The NSF/DOE Partnership in Basic Plasma Science & Engineering at 20

Report on the Anniversary Workshop

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Executive Summary

A workshop recognizing the 20th anniversary of the NSF/DOE Partnership in Basic Plasma Science and Engineering was held at NSF on January 9-11, 2017. The workshop demonstrated some of the remarkable research and broader impacts achieved with Partnership support. It provided an opportunity to reflect on the role of the Partnership in supporting plasma research and education, and as a model for interagency cooperation and agency responsiveness to community needs.

The Partnership was created following several years of study by an NSF Plasma Working Group representing multiple Directorates, recommendations by the NAS/NRC study report "Opportunities in Plasma Science and Technology" that included a target figure of $15M/year ($24M in 2016 dollars), and a DOE commitment to direct funds to basic plasma science. Community response was strong, with the initial solicitation yielding 285 proposals despite a short timeline for submission.

The Partnership remains highly competitive, and impacts a broad swath of STEM fields. It has reviewed over 2500 proposals and awarded more than $150M in individual investigator grants to over 200 PIs for projects such as plasma based medicine, plasma based accelerators, ultrashort wavelength light sources, advancements in underlying plasma theory, low-temperature plasma applications, plasma in the Earth's magnetosphere, and plasma near black holes and neutron stars. Plasma based inquiries into fundamental physics, breakthroughs in scientific computing, and development of advanced plasma diagnostics have all occurred under the Partnership. The Partnership footprint at colleges and universities is significant, with about 150 postdoctoral scientists, 300 PhD[1], and 500 undergraduate student researchers funded in the last 20 years.

Compelling personal testimony from PIs at panel discussions and throughout the Workshop made it clear that Partnership funding has been pivotal in providing flexibility for new lines of research, garnering faculty positions, achieving academic tenure, and student placement. The coordination between NSF and DOE and the rigorous, constructive, proposal review process were called out for notable praise, and the Workshop itself was held to be a productive exercise in community building.

While recognizing the science opportunities presented at the Workshop, a few concerns were also highlighted:

- Nationwide, the number of plasma faculty remains small, and the limited opportunities for student exposure to plasma physics in an academic setting

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[1] This figure reflects full funding for 5 or more years of PhD thesis work; including partial support would boost the number significantly.

make the problem self-perpetuating. **A modest, but strategically targeted, additional investment in academic plasma science would have a large and positive impact, especially in light of the disparity between the Partnership budget and the recommendation of the NAS report**. Under what auspices such a targeted investment should occur is an open question, given the many programs and agencies that support plasma science and its applications. The optimal solution would maximize resources while contributing to the recognition of plasma science as both cross-cutting and cohesive.

- Although the Partnership has contributed to broadening participation of female scientists and members of under-represented minority groups in plasma science, the representation of women and minorities in plasma science continues to be low even among STEM fields. **The Partnership has the responsibility to be proactive in promoting demographic diversity within the discipline.**

The broad relevance of plasma science to many subfields underscores the power of plasma science as an intellectual discipline and draws attention to the many ways the applications themselves drive fundamental advancements in knowledge. Plasma science plays a key role in enabling progress in some of the most important areas of the world economy, such as the semiconductor industry. **After twenty years of success, this is an opportune time for the scientific community and the supporting funding agencies to undertake a comprehensive study of how best to continue its support for the critical discipline of plasma science and engineering.**

I. Historical Background

The NSF-DOE Partnership in Basic Plasma Science and Engineering (hereafter the Partnership) arose from many years of broad based effort. NSF ENG/GEO/MPS announced support for an NAS/NRC study on plasma science and technology in 1989. By the early 1990s, efforts were underway at NSF to assess support for plasma science and engineering within the agency, culminating in formation of a cross directorate (ENG/GEO/MPS/OPP) working group. Although many individuals contributed to the working group and the activities that led to its formation, it's appropriate to acknowledge Tim Eastman, whose advocacy and leadership from within NSF's geospace program were pivotal. During the same years, the NAS/NRC study on Opportunities in Plasma Science and Technology (OPST), chaired by Cliff Surko and John Ahearne, began its work. The panel was tasked with examining all aspects of plasma science and technology in the United States, identifying key issues, and making recommendations.

These efforts crystallized in 1995 with two important events. First, the NAS released the impactful OPST panel report entitled *Plasma Science: From Fundamental Research to Technological Applications.* In several key findings, the report recommended that the NSF should provide increased support for basic plasma science and the agencies supporting plasma science should coordinate plasma science policy and funding. The report indicated that $15M ($24M in 2016 dollars)

Figure 1 Larry Goldberg, Anne Davies, Virginia Ayres, and Barry Schneider in December 1996 signing the Memorandum of Understanding that created the Partnership. (Image Credit: Larry Goldberg.)

per year should be allocated for university-scale experiments, theory, and simulation in plasma science, and that a reassessment of the relative allocation of funds between large focused programs and individual and small-group research should be undertaken. At the same time, Congress instructed the Department of Energy (DOE), with the participation of the fusion research community and the Fusion Energy Advisory Committee (FEAC) to prepare a strategic plan for a restructured Fusion Energy Sciences program. Released in January 1996, the newly-named U.S. Fusion Energy Sciences Program (FES) was directed towards a new mission: "Advance plasma science, fusion science, and fusion technology — the knowledge base needed for an economically and environmentally attractive fusion energy source." A centerpiece of the new FES Program was to broaden the intellectual and institutional base of fundamental plasma science and technology in partnership with other agencies.

As direct result of these two recommendations, in December 1996, the NSF-DOE Partnership was formed under the leadership of Virginia Ayres, Larry Goldberg, and Barry Schneider at NSF, and Anne Davies at DOE. The first proposals were submitted in response to an NSF program announcement in March 1997. The Partnership was officially recognized in the DOE/FES FY 1998 Budget Request with the language: "A new initiative in general plasma science and engineering began in FY 1997, including a joint program with NSF targeted at university programs and a young investigators program providing research opportunities for tenure-track faculty in plasma science."

In the 20 years since its inception, the Partnership has awarded over $150M in individual investigator awards to over 200 distinct PIs. The Partnership has supported wholly or in part an estimated 300 PhD theses and 150 postdocs. In addition, the Partnership has provided support for operation of the Basic Plasma Science Facility at UCLA (including LAPD) and partial support for the Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas.

The **P**hysics in **L**aboratory, **A**strophysics, **S**pace and **M**anufacturing 20th **A**nniversary (PLASMA) Workshop in celebration of the Partnership was held January 9-11, 2017

Figure 2 C. Denise Caldwell, NSF (left) and James Van Dam, DOE (right) in the first session of the PLASMA Workshop.

at NSF Headquarters in Arlington, VA with a scientific organizing committee comprised by Ellen Zweibel, Jorge Rocca, and Edward Thomas working in consultation with Vyacheslav Lukin (NSF), Carrie Black (NSF), and Sean Finnegan (DOE). The agenda (Appendix A) included talks on the history of the Partnership, scientific talks that encompassed to the extent possible the entire scope of plasma science supported by the Partnership, a poster session, and two panel discussions. Scientific topics included questions in fundamental plasma physics from magnetic reconnection and MHD turbulence, to laser-plasma interactions, to strongly coupled high energy density and dusty plasmas; and explored a number of applications of basic plasma science to industrial and medical plasmas, space and astrophysical plasmas, particle accelerators, and fusion energy research.

The panel discussions addressed the impacts of the Partnership on the research of individual PIs and on the broader scientific community, how Partnership funds are leveraged, the near-term outlook for academic plasma science and the role the NSF-DOE Partnership might play in increasing the plasma science academic footprint.

Figure 3 Left: Amy Wendt and Greg Severn at a morning coffee break. Right: Ed Thomas, Jeremiah Williams, and Tim Eastman at the poster session.

II. Highlights from the Workshop

A. The Breadth of Plasma Science

The research scope of the NSF/DOE Partnership in Basic Plasma Science and Engineering spans the breadth of plasma science and its applications. Beginning with the first announcement for the Partnership (NSF 97-39, December 1996), the program's aim has been "to address fundamental issues in plasma science and engineering which can have impact in other areas or disciplines in which improved basic understanding of the plasma state is needed." The scientific presentations, consisting of twenty-six (26) oral talks and twenty-eight (28) posters, were emblematic of how fundamental plasma physics contributes to a broad range of basic and applied physics pursuits and constitutes a vital intellectual discipline.

Lively discussions of both a specialized and general nature followed each talk and continued into the poster session, the breaks, and the meals.

It is impossible in this brief report to give a comprehensive summary of all the forefront research presented at the workshop. The reader is referred to the workshop agenda (Appendix A) for the full spectrum of talks and posters. Here, we present a few notable highlights in a larger context.

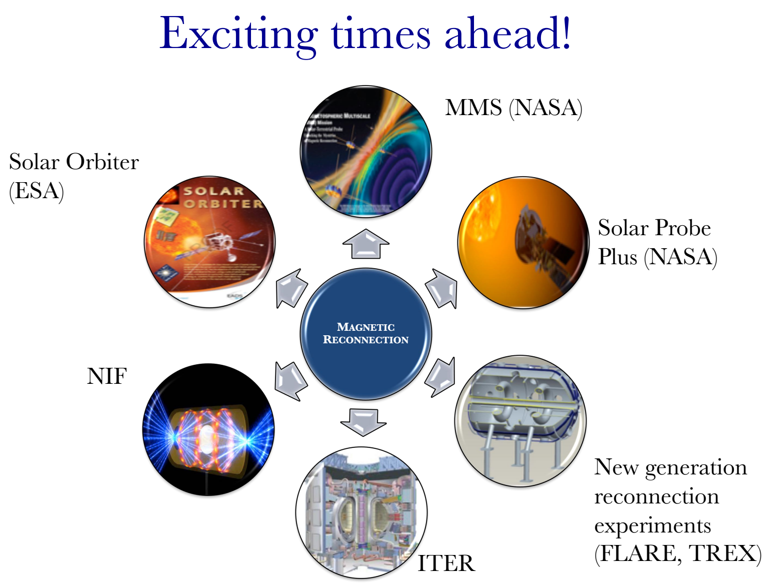

Figure 4 Natural phenomena and lab experiments supported by Partnership research on magnetic reconnection. (Image credit: Nuno Loureiro.)

Fundamental plasma physics is well represented in the Partnership. The oral presentations from Chen, Drake, Louriero, Lyutikov, and Velli on magnetic reconnection, the breaking of magnetic field lines in highly conducting plasmas with corresponding rapid conversion of magnetic energy to particle energy illustrate this very well. The range of application of these talks, which included laboratory, space, solar, and astrophysical plasmas, demonstrated the broad applicability of plasma physics, while the synergism with major projects, most recently NASA's Magnetospheric Multiscale Mission, show the extent to which the Partnership is leveraged by other agency programs.

Versatile facilities are an important aspect of Partnership research. Talks by Carter and Forest highlighted the role of a long established experimental facility, the BaPSF at UCLA, and a relatively new one, the WiPAL at U. Wisconsin. The challenges and rewards of maintaining such a facility for optimal integration of research and education at an undergraduate institution were summarized by Brown. Likewise, the Partnership has supported major advances in computational methods, some of which were illustrated by the talks by Militzer and Mori.

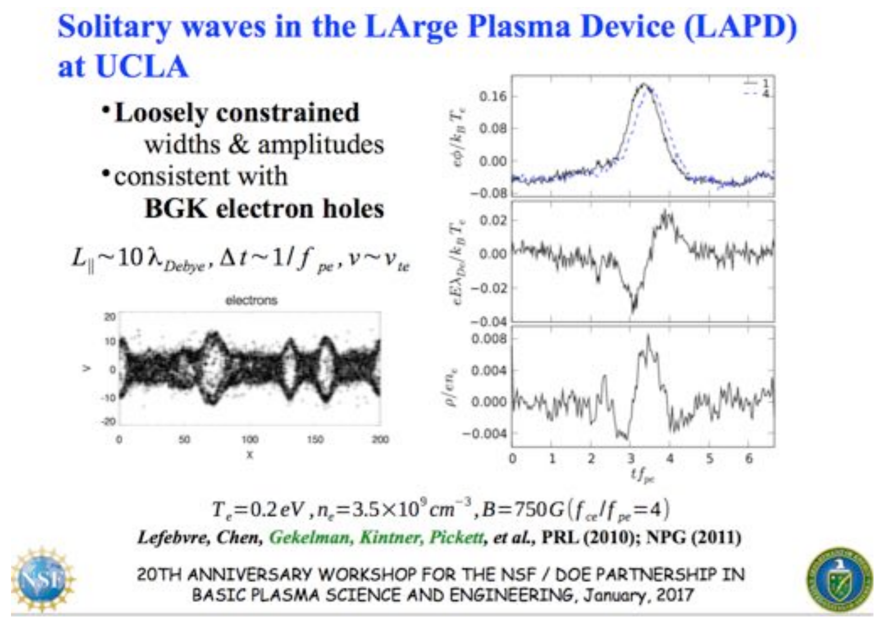

Figure 5 Montage of data from LAPD with numerical simulation. The results of this experiment have been useful for interpretation of spacecraft data. (Image credit: Li-Jen Chen.)

Diagnostics and tools are another important component of the Partnership. This was represented for low temperature plasma diagnostics and modeling from Kushner and Wendt for plasma aided manufacturing, from Mikhailova for attosecond x-ray radiation sources, from Joshi and Milchberg for particle acceleration, and from Scales for atmospheric modification. The extraordinary versatility of plasma science came through in Keidar's talk on plasma based cancer therapy, and Thagard's plasma probes of chemistry at interfaces.

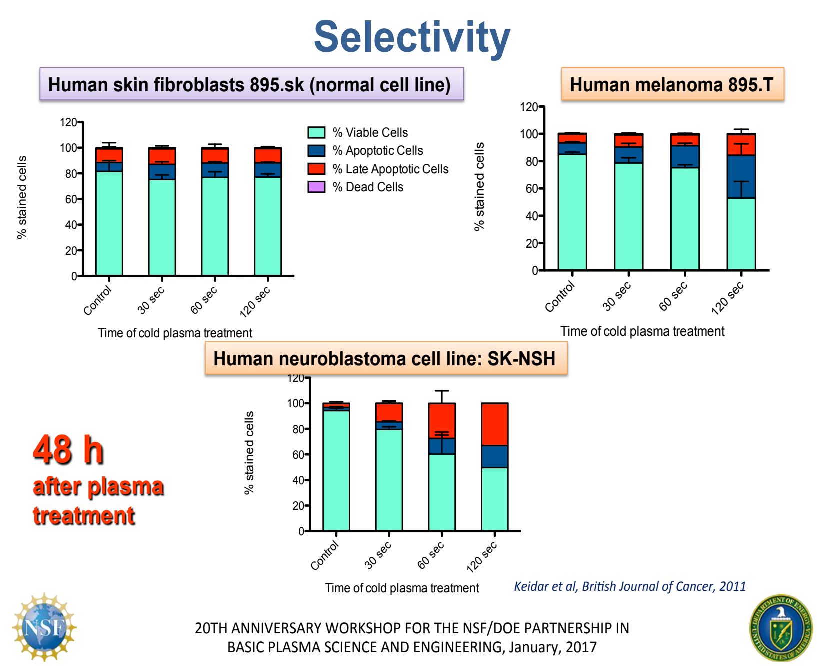

Figure 6 Experimental treatment of cancer cells with a plasma jet. (Image credit Michael Keidar.)

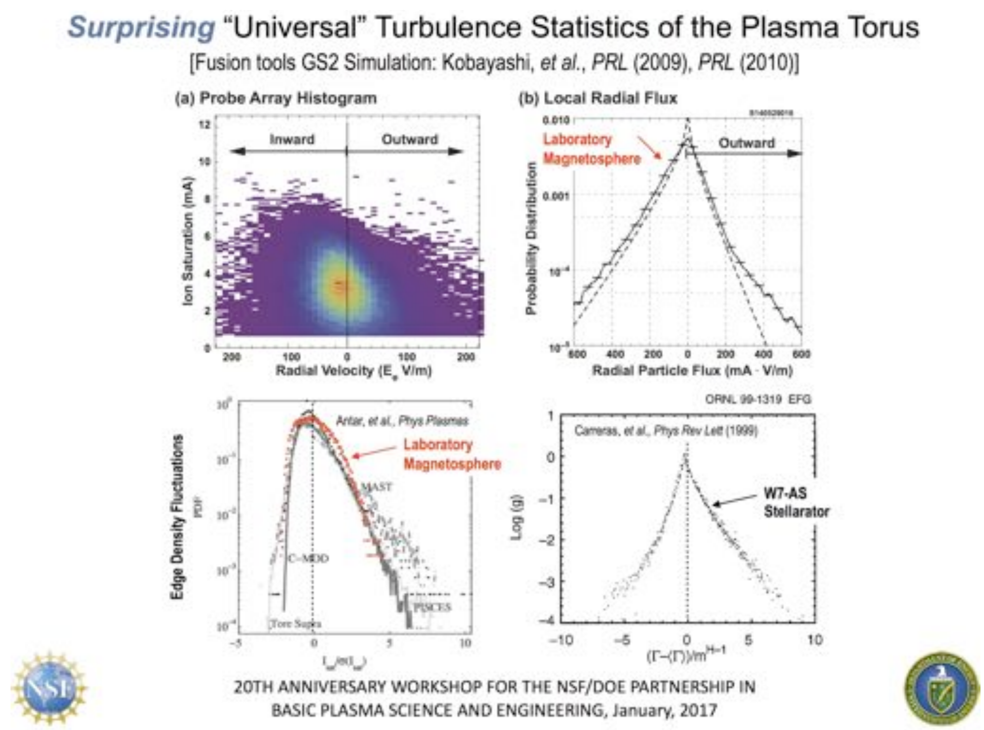

Figure 7 Comparison of turbulence statistics in fusion and basic laboratory experiments. (Image credit: Michael Mauel.)

Synergism with other plasma programs was emphasized by the talks by Betti and Mauel, which dealt, respectively, with the impact of the Partnership on inertial confinement and magnetic fusion. While the parent agencies of the fusion program are mission driven, the Partnership provides an important complement by supporting fundamental research, driven by curiosity. Yet, as shown in Figure 7,

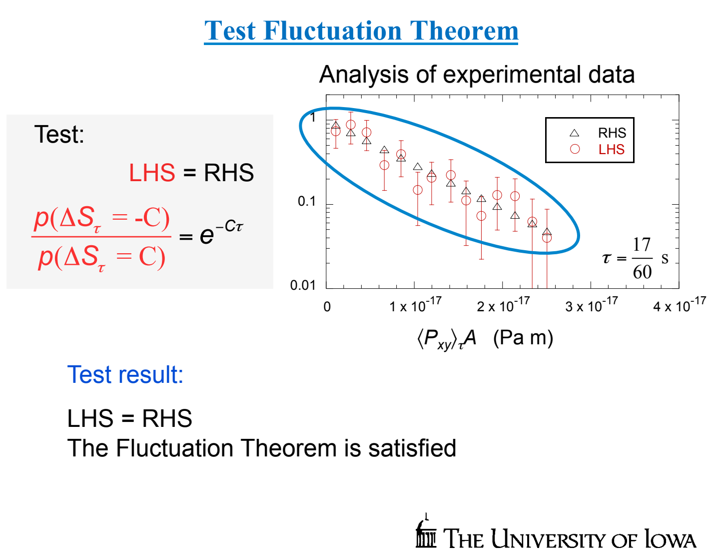

Figure 8 First experimental test of the fluctuation theorem for entropy production first proved in 1993. (Image credit: John Goree.)

fundamental research is relevant to a host of applications, and reveals surprising synergisms and commonalities among very disparate systems.

Plasma physics within basic physics studies perhaps epitomizes the broad reach of the Partnership. Fajan's talk on the spectroscopic measurements of antihydrogen and Goree's talk on probing fundamental thermodynamics and statistical physics with dusty plasmas provided two illustrations of this.

B. Impact on Education and Career Progression

The large impact that the Partnership has had on training new generations of scientists and engineers and in advancing their careers was clearly apparent at the workshop. This impact was illustrated by the statistics, as well as by the presentations and comments by several of the attendees. The Partnership grants have supported about 300 PhD theses and 150 post-doc appointments wholly or in part, and have introduced an estimated 500 undergraduate students to plasma research.

The Partnership has significantly contributed to advancing the careers of junior researchers. For several of the attendees, who are now among the leaders in their areas, the Partnership support was career changing, allowing them to start new programs and in some cases providing the key support that allowed them to gain permanent positions as faculty. As the result, several junior scientists in plasma physics, both theorists and experimentalists, became faculty members at leading research universities in the US. Partnership PIs generally hold multiple grants from a variety of government and nongovernment agencies, thus significantly leveraging Partnership funds.

Twelve NSF CAREER awards were made by the Division of Physics in the area of plasma physics during the past 20 years. These and other such high impact awards to junior faculty are of great significance in convincing university administrators to create and grow faculty positions in this enabling area of science and engineering. In particular, we call out the DOE FES Junior Faculty and Early Career Research Programs, which over the past 20 years have made awards to 53 junior university and college faculty in all subfields of plasma science. It is anticipated that a continued emphasis on early career awards in plasma science, if sustained over time, will have a large impact on plasma research and education.

The Partnership has also contributed to broadening participation of female scientists and members of under-represented minority groups in plasma science (see Appendix B). Nevertheless the fraction of PIs who are female and/or minorities is low. This reflects the representation of women and minorities in plasma science, which is low even among STEM fields. We strongly encourage the Partnership to continue to be proactive in promoting demographic diversity within the discipline.

III. Summary of Panel Discussions

An important part of the Workshop was two panel discussions – held on the first and last day. The first panel, on the Monday afternoon, was a "look back" on the twenty years of the Partnership and its impact on the plasma science community. The second panel, on the Wednesday afternoon, focused on the present and future of the Partnership and its role in shaping universities and fostering collaboration among federal agencies.

A. Panel on the Impact of the Partnership in Supporting Advances in Plasma Science & Engineering

[Moderated by Vyacheslav Lukin & Sean Finnegan]

The first panel was organized in the format of a community-wide discussion that centered on three questions presented by Drs. Lukin and Finnegan. Attendees were invited to respond to the three questions. What followed was a robust conversation among the participants.

Q1: What has been the impact of the Partnership on PI's programs and the broader science community (science, workforce, etc.)

Common themes included:

a. The Partnership offers PIs an opportunity to focus on "basic science" whether in the form of theory or experiment. This allows PIs to explore scientific questions of fundamental importance and long-term impact without having to respond to a specific agency or programmatic mandate. This is seen as relatively unique among federally funded programs which support plasma science, and a great strength of the Partnership.
b. Similarly, the Partnership allows PIs a degree of intellectual flexibility. PIs are given the freedom to pursue research topics and to follow their scientific curiosity. It was pointed out that the flexibility offered by the Partnership enabled the development of tools and techniques (e.g., in accelerator physics and low temperature plasmas) that have led to new technologies that may have broad societal impact, e.g., next-generation compact accelerators, next generation semiconductor devices, and the use of low temperature plasmas for medicine and agriculture.
c. The Partnership has had a significant impact on the training of the next generation of plasma scientists. Several participants noted the critical role of Partnership funding in supporting both undergraduate and graduate students in their research.
d. The Partnership provided a single, unified location from which funds for basic plasma science research could be requested. The participation of several NSF Directorates and the DOE Office of Science were important for

raising the visibility of plasma science. And the Partnership is a visible place where faculty can tell university administrators that there *is* a source of funding for plasma science research – particularly when trying to create new faculty lines in a department.

Other comments raised by participants included:

- The Partnership came "at the right time" to encourage the support of basic plasma science.
- For current early and mid-career scientists, the Partnership has been a very important source of support over the last 20 years.
- The Partnership has become a "role model" for inter-agency cooperation. It provides a template for how to build partnerships, and the review process used by the Partnership has become a model used by other programs and agencies.
- The Partnership has contributed to building a broad basic plasma science community that cuts across many different disciplines and impacts many fields.

For Questions 2 and 3, there were fewer central themes and the community responses can be described as more anecdotal. Nonetheless, there are common themes in several points raised by participants.

Q2: How has the Partnership been leveraged?

A point raised by several participants was the leveraging of the Partnership support for students. At both national labs and universities, the presence of Partnership support helped to enable students to participate in a variety of on- and off-campus undergraduate research activities.

Other points:

- The Partnership funding levels have enabled a variety of new, basic plasma experiments to be built – often leveraging Partnership funds with other sources (e.g., equipment from NSF Major Research Instrumentation, NASA, NNSA).
- The Partnership has enabled researchers to focus on basic science rather than applications – which broadly benefits the entire field of plasma science (reiterating point (a), above).
- The Partnership provides a "lever" by which the community can influence both the NSF and DOE.

Q3: What is the community view of the Partnership between NSF & DOE?

A common theme in the responses to this question is the perceived value of plasma science because of the Partnership. Comments include the fact that the Partnership demonstrates "intellectual legitimacy of plasma physics" and that "plasma physics is not just fusion".

And while the Partnership is generally viewed as a very good program, participants also raised a few concerns. It was noted that the growth in the Partnership funding has been constrained and the original vision for a substantially larger and multi-disciplinary plasma science program has not yet been fully achieved. It was questioned whether it has become a "home" for plasma physics, as envisioned by some. Finally, has the Partnership done enough to expand a broader portfolio of plasma science support across the federal government? Support for plasma science across agencies has narrowed to some degree; is there a perception that plasma science is "taken care of" because of the Partnership?

B. Panel on the Present and Future Role of the NSF/DOE Plasma Partnership in Stewarding Plasma Science

[Moderated by Ellen Zweibel]

The second panel was organized in the format of a more traditional panel with selected group of participants asked to speak on two questions (which had been posted on the Workshop website for comment), followed by a broader discussion including attendees of the Workshop. The Panel consisted of a spectrum of plasma researchers representing universities and national labs, faculty members and department chairs, and research fields ranging from fusion, laser-plasma interactions, laboratory plasmas, and space/astrophysical plasmas. [Panel members: Jorge Rocca, Lorin Matthews, Earl Scime, Edward Thomas, Stuart Prager and Gary Zank]

Q1: What is the present situation and near-term outlook for US university faculty positions in plasma physics and related disciplines? How could the NSF/DOE Plasma Partnership facilitate an increase in the academic footprint in the disciplines with limited university presence?

Summary of comments from panel members:

<u>Stability and growth of faculty lines</u>: The Partnership is an important indicator to departments that there are individual investigator grants in plasma science and engineering. However, there were a variety of opinions about the impact and role of the Partnership. While the Partnership does provide support the funding levels are often not enough to adequately support an experimental program. Additionally, while the presence of the Partnership has enabled departments to grow their plasma programs, the relatively slow growth in the overall Partnership funding acts to limit growth in plasma faculty. Finally, it was indicated that a recent UFA report

suggests a “crisis” in the number of fusion faculty – does this also extend to the larger plasma physics and engineering community?

Plasma physics pipeline: The Partnership has become critical for maintaining the plasma science career pipeline – particularly now that DOE has subsumed the undergraduate NUF (National Undergraduate Fellowship) program into the laboratory internship SULI (Science Undergraduate Laboratory Internship) program and eliminated DOE graduate fellowships held at universities. As a result, the Partnership has taken on an even larger role in maintaining the training of undergraduate and graduate students. Combined with the fact that Partnership awards are often not enough to support postdocs, the Partnership is under stress when it comes to training the next generation of plasma scientists and engineers.

Early career plasma scientists: While the 12 NSF Career Grant awardees in plasma physics are to be celebrated, this number over the 20 years of the Partnership seems low - not much better than 1 every 2 years. Doubling that number would be appropriate and would likely stimulate new plasma hires as well as dramatically change the landscape for the young faculty who get these awards.

General comments from participants and outstanding questions:

- More effort needs to be placed by the community on promoting plasma science – in academia and the general public. Outside of departments that have existing plasma research programs, there is very little formal education in plasma physics.
- One particular challenge: Is plasma a victim of its multi-disciplinarity? Does the fact the plasma science encompasses a broad spectrum of basic and applied research limit the appreciation of the field?
- Why is plasma science not broadly represented among the physics sub-disciplines? Is a broad national set of goals needed for plasma science?
- Can a “block grant” approach to support plasma science be effective (e.g., similar to what is done in high energy physics)?
- Are dedicated programs for supporting the plasma physics pipeline needed (e.g., from REU program to specific post-doc programs)?

Q2: What is the place and role of the NSF/DOE Plasma Partnership among the multiple government agencies and programs that support basic and applied research in plasma science?

Summary of comments from panel members:

Partnership as a model program for multi-agency support: The Partnership has worked and plays an indispensable role. It has created a clearly identifiable place in the federal government where researchers can seek support for basic plasma science and engineering. It has provided flexibility and stability and provides funding for "plasma physics unconstrained by topic". It is unquestionably, "de facto leader of plasma science support".

Effect of the Partnership on the broader government support for plasma science: A concern is whether the Partnership is "a victim of its own success". Have other federal agencies cut back on their support for basic plasma science because of the existence of the Partnership? While there is anecdotal evidence for this, is this the time to conduct a broad review of how plasma science is funded across the federal government? Could the NAS/NRC decadal survey provide insight into this?

General comments from participants and outstanding questions:

- Re-iterating that advocacy and educating the public and other scientists is important; education and outreach to other agencies and other directorates within the NSF is needed to advance the understanding of the role plasma science plays in understanding the universe and enabling new technologies.
- Plasma science education at the undergraduate level is virtually nonexistent outside of institutions that pursue plasma research. Can the Partnership play a role in broadening the reach of plasma science into the broader physics curriculum?
- Plasma physics is near the bottom in terms of diversity [see ix B]. Could the Partnership more effectively work to advance diversity?
- While the Partnership brings stability and visibility to plasma science, does plasma science still need a permanent home?

IV. Conclusions

The NSF-DOE Partnership in Basic Plasma Science and Engineering has supported remarkable research across a broad spectrum of plasma topics. Partnership support has directly impacted the education and careers of over a thousand persons, raised the profile of plasma science in academia and society as a whole, and set a standard for interagency cooperation. This has been done with about half of the $15M annual budget recommended by the 1995 NRC report. The many successes of the Partnership are cause indeed for a 20th anniversary celebration, and taken together with the budget recommendations of the NRC report, suggest that even a modest but strategically targeted additional investment in academic plasma science would have a large, positive impact.

One of the outcomes of the Workshop was the very visible demonstration that plasma science is both tremendously broad and intellectually unified. While the breadth is encapsulated by the written agenda of the workshop, we also saw this at the "grass roots", as participants who worked in different subfields found common ground, and expressed a wish that similar workshops occur in the future. This breadth is indicated by the multiple programs and agencies appearing in the funding profiles of PIs.

This duality is both an opportunity and a challenge: how to grow the core of plasma science as a recognized, coherent discipline while supporting the penetration of plasma science into the many fields in which it is vital. Addressing this issue is beyond the scope of this report, but we urge the supporting funding agencies, together with the scientific community, to undertake a comprehensive study of how best to continue its support for the critical discipline of plasma science and engineering.

Figure 9 Group photo taken at the poster session in the Atrium at NSF's Arlington, VA Headquarters.

V. Acknowledgements & Disclaimers

We are happy to acknowledge financial support for the Workshop from NSF through PHY 171984, DOE Office of Science FES, significant help from NSF and DOE staff in gathering material the informed our perspective, and comments on a draft of the report from Lorin Matthews, Stewart Prager, Earl Scime, and Gary Zank. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation or the US Department of Energy.

Appendix A: Program of the Workshop

Scientific Organizers:

Ellen Zweibel (University of Wisconsin - Madison), Chair
Jorge Rocca (Colorado State University)
Edward Thomas, Jr. (Auburn University)

Logistics

Important Guidelines for the Presenters

Because of the broad nature of the Partnership and the Workshop audience, all presenters are asked to abide by a few general guidelines:

1) Presentations should be made to appeal to a diverse audience of scientists.

2) Presentations should highlight the impact of the Partnership in enabling the presented work.

3) Presentations ***must not*** discuss any work that is a part of a pending proposal to NSF or DOE.

Speakers: All talks and panel discussions are being webcast live. You are asked to deliver your presentation via email, download, or thumb drive to the A/V support staff ahead of time to enable the live webcast from a master server.

Poster presenters: The poster session is being held in the Atrium on the first floor of the NSF Stafford I building from 3:30pm until 6pm on Tuesday, January 10^{th}. **Posters can be put up in the morning prior to the beginning of the oral sessions at 8am, or at any time thereafter. Posters have to be taken down at 6pm to allow for the timely removal of the poster boards.** The poster session has been subdivided into two sub-sessions, with the presenters expected to attend to their poster during the assigned sub-session. **See below for the numbered listing of the posters and the sub-session information.**

Workshop Dinner: The restaurant information for the Workshop dinner scheduled for 6:30pm on Tuesday, January 10^{th} is provided at the end of this brochure.

Travel alert: The DC Metro system is undergoing a significant construction that may cause delays. Workshop participants that plan to use Metro should check the website: http://www.wmata.com/ in order to minimize possible travel disruptions.

Day 1 [January 9th, 2017]

Chair: Ellen Zweibel (U. Wisconsin – Madison)

8:30 (AM)	Welcome: Fleming Crim (NSF) & Jim Van Dam (DOE)
8:45	Denise Caldwell (NSF): History of the Partnership, Introductory talk
9:15	Ronald McKnight (DOE, retired): "Some Thoughts About the Early Days of the Plasma Partnership"
9:30	Cliff Surko (UCSD): "With an Eye Toward the Partnership: The 1995 NRC Plasma Science Report"
9:45	Timothy Eastman (Wyle - NASA Goddard): "Plasma Science at NSF Prior to the Partnership"
10:00	**Coffee Break**

Chair: Vyacheslav Lukin (NSF)

10:30	Nat Fisch (Princeton U.): "Some Opportunities in Rotating Plasma"
11:00	Cary Forest (U. Wisconsin – Madison): "Energy Conversion Between Forms in the Big Red Ball"
11:30	John Goree (U. Iowa): "The breadth of plasma physics topics explored in dusty plasma experiments"
12:00	Joel Fajans (UC Berkeley): "Plasma Physics and Antihydrogen"
12:30	**Working Lunch at NSF**: Presentations from NSF Partnership Programs
	1:00pm JoAnn Lighty (NSF), ENG/CBET Division Director
	1:20pm Ilia Roussev (NSF), GEO/AGS Program Director

Chair: Ed Thomas (Auburn U.)

1:45	Warren Mori (UCLA): "Full-scale 3D particle-in-cell numerical experiments of high-intensity particle and laser beam-plasma interactions: Past and Future impact"
2:15	Li-Jen Chen (U. Maryland – College Park): "From solitary waves in LAPD to the center of magnetic reconnection"
2:45	Michael Brown (Swarthmore C.): "Challenges and opportunities of conducting research at undergraduate-only institutions"
3:15	**Coffee Break**
3:30	Mark Kushner (U. Michigan – Ann Arbor): "Contributions of Basic Plasma Physics to Technology Development Enabled by Modeling"
4:00	Burkhard Militzer (UC Berkeley): "Path integral Monte Carlo simulations of dense plasmas"
4:30	Vyacheslav Lukin (NSF) & Sean Finnegan (DOE): Introduction to Panel on the Impact of the Partnership in Supporting Advances in Plasma Science & Engineering
4:40	Panel Discussion [moderated by Vyacheslav Lukin & Sean Finnegan]
5:40	**Adjourn**

Day 2 [January 10^{th}, 2017]

Chair Ilia Roussev (NSF)

8:00 (AM) Nuno Loureiro (MIT): "Uncovering new regimes in plasmoid-dominated magnetic reconnection"

8:30 Maxim Lyutikov (Purdue U.): "Explosive reconnection and particle acceleration in relativistic plasmas"

9:00 Marco Velli (UCLA): "Triggering Fast Reconnection in the Heliospheric Plasma"

9:30 Daniel Savin (Columbia U.): "Experimental Investigations of Alfven Wave Damping Processes Relevant to the Solar Corona"

10:00 **Coffee Break**

Chair: Jorge Rocca (Colorado State U.)

10:15 Chandrashekhar Joshi (UCLA): "Risky Behavior At the Frontiers of Plasma Science"

David Hammer (Cornell U.) kindly served as a replacement speaker

10:45 ~~Margaret Murnane (U. Colorado – Boulder): "Extreme Nonlinear Optics in Plasmas: Quantum Control with sub-Å and sub-Attosecond Precision"~~

11:15 Selma Mededovich (Clarkson U.): "Chemical and transport processes at a plasma-liquid interface"

11:45 Michael Keidar (George Washington U.): "Cold atmospheric plasma physics and application in cancer therapy"

12:15 **Lunch on your own**

Chair: Ellen Zweibel (U. Wisconsin – Madison)

1:45 Troy Carter (UCLA): "The Basic Plasma Science Facility: Research at the frontiers of fundamental plasma science, enabled by the Partnership"

2:15 James Drake (U. Maryland – College Park): "Particle acceleration during magnetic reconnection"

2:45 Wayne Scales (Virginia Tech): "Some recent advances in studying space plasmas with high power high frequency HF radiowave heating"

3:15 **Coffee Break**

3:30 Poster Session [NSF, Stafford I Atrium]

6:00 **Adjourn**

6:30 **Workshop Dinner** [to be paid for individually]: http://www.rus-uzcuisine.com/

Day 3 [January 11th, 2017]

Chair: Jorge Rocca (Colorado State U.)

8:15 (AM) Farhat Beg (UCSD): "Physics of high intensity laser matter interactions and energetic particle acceleration"

8:45 Howard Milchberg (U. Maryland – College Park): "Spatio-temporal optical vortices"

9:15 Julia Mikhailova (Princeton U.): "Waveform-controlled high-order harmonic emission from plasmas"

9:45 **Coffee Break**

Chair: Sean Finnegan (DOE)

10:00 Amy Wendt (U. Wisconsin – Madison): "Optical Emissions from low-temperature plasmas: using relative spectral intensities to determine plasma properties"

10:30 Michael Mauel (Columbia U.): "Advancements of Basic Plasma Physics enabling Progress in Magnetic Fusion Energy"

11:00 Riccardo Betti (U. Rochester): "The interplay of fundamental science and inertial fusion"

11:30 **Break**

11:40 Panel Discussion: The Present and Future Role of the NSF/DOE Plasma Partnership in Stewarding Plasma Science

Chaired by

Ellen Zweibel (U. Wisconsin - Madison)

with panelists

Lorin Matthews (Baylor U.)
Stewart Prager (Princeton U.)
Jorge Rocca (Colorado State U.)
Earl Scime (West Virginia U.)
Edward Thomas, Jr. (Auburn U.)
Gary Zank (U. Alabama - Huntsville)

Discussion Questions:

Q1*: What is the present situation and near-term outlook for US university faculty positions in plasma physics and related disciplines? How could the NSF/DOE Plasma Partnership facilitate an increase in the academic footprint in the disciplines with limited university presence?*

Q2: *What is the place and role of the NSF/DOE Plasma Partnership among the multiple government agencies and programs that support basic and applied research in plasma science?*

12:50 Wrap-up

1:00 **Adjourn**

Poster Session [NSF Stafford I, Atrium], 3:30pm – 6pm, January 10th.

Sub-session 1: 3:30pm – 4:45pm – all odd-numbered posters

Sub-session 2: 4:45pm – 6:00pm – all even-numbered posters

#	First Name	Last Name	Poster Title
1	Paul	Bellan	Resolving interaction between MHD and non-MHD phenomena in a lab experiment
2	Alain	Brizard	Lifting of the Vlasov-Maxwell Bracket by Lie-transform Method: Theory for Theory's Sake
3	C. Fred	Driscoll	Long-Range Collisions and Transport: a 20 Year Review
4	Charles	Durfee	Control of electron dynamics with tilted ultrafast laser pulses
5	Fatima	Ebrahimi	Three-dimensional plasmoid reconnection - Application to fusion and astrophysical plasmas
6	Jan	Egedal	Dynamics of the Electron Diffusion Region in the Terrestrial Reconnection Experiment (Trex)
7	John	Foster	Plasma physics in liquid water with application to water purification
8	Pierre	Gourdain	Exploring the properties of warm dense matter in the cores of Mega-Earths using pulsed-power generators
9	Nathaniel	Hicks	Initial Study of Plasma Response to a Variable Electric Multipole Configuration
10	Yi-Min	Huang	Plasmoid instability and onset of fast reconnection
11	Hantao	Ji	FLARE: A New User Facility to Study Multiple-Scale Physics of Magnetic Reconnection Through in-situ Measurements
12	Michael	Murillo	Molecular dynamics investigations of non-equilibrium, heterogeneous charged systems
13	Nicholas	Murphy	PlasmaPy: beginning a community developed Python package for plasma physics
14	Chung-Sang	Ng	Surface Currents during a Major Disruption
15	Nikolai	Pogorelov	Modeling Flows of Partially Ionized Plasma with the Multi-Scale Fluid-Kinetic Simulation Suite
16	Jorge	Rocca	Ultra High Energy Density Plasmas
17	Greg	Severn	Are the things you read in theory papers that have not been experimentally validated true?
18	Mikhail	Sitnov	Magnetic reconnection, buoyancy and flapping motions in the magnetospheric tail

#	First Name	Last Name	Poster Title
19	Frederick	Skiff	Studies of the kinetic degrees of freedom of plasma waves
20	Matthew	Stoneking	Electron Plasma in a Purely Toroidal Magnetic Field
21	Cliff	Surko	Strong-Drive Regime of Rotating-Wall Compression - a Workhorse for Physics with Antimatter
22	Edward	Thomas, Jr.	Laboratory studies of dusty plasmas in unmagnetized and magnetized plasmas
23	Petros	Tzeferacos	Numerical modeling of laser-driven experiments that aim to demonstrate magnetic field amplification via turbulent dynamo
24	Joseph	Wang	3-D Particle-in-Cell Simulations of Electron and Ion Dissipation by Whistler Turbulence
25	Jeremiah	Williams	Measurement of the thermal and transport properties in weakly-coupled dusty plasmas
26	Peter	Yoon	Fundamental Kinetic Plasma Processes
27	Gary	Zank	Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence
28	Ellen	Zweibel	Cosmic Rays at Work

Registered Participants (as of Jan 3rd, 2017)

First Name	Last Name	Institution
Snezhana	Abarzhi	Carnegie Mellon University
Kramer	Akli	DOE
Spiro	Antiochos	NASA/GSFC
Thomas	Antonsen	University of Maryland
Michael	Bakas	Bennett Aerospace
Kurt	Becker	NYU
Farhat	Beg	University of California San Diego
Paul	Bellaire	NSF (Retired)
Paul	Bellan	Caltech
Riccardo	Betti	University of Rochester-LLE
Carrie	Black	NSF/AGS
Alain	Brizard	Saint Michael's College
Michael	Brown	Swarthmore College
Troy	Carter	UCLA
Li-Jen	Chen	University of Maryland at College Park
Jean	Cottam	NSF
Vladimir	Demidov	West Virginia University
Danil	Dobrynin	Drexel University
Bill	Dorland	University of Maryland
James	Drake	University of Maryland
C. Fred	Driscoll	University of California at San Diego
Charles	Durfee	Colorado School of Mines
Timothy	Eastman	Wyle - NASA Goddard Space Flight Center
Fatima	Ebrahimi	Princeton University / PPPL
Joel	Fajans	U.C. Berkeley
Sean	Finnegan	Department of Energy
Nat	Fisch	Princeton University
Cary	Forest	University of Wisconsin Madison
John	Foster	University of MIchigan
John	Gillaspy	NSF

Steven	Gitomer	Los Alamos National Laboratory (retired)
Lawrence	Goldberg	National Science Foundation
John	Goree	The Univ. of Iowa
Pierre	Gourdain	University of Rochester
David	Hammer	Cornell University
James	Hawreliak	Washington State University
Nathaniel	Hicks	University of Alaska Anchorage
Yi-Min	Huang	Princeton University
Truell	Hyde	Baylor University
Hantao	Ji	Princeton University
Chandrashekhar	Joshi	UCLA
Michael	Keidar	The George Washington University
James	Klimchuk	NASA Goddard Space Flight Center
Mark	Koepke	West Virginia University
Mark	Kushner	University of Michigan
Martin	Laming	Naval Research Laboratory
David	Lang	National Academy of Sciences
Yue Ying	Lau	University of Michigan
Wim	Leemans	Lawrence Berkeley National Laboratory
L.K.	Len	U.S. Department of Energy
Edison	Liang	Rice University
Nuno	Loureiro	MIT
John	Luginsland	AFOSR
Vyacheslav	Lukin	NSF
Maxim	Lyutikov	Purdue University
Jason	Marshall	AFOSR
Lorin	Matthews	Baylor University
Mike	Mauel	Columbia University
Ronald	McKnight	self
Selma	Mededovic	Clarkson University
Tom	Mehlhorn	Naval Research Laboratory
Bogdan	Mihaila	NSF

Yulia	Mikhaylova	Princeton University
Howard	Milchberg	University of Maryland
Burkhard	Militzer	University of California, Berkeley
Warren	Mori	UCLA
Michael	Murillo	Michigan State University
Margaret	Murnane	JILA/University of Colorado at Boulder
Nicholas	Murphy	Smithsonian Astrophysical Observatory
Chung-Sang	Ng	University of Alaska Fairbanks
Nirmol	Podder	Department of Energy
Nikolai	Pogorelov	University of Alabama in Huntsville
Stewart	Prager	Princeton University
Chuang	Ren	University of Rochester
Jorge	Rocca	Colorado State University
Ann	Satsangi	DOE
Daniel Wolf	Savin	Columbia University
Wayne	Scales	Virginia Tech
Barry	Schneider	NIST
Earl	Scime	West Virginia University
Greg	Severn	University of San Deigo
Uri	Shumlak	University of Washington
Mikhail	Sitnov	JHU/APL
Fred	Skiff	University of Iowa
Matthew	Stoneking	Lawrence University
Clifford M.	Surko	University of California, San Diego
Edward	Thomas	Auburn University
Petros	Tzeferacos	University of Chicago
Ryan	Umstattd	ARPA-E
James	Van Dam	U.S. Department of Energy
Marco	Velli	UCLA
Joseph	Wang	University of Southern California
Amy	Wendt	University of Wisconsin - Madison
Jeremiah	Williams	Wittenberg University

Peter	Yoon	University of Maryland
Gary	Zank	University of Alabama in Huntsville
Ellen	Zweibel	U. Wisconsin-Madison

Appendix B: Demographic Diversity in the Partnership and Selected NSF Divisions

The table below shows that the fraction of Partnership proposals with female or underrepresented minority PIs which are funded is greater than or equal to the funding rate for the Partnership as a whole. However, the fraction of proposals received from females or underrepresented minorities is low, even compared to that in related fields.

	FY10 through FY16	Total	Underrepresented minorities	Race/ethnicity not known	Female
PHY-Plasma	Total Actions:	966	34	116	67
	Total Awards:	203	11	24	16
	Av. Funding Rate:	21.0%	32.4%	20.7%	24%
	PI Fraction		3.5%	12.0%	6.9%
PHY	Total Actions:	6,765	384	727	872
	Total Awards:	2,474	137	202	362
	Av. Funding Rate:	36.6%	35.7%	27.8%	42%
	PI Fraction		5.7%	10.7%	12.9%
AST	Total Actions:	7,270	336	708	1,490
	Total Awards:	1,431	68	121	310
	Av. Funding Rate:	19.7%	20.2%	17.1%	21%
	PI Fraction		4.6%	9.7%	20.5%
CBET	Total Actions:	26,162	1,804	2,398	5,067
	Total Awards:	4,201	267	335	859
	Av. Funding Rate:	16.1%	14.8%	14.0%	17%
	PI Fraction		6.9%	9.2%	19.4%
ECCS	Total Actions:	10,531	558	892	1,344
	Total Awards:	2,101	114	189	294
	Av. Funding Rate:	20.0%	20.4%	21.2%	22%
	PI Fraction		5.3%	8.5%	12.8%
AGS	Total Actions:	5,570	220	551	1,136
	Total Awards:	2,210	78	202	440
	Av. Funding Rate:	39.7%	35.5%	36.7%	39%
	PI Fraction		3.9%	9.9%	20.4%