, but rather as an opportunity to balance a genuine passion for education and mentoring with an ambitious research agenda designed to engage undergraduate students, while advancing the field of astronomy through original research and publication.

Clearly the reasons why an astronomer may choose a career at a PUI, or why a career at a PUI may be appropriate for an astronomer, can vary dramatically on a case-by-case basis. However, there are several appealing and distinct aspects associated with working at PUIs that are often highlighted in support of PUI careers. These reasons include i) a career where teaching and mentoring will be valued to a similar extent as research productivity (and sometimes even more so), ii) the ability to mentor undergraduate students through substantial research projects, iii) the freedom to explore new research interests, including education and pedagogy research, iv) less pressure to secure external funding. Interestingly, many astronomers at PUIs had their own positive educational experiences as students at PUIs and the opportunity to provide similarly transformative experiences to the next generation of students is one of their primary motivators.

While it is common for astronomers to work at PUIs, stand-alone Astronomy Departments at PUIs are exceedingly rare and as such, astronomers are primarily working in Physics Departments or more general Departments encompassing various natural science disciplines. It is not uncommon to be the only astronomer employed at the institution, resulting in opportunities and challenges that are somewhat unique in the professional astronomy community. Astronomers at PUIs are often expected to teach across the physics curriculum of their program, in addition to teaching or designing the department astronomy offerings and organizing campus or community-wide public observing events. These responsibilities make for an engaging and fulfilling career for astronomers at PUIs, but also underscore some of the training and experience necessary for an astronomer to be successful in the PUI environment, which is not necessarily the same training and experience necessary for success at a more research-oriented institution.

3 Teaching

At nearly all PUIs, teaching is the primary job responsibility for faculty. What this means in practice can vary significantly across PUIs: at 2-year institutions, faculty often teach a 5-5 load (meaning 5 courses in the fall semester and 5 courses again in the spring semester), while at 4-year institutions teaching loads can vary from 4-4 to 2-2, where typically the lower teaching loads are balanced with expectations of greater grant and research productivity. For these reasons, it is difficult to generalize the typical teaching load for faculty working at PUIs. However, since teaching across the physics and astronomy curriculum is often a standard requirement at PUIs, an astronomer pursuing a career at a PUI should be open to (and enjoy) teaching a variety of courses.

For many faculty working at PUIs, the emphasis on teaching is one of the most appealing aspects of the job. While there is a general expectation of teaching excellence, faculty at PUIs often have the freedom to explore novel approaches to physics and astronomy pedagogy. This freedom is supported by the relatively small class sizes typically found at PUIs. This is particularly true for introductory astronomy courses where it is common for enrollments at PUIs to be an order of magnitude smaller than enrollments at many large research institutions. This situation allows faculty at PUIs to explore activities and assessments that may be more labor intensive, but which remain manageable with lower enrollments. An important fruit of smaller class sizes in

introductory astronomy is the opportunity to engage students not majoring in quantitative fields with activities designed to deliberately encourage growth in quantitative literacy.

While PUI faculty are encouraged to design and/or implement curriculum supported through various pedagogical research groups, including both the Physics Education and Astronomy Education Research communities, faculty are also given the freedom to pursue approaches to curricular development that are often untenable in courses with large class sizes. This freedom can give rise to creative attempts to design labs and hands-on activities that address common misconceptions in physics and astronomy courses and can lead to peer-reviewed publications summarizing the design and implementation of the activity (e.g., Ribaldo 2016, 2017).

When working at a PUI it is common to teach introductory physics and astronomy courses, labs, general education courses, and advanced physics courses all within the relatively short time span of a few semesters. This variety demands faculty at PUIs remain intellectually flexible and adaptable throughout the course of their careers. PUIs also provide astronomers with freedom to explore pedagogy beyond the physical sciences. At many PUIs there is growing interest in multi- or interdisciplinary courses team-taught by faculty from different departments or divisions. Thus, it is increasingly likely that astronomers at PUIs will be encouraged or required to develop courses with colleagues across the curriculum, including the arts, humanities, and social sciences.

Beyond having a general familiarity with broad physics topics and courses, it is helpful to have actual experience as the instructor of record when applying for faculty positions at PUIs. This poses a challenge as the experience needed to land a permanent faculty position at many PUIs can most easily be obtained by working in a faculty position at a PUI. However, there are frequently visiting faculty positions available at PUIs that can serve as pedagogical “post-docs”. Some are even formal post-docs with a faculty mentor and reduced teaching load designed specifically to help astronomers aspiring to a career at a PUI enhance their experience and skills. One of our recommendations is for the astronomy community to further support these types of post-doctoral opportunities - allowing astronomers to better position themselves for a career at PUIs.

Recommendation: As a professional community we need to provide students and early-career astronomers with opportunities that will best position them for their careers. For those aspiring to a PUI-career this requires formal teaching experience, training, and mentoring. Ph.D. programs should expand their career training and support structures to include formal teaching opportunities. Funding agencies should support these efforts by establishing funding streams that allow for teaching and pedagogy-focused training.

4 Research and Mentoring

A common misconception regarding research at PUIs is that the faculty have little interest in establishing and maintaining an active research program. While it is true that the teaching responsibilities at PUIs can make the process more challenging, nearly all astronomers at PUIs want to establish a sustainable research program. In fact, in all but the most extreme situations faculty at PUIs are expected to maintain an active scholarship portfolio.

What an active scholarship profile translates to will depend on the specific institution, just as the teaching responsibilities at PUIs can also vary considerably by institution. However, often the expectation is that PUI faculty are presenting their work at conferences, publishing their work

in peer-reviewed journals, pursuing external funding, and perhaps most importantly, mentoring undergraduate student researchers and providing them the opportunity to experience the previously mentioned components of a scholarship portfolio. In other words, the scholarship portfolio at PUIs consist of many of the same components expected at more research-focused institutions. Of course, usually the frequency with which these components are expected to be realized is significantly lower than an astronomer would find at a more research-focused institution, but some level of productivity is expected at nearly all PUIs.

A fundamental component to research programs at PUIs is the involvement of undergraduate students throughout the research process. In astronomy this can mean including students on observing proposals, bringing students on observing runs, training students to reduce and analyze various types of observational data, assisting students in the write-up of the project for publication, and arranging for students to present the results of the project at local, regional, or national conferences. For many students at PUIs, the research opportunities provided by physics or astronomy faculty are the only opportunities these students will have to engage with an authentic research project. These experiences have the potential to be genuinely transformative for students, allowing for personal and professional growth well beyond what can be realized in the traditional learning environment of the classroom.

The important role faculty play in providing substantive research experiences cannot be overstated - in fact several recent studies have shown the majority of undergraduate research activities are not the result of sponsored programs from major national funding agencies (such as NSF, NASA, or NIH), but rather are the result of local or informal opportunities (Russell et al. 2007, Sadler et al. 2010). From Sadler et al. (2010), over 50% of STEM majors engaged in independent or mentored research, while only 7% of STEM majors were engaged with research sponsored by major national agencies. While faculty at PUIs are a critical component of the undergraduate research experience, the reality is the majority of PUI mentoring interactions are not formally or fully compensated by the institution (for faculty). This typically means the academic year research projects at PUIs are in addition to the already heavy teaching responsibilities and research and service expectations. Summer research projects can also be a challenge, with limited institutional support often requiring faculty at PUIs to mentor summer students without any compensation. Providing the appropriate support to allow for quality mentoring and research experiences at PUIs should be a priority for the astronomy community throughout the next decade.

Currently, there are just a few funding opportunities that specifically target PUI-affiliated participation and most of these are not designed exclusively for PUIs, but rather allow for the consideration of how a funding award may impact PUIs. The most well-known of these in the astronomy community are awards associated with NSF programs, such as the Research at Undergraduate Institutions (RUI) and Research Opportunity Awards (ROA) programs. However the RUI program is only a designation that can be assigned to a proposal solicited from a separate program and as such, RUIs are evaluated for intellectual merit and broader impacts along with all non-RUI proposals submitted. Additional NSF programs that often fund or support PUI-affiliates include the Research Experiences for Undergraduates (REU), the Improving Undergraduate STEM Education (IUSE), and the New Faculty Workshop, however all of these programs solicit participation from PUI and non-PUI applicants alike. Beyond the NSF, funding agencies such as NASA, NASA Space Grant, and Research Corporation regularly fund PIs from PUIs. But again, the majority of the available funding awarded by these agencies is not targeted to PUI-affiliates.

Recommendation: Funding agencies should increase the number of targeted grant programs for PUI-affiliates. Ideally this would include solicitations open only to PUI-affiliates and also include review-panels consisting primarily of PUI-affiliated experts. Given the unique challenges associated with research at PUIs, allowing for awards up to 5 years would facilitate successful and sustainable projects.

5 Support and Resources Needed for the Next Decade

Over the last few decades the collective astronomy community has made a concerted effort to establish policies and best practices that allow for a more inclusive and supportive professional environment for astronomers from all backgrounds, identities, and career-trajectories. In doing so it has become clear there is a need within the community to better value the career opportunities accessible to astronomers that diverge from a research-focused career and value the contributions astronomers are making to the field from beyond research-focused positions.

5.1 Employment

With regard to faculty employment opportunities, the American Institute of Physics (AIP) regularly reports employment statistics for Physics and Astronomy Departments, providing a variety of metrics and graphics to characterize the employment environment across these adjacent fields. Several of these metrics establish that PUIs provide a substantive fraction of the full-time faculty positions in Physics and Astronomy.

In an attempt to understand the employment opportunities at PUIs available to astronomers, we examined the archived job postings from the Job Register maintained by the American Astronomical Society (AAS) and provided to us by the AAS Committee on Employment - see the White Paper by Kamenetzky et al. entitled *Astronomy-driven Careers in the 2020's*. We performed a simple analysis of the archived job postings, which span roughly fifteen years, back to 2003. When a position is advertised on the Job Register, a variety of flags/categories get assigned - these include Institution Type, Position Type, Position Title, etc. The number of advertised faculty positions (tenure-track and non tenure-track) were examined for institutions classified as 'Small Academic', the closest classification to the PUI distinction. Figure 1 shows the results of our analysis. From this we see the relative number of astronomy positions at PUIs advertised on the Job Register has been gradually decreasing over the last decade. Taken at face value this would give the impression that the opportunities for astronomers to pursue a career at PUIs are diminishing. However, the majority of openings at PUIs are in Physics Departments, often without a research specialty designation, meaning it is likely that the majority of openings at PUIs will not be advertised on the Job Register.

To expand on this, we examined several of the recent AIP reports focused on employment at various institution types over the last few decades. Figure 2 is a recreation of the Fall 2017 Physics Trends graphic published by the AIP,⁴ where the number of tenured and tenure-track faculty hires in Physics Departments are plotted for various institution types over the last 15 years. Nearly half of the new Physics faculty hires in 2016 were hired into Departments at PUIs (without taking into account the new hires at Associate's degree-granting institutions). This statistic is particularly

important for the astronomy community to be aware of as Ph.D.s with astronomy expertise will be hired into Physics Departments at these institutions.

Recommendation: Expand the formal assessment of careers in astronomy to include an analysis of PUI-careers. This could be done as part of the AAS Committee on Employment or with the formation of a new AAS committee/sub-committee.

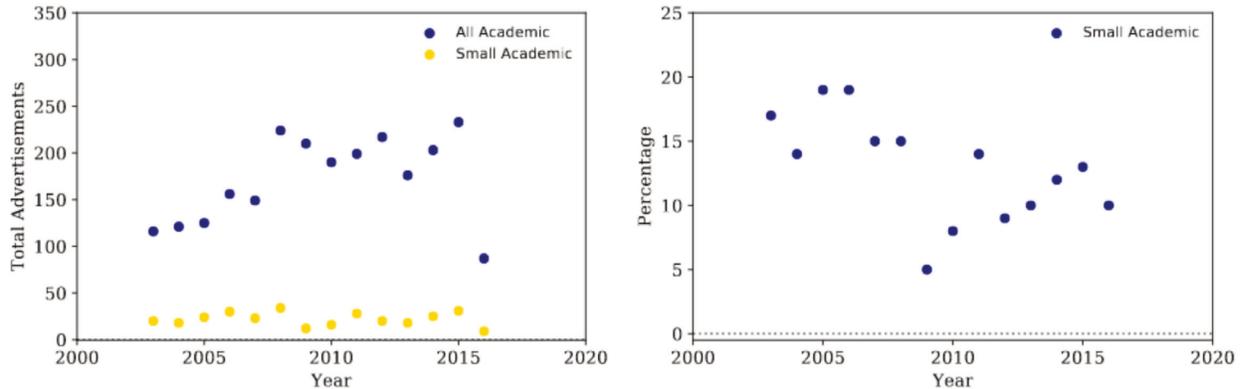


Figure 1: Shown here are the faculty job postings on the AAS Job Register over the last 15 years. **Left Panel:** the total number of academic faculty positions advertised over the last 15 years along with the positions classified as ‘Small Academic’. **Right Panel:** the percentage of faculty job postings classified with institution type ‘Small Academic’ over the last 15 years. For both figures the positions include both tenure-track and non tenure-track listings.

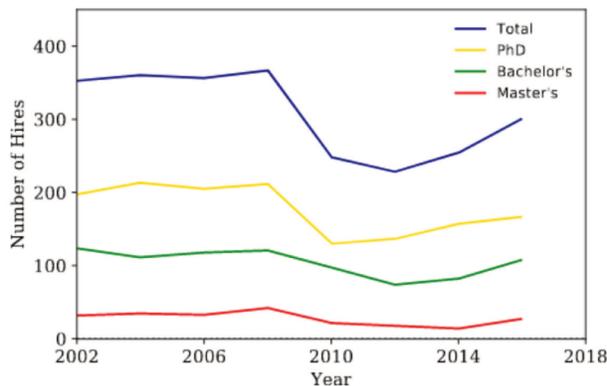


Figure 2: Shown here are the number of new faculty hires in Physics Departments as reported by AIP in 2017. The increase in hires in recent years appears to be driven by an increase in hiring at PUIs (both Bachelor’s and Master’s degree-granting institutions). Note - this does not take into account the additional PUI hires at 2-year Associate’s degree-granting institutions.

5.2 Research Contributions

With the potential for growth in PUI-careers over the last few decades, an interesting question to consider is whether the scholarly contributions of PUI-affiliates has evolved significantly over the same time frame. In what follows we have attempted to quantify the scholarship contributions of PUI-affiliates (faculty and students) to the astronomy community through an analysis of the publication and presentation archives accessible through the Astrophysics Database System (ADS) API.⁵

Using the 2-year and 4-year institution list generated by the Council for Undergraduate Research,⁶ we performed searches of the ADS for entries published in each of The Astrophysical Journal (ApJ - one of our most popular peer-reviewed publications) and the American Astronomical Society (AAS - one of our most popular venues for faculty and student presentation abstracts). While the CUR-lists are not identical to the NSF PUI distinction, we believe the significant overlap between the two lists allow for an overall assessment of the evolution of PUI-contributed research on the ADS.

Using a simple matching criterion we performed total publication searches for PUI-affiliated authors relative to the total number of publications for each year for the last thirty years. We find that the percentage of publications with PUI-affiliated authors has steadily increased for publications in ApJ and AAS. The general growth trends can be seen in Figure 3, where the right panel shows the increase in AAS authorship is where the most significant growth in productivity has occurred. This isn't surprising as the AAS entries primarily correspond to presentation abstracts for the winter and summer AAS meetings, a typical venue for PUI faculty and undergraduate student presentations.

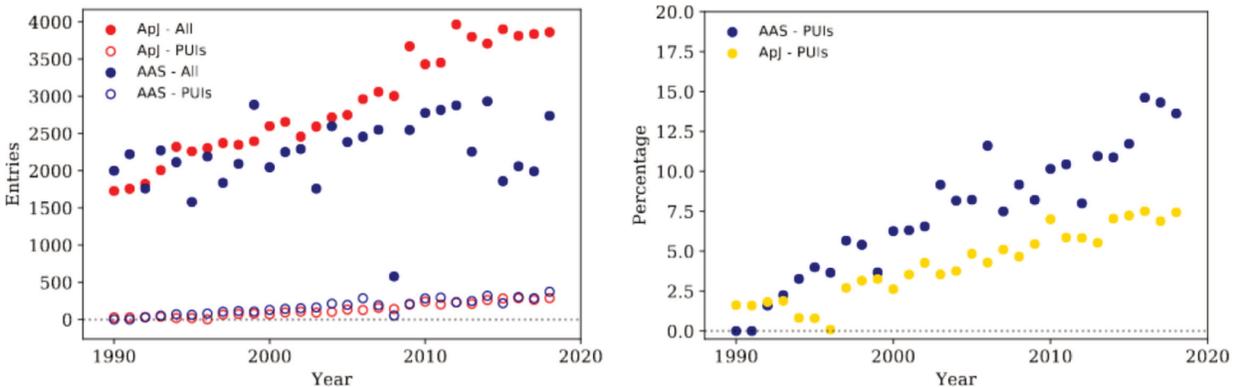


Figure 3: Shown here are the entries on the ADS with co-authors from PUIs (as matched through the ADS API with a PUI list from the Council on Undergraduate Research). **Left Panel:** the total number of ADS entries associated with ApJ and AAS, with entries from PUI-affiliated authors overplotted. **Right Panel:** the percentage of the ApJ/AAS ADS entries with PUI-affiliated authors.

A more robust assessment of the scholarship contributions of PUI faculty and students would be appropriate for the astronomy community to prioritize in the next decade, allowing for a better understanding as to the direct impact PUI-affiliates are having on science productivity in astronomy. For example, the ApJ and AAS entries we examined as part of this work are only a portion of the publications cataloged with the ADS each year and it would be useful to analyze a larger portion of the ADS entries. A similar analysis should also be considered for the various funding agencies that typically support astronomy-related research.

Recommendation: Establish a robust assessment of the contributions of PUI-affiliates when it comes to scholarly research publications, conference talks, and funding awards.

5.3 Regional Astronomy Groups

It is not uncommon for an astronomer working at a PUI to be the only astronomer at the institution. With this isolation comes the challenge of remaining engaged in the broader astronomy community and maintaining an active research program with minimal local support. One of the most important and accessible resources in this situation can be the regional astronomy community and regularly scheduled regional meetings. Regional meetings are particularly appealing when working at PUIs as the travel costs associated with attending are significantly lower than most national meetings. This is an important consideration because the financial support at many PUIs is not at a level that would cover travel costs for faculty and students to attend a national meeting. In addition, the timing of the January AAS meeting can lead to conflicts with the start of the academic term, making it a challenge for some PUI-faculty and undergraduates to attend.

For the majority of undergraduate students, the opportunity to simply attend a science meeting, let alone present an original research project, can have a dramatic impact on personal, professional, and social development. Regional meetings make these experiences more accessible for students at PUIs and are one of the primary reasons the astronomy community should make a deliberate effort in the next decade to support the development of more regional astronomy groups and their corresponding regional meetings. The blueprint for this already exists as regional meetings are ubiquitous throughout the physics community, with Sections of the American Physical Society (APS) and American Association of Physics Teachers (AAPT) regularly organizing regional meetings.

The AAS officially recognizes and endorses regional meetings that satisfy a few basic rules and the meeting websites are linked-to on the AAS website.⁷ These regional meetings are not organized by the AAS, but rather a regional astronomy organization or a collective of astronomers from throughout a region. In the past five years the AAS has endorsed several regional meetings including the Mid-American Regional Astrophysics Conference, the Kentucky Area Regional Meeting, and the Meetings of the Astronomical Society of New York.

For example, the Astronomical Society of New York (ASNY), has been organizing annual science conferences in the captial region of New York state for the last 50 years. ASNY is the science arm of the New York Astronomical Corporation and there are more than 30 colleges and universities in New York that are currently member institutions affiliated with ASNY. ASNY serves as a critical resource for affiliates of PUIs and research institutions alike, providing student travel awards, student research prizes, and small-meeting opportunities for undergraduate and graduate students to present their research. PUI-faculty benefit from all of these along with opportunities to take on significant service and leadership roles within the astronomy community. For these reasons, regional astronomy associations are an excellent investment for the astronomy profession.

Recommendation: Given the significant impact on the entire astronomy community, and particularly PUI-affiliates, the AAS and funding agencies should prioritize the development and support of regional astronomy associations along with regional astronomy meetings. Regional models used by the APS and AAPT should be used as guidance initially.

5.4 PUI-focused Research Collaborations

The essence of a research program at PUIs, where undergraduate student involvement is an integral component of the research experience, can lead to challenges that are unique to astronomers at PUIs. One of the primary issues is the fact that undergraduate research primarily consists of short-duration projects that are started and finished within a semester or a summer. Often students working on research projects have little course-work or training in the research field of their project and care must be taken to not overwhelm students early on in the project. In addition, the short duration of typical projects and the relatively little time a particular student will work on a project (often less than a year) make it difficult to establish a continuous and cohesive research strategy that seamlessly transitions from one student participant to the next. One possible remedy for this particular challenge is to build long-running research projects that benefit from the contributions of a large collaboration.

Programs such as the SDSS FAST Initiative,⁸ the Keck Northeast Astronomy Consortium (KNAC) REU,⁹ and the NSF-sponsored Undergraduate ALFALFA Team (UAT)¹⁰ are specifically designed to engage PUI faculty and students with high-impact research experiences. These types of programs, where faculty are trained and exposed to research projects along with students are particularly effective at generating sustained research engagement. KNAC is an organization that falls both into the regional association category as well as a PUI-focused collaboration, consisting of a network of faculty and students from eight liberal arts colleges in the North East. The REU program pairs students with faculty for summer research projects and the fall KNAC Meeting allows for the students and faculty to share the results of their projects. With this Regional Consortium/REU model students and faculty are able to more easily maintain connections after the initial summer REU experience, allowing for a more sustained impact compared to a typical REU.

Going beyond the REU model, the UAT was founded with faculty development as well as undergraduate research opportunities in mind, with the purpose to provide long-term collaborative research opportunities for faculty and students from a wide range of public and private undergraduate-focused colleges in the context of the extragalactic ALFALFA HI survey. In the past 12 years of funding, 34 mainly PUI faculty (44% women) have participated. The UAT provides a support structure for PUI faculty that maximizes the time that they can devote to the project and develops their research and education skills. Over the 12 years of funding, they have benefited from the opportunity to learn about and participate in the project, bringing their own sets of skills, experience, and expertise to the collaboration and developing a network of collaborators throughout the U.S. Further details are provided in *Integrating Undergraduate Research and Faculty Development in a Legacy Astronomy Research Project* (Koopmann et al.).

Recommendation: Funding agencies should prioritize and incentivize large-scale research collaborations, including regional consortia, that primarily leverage PUI-affiliates to execute and support the research objectives. These types of legacy research programs may not easily fit into the current funding program structures, highlighting the need for funding solicitations that encourage the development of new initiatives.

References

Ribaudo, J. 2016, *The Physics Teacher*, 54, 330

Ribaudo, J. 2017, *Physics Today*, 70, 10

Ribaudo, Joseph; Koopmann, Rebecca A.; Haynes, Martha P.; Balonek, Thomas J.; Cannon, John M.; Coble, Kimberly A.; Craig, David W.; Denn, Grant R.; Durbala, Adriana; Finn, Rose; Hal-lenbeck, Gregory L.; Hoffman, G. Lyle; Lebron, Mayra E.; Miller, Brendan P.; Crone-Odekon, Mary; O'Donoghue, Aileen A.; Olowin, Ronald Paul; Pantoja, Carmen; Pisano, Daniel J.; Rosen-berg, Jessica L. Troischt, Parker; Venkatesan, Aparna; Wilcots, Eric M.; ALFALFA Team 2017, AAS Meeting 229, id. 137.03

Russell SH, Hancock MP, McCullough J. Benefits of undergraduate research experiences. *Sci-ence*. 2007;316:548–549

Sadler, Troy D., Burgin, S., McKinney, L. 2010 “Learning science through research apprentice-ships: A critical review of the literature.” *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching* 47.3, 235

Notes

¹ https://www.nsf.gov/funding/pgm_summ.jsp?pim_id=5518

² https://nces.ed.gov/programs/digest/d18/tables/dt18_317.40.asp

³ <https://nces.ed.gov/pubs2018/2018009.pdf>

⁴ <https://www.aip.org/statistics/physics-trends/number-faculty-hired-physics-departments>

⁵ <https://github.com/adsabs/adsabs-dev-api>

⁶ https://www.cur.org/assets/1/7/Slocum_and_Scholl-Table_6.pdf

⁷ <https://aas.org/meetings/regional-meetings>

⁸ <https://www.sdss.org/education/faculty-and-student-team-fast-initiative/>

⁹ <https://astro.swarthmore.edu/knac/>

¹⁰ <http://egg.astro.cornell.edu/alfalfa/ugradteam/ugradteam.php>