Preview of Award 1066293 - Annual Project Report

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1066293
Project Title:	Programs on Critical Problems in Physics, Astrophysics and Biophysics at the Aspen Center for Physics
PD/PI Name:	Rosemary F Wyse, Principal Investigator Karin Rabe, Co-Principal Investigator
Recipient Organization:	Aspen Center For Physics
Project/Grant Period:	10/01/2011 - 09/30/2016
Reporting Period:	10/01/2013 - 09/30/2014
Submitting Official (if other than PD\PI):	Karin Rabe Co-Principal Investigator
Submission Date:	07/09/2014
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Karin Rabe

Accomplishments

*** What are the major goals of the project?**

The primary major goal of the Aspen Center for Physics is to nurture cutting-edge research in physics and related disciplines by providing a unique physical and scientific environment ideally suited for stimulating interactions, collaborations and innovation.

An additional major goal is to conduct public outreach at all levels, from children to the general public, to increase understanding of and interest in physics, and to encourage young people in pursuing careers in STEM. The value of these outreach activities is enhanced by the fact that Aspen attracts visitors from all over the world both in winter and in summer, so that the Center's outreach has a broad national and even international impact.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: In summer 2013, the Aspen Center for Physics hosted 561 leading international

researchers from a broad range of institutions around the world. A total of 505 researchers participated in the winter 2014 conferences.

The summer scientific programs emphasize open problems at the cutting edge and the format is designed to maximize informal interactions within each area and crossfertilization between different areas. This is accomplished by a program of informal workshops spanning a wide range of physics and related disciplines, with two or three workshops running concurrently, combined with small working groups and visits by individuals. The Summer Workshops are selected from the proposals received from the international physics community by a committee of General Members of the ACP, with the goal of selecting timely and exciting topics which will attract the most outstanding researchers. The titles and organizers of the 2013 Summer Workshops are listed in an attached file (summerworkshops2013.pdf); topics included superconformal field theory, LHC physics, dark matter searches, galaxies, and topology in quantum condensed matter. The quality of the researchers in the summer programs at the Center is ensured by a competitive admissions process. For summer 2013, 665 of 1030 applicants were offered admission, yielding 561 participants. Special attention was paid to including junior researchers (72 assistant professors, 109 postdocs, and three particularly outstanding senior graduate students). In addition, each workshop is required to have a member of the organizing committee who is the Diversity coordinator, and a member of the ACP's Diversity Committee serves on the Admissions Committee, with the result that a record number of 110 participants (20%) were women and 9 were from small universities (fewer than 3 physics PhDs annually). Participants need not be affiliated with a specific workshop: 13 different small working groups (35 physicists in total) were hosted, together with 39 physicists who applied primarily to undertake Individual research.

The physics ideas under discussion in the summer workshops are disseminated to the ACP participants in other sub-fields through a colloquium held weekly at the ACP, presented by a participant in an ongoing workshop. These colloquia also facilitate cross-disciplinary collaboration. The titles and speakers of the summer 2013 colloquia are reported in an attached file (Colloquia2013.pdf).

The purpose of the Winter Conferences is to respond rapidly to breaking developments in areas of current interest in physics and interdisciplinary research. These one-week winter conferences, like the summer workshops, are selected from proposals received from the international physics community by a committee of ACP General Members. These conferences, with up to 100 participants each week, have a full schedule of formal presentations, geared to dissemination of the latest results, complementary to the summer program's focus on unsolved problems. The full list of winter conferences held in 2014 is included in an attached file (winterconf2014.pdf); the topics covered cutting-edge physics across many fields. The quality of participants is ensured by a competitive admissions procedure conducted by the organizers of each conference, with the additional goal of encouraging junior participants (including graduate students) and diversity. Of the 2014 winter participants, 76 (16%) were women.

The research activities of the Center spanned the fields of high energy physics, astrophysics, condensed matter physics, biophysics and related disciplines. In summer 2013, of a total of 42 workshop weeks, 12 weeks were in high energy (3 high energy workshops and one workshop interdisciplinary with astrophysics), 14 weeks were in astrophysics (4 workshops plus the interdisciplinary workshop), 11 weeks were in

condensed matter (3 workshops), and 5 in biophysics (1 workshop). Of the seven winter conferences, one was in high energy physics, one was interdiscipiinary betwen high energy and condensed matter physics, two were in condensed matter physics, one was in astrophysics and one was in quantum computation. Of the 565 papers, conference proceedings, and book chapters citing the Center and the NSF grant in the year starting July 1, 2013, 192 (34%) were in high energy physics, 213 (38%) were in astrophysics, 142 (25%) were in condensed matter physics and 18 (3%) were in biophysics.

In both summer 2013 and winter 2014, the Aspen Center for Physics continued to develop its increasingly rich and visible public outreach program. In both summer and winter, a series of public lectures is offered to introduce the public to the most exciting directions of current physics research, as well as to issues concerning science policy. These lectures are subsequently broadcast on public television, accompanied by separate interviews with the lecturers. The lectures and interviews are freely available on the internet for viewing in a video archive accessible through the ACP website. In the winter, the public lecture is preceded by a Physics Cafe, during which selected physicists from the winter conference engage the public in a conversational Q & A session. In the summer, the public lectures are complemented by more informal Dialogues, which are get-togethers where leading researchers discuss their current research in a relaxed setting in which questions and discussions between the speaker and the audience are strongly encouraged. Also in the summer, the 'Physics is for Kids' Family Barbeques feature an informal lecture, often accompanied by demonstrations and/or hands-on activities, by a physicist from the summer program. The full listings of these series of events are given in an attached pdf file (outreach2013-2014.pdf). The Summer 'Physics is for Kids' Family Barbeques and the Physics Cafes are cohosted by the Aspen Science Center (ASC). The ASC is a non-profit organization, based in Aspen, and was founded `to bring science into our lives in a compelling way and use the power of good science to create a better future for all of us'. The collaboration between the ACP and the ASC is very fruitful, with ACP providing the physics experts and the ASC providing outreach experience and hands-on experiments for the BBQs.

The interactions between the ACP and local high school students have been strengthened by the 'go-fer' program at ACP, whereby the ACP asked teachers of advanced physics classes to recommend their students as 'gofers' at the ACP during the summer months. ACP hosted 12 such students in summer 2013. The students do not just undertake (paid) mundane tasks such as making coffee; the ACP also arranges one-on-one meetings for them with physicists who are working in an area of the student’s special interest or who are from a university to which the student may apply. The high-school students leave the Center with greater enthusiasm for furthering their science education. A second outreach activity, also first introduced in 2012, is a monthly radio program on physics, broadcast on KDNK, a local community access station. It features a participating physicist being interviewed by high-school students, including past or current high-school 'go-fers'. This format allows the students to gain a deeper appreciation for who physicists are and what they do, and to encourage them to envisage themselves as physicists. Past programs are available on the web and as free podcasts in iTunes.

The Center has 75 general members, mostly senior scientists who volunteer their efforts to the Center for five-year terms. 16 (21%) are women. One focus is on using their knowledge of the scientific community to encourage organization of workshops

and conferences. The organizers themselves are predominantly not general members: 7 of the 54 workshop organizers in 2013 and 4 of the 25 conference organizers in 2014 were general members, with 44 general members participating in the summer program.

Specific Objectives: The specific objectives identified as essential to reaching the goal of the Aspen Center for Physics to nurture cutting-edge physics include:

(1) to free researchers from the usual constraints and distractions of their home institutions by the smooth administration of the logistics and facilities of the Center;

(2) to create each week, in both summer and winter, a community of outstanding researchers with related interests and complementary expertise;

(3) to encourage free discussion within this community to identify the most important unsolved problems and to explore creative ideas;

(4) to strengthen existing collaborations between researchers from different institutions and to promote the formation of new collaborations;

(5) to choose summer colloquium speakers who can clearly convey the ideas and importance of the work in their area to their nonspecialist fellow participants at the Center, and

(6) to stimulate and energize the passion for science that drives the most inspiring and successful researchers, mentors and teachers.

The specific objective identified as essential to reaching the goals of the Aspen Center for Physics in outreach to the public is to recruit public lecturers, dialogue hosts and kids' barbeque speakers who combine a record of outstanding accomplishment in their field with the gift of making science come alive for the layperson.

Significant Results: The major scientific results from the activities supported under this NSF grant are the 385 published research papers and 180 preprints, conference proceedings and book chapters resulting from participation in the ACP programs, appearing during this reporting period and citing this NSF grant. These are reported as pdf files in the 'Products' section of this report. Highlights include (note the paper number is from the pdf file of refereed publications):

High Energy Physics #24: "Buckets of Tops," M. R. Buckley, T. Plehn and M. Takeuchi, Journal of High Energy Physics 8, 86 (2013)

Reconstructing hadronically decaying top quarks is a key challenge at the LHC, affecting a long list of Higgs analyses and new physics searches. We propose a new method of collecting jets in buckets, corresponding to top quarks and initial state radiation. This method is particularly well suited for moderate transverse momenta of the top quark, closing the gap between top taggers and traditional top reconstruction. Applying it to searches for supersymmetric top squarks we illustrate the power of buckets.

High Energy Physics #75: "Coupling a QFT to a TQFT and duality," A. Kapustin and N. Seiberg, Journal of High Energy Physics, 4:1 April 2014.

We consider coupling an ordinary quantum field theory with an infinite number of degrees of freedom to a topological field theory. On $\mathbb{R}d$ the new theory differs from the original one by the spectrum of operators. Sometimes the local operators are the same but there are different line operators, surface operators, etc. The effects of the added topological degrees of freedom are more dramatic when we compactify $\mathbb{R}d$, and they are crucial in the context of electric-magnetic duality. We explore several examples including Dijkgraaf-Witten theories and their generalizations both in the continuum and on the lattice. When we couple them to ordinary quantum field theories the topological degrees of freedom allow us to express certain characteristic classes of gauge fields as integrals of local densities, thus simplifying the analysis of their physical consequences.

Astrophysics #15: "Signatures of Cool Gas Fueling a Star-Forming Galaxy at Redshift 2.3," N. Bouche, et al, Science, 341:50-53, 2013

The high rates of star formation in high-redshift galaxies require the gas in those galaxies to be continuously replenished by accretion from the surrounding intergalactic medium. Such cold, accreting gas is difficult to see directly. This paper reports observations of gas accreting onto a distant galaxy inferred from the fact that the gas absorbs light from a more distant quasar that happens to be near the line of sight to the galaxy. This work published in Science helps illuminate the early evolution of galaxies.

Astroparticle Physics #2: "Cosmologically Safe eV-Scale Sterile Neutrinos and Improved Dark Matter Structure," B. Dasgupta and J. Kopp, Phys. Rev. Lett. 112(3):031803, 2014

Some short-baseline neutrino oscillation results have been interpreted as possible evidence for light, sterile neutrinos. However, cosmological constraints disfavor eV-scale sterile neutrinos. This paper shows that if such sterile neutrinos interact via a light boson in a hidden sector, then oscillations between ordinary and sterile neutrinos in the early universe are suppressed, and the cosmological bounds can be satisfied. If such a hidden-sector boson also couples to dark matter particles, it could have interesting implications for structure formation.

Condensed Matter #42: "Spin-Orbit Coupling and Quantum Spin Hall Effect for Neutral Atoms without Spin Flips," C. J. Kennedy, G. A. Siviloglou, H. Miyake, W. C. Burton, and W. Ketterle. Physical Review Letters, 111(22):225301, November 2013.

We propose a scheme which realizes spin-orbit coupling and the quantum spin Hall effect for neutral atoms in optical lattices without relying on near resonant laser light to couple different spin states. The spin-orbit coupling is created by modifying the motion of atoms in a spin-dependent way by laser recoil. The spin selectivity is provided by Zeeman shifts created with a magnetic field gradient. Alternatively, a quantum spin Hall Hamiltonian can be created by all-optical means using a period-tripling, spin-dependent superlattice.

Condensed Matter #63: "Magnetic Field Induced Transition in Vanadium Spinels," E. D. Mun, G.-W. Chern, V. Pardo, F. Rivadulla, R. Sinclair, H. D. Zhou, V. S. Zapf, and C. D. Batista. . Physical Review Letters, 112(1):017207, January 2014.

We study vanadium spinels AV(2)O(4) (A = Cd, Mg) in pulsed magnetic fields up to 65 T. A jump in magnetization at mu H-0 approximate to 40 T is observed in the single-crystal MgV2O4 , indicating a field induced quantum phase transition between two

distinct magnetic orders. In the multiferroic CdV_2O_4, the field induced transition is accompanied by a suppression of the electric polarization. By modeling the magnetic properties in the presence of strong spin-orbit coupling characteristic of vanadium spinels, we show that both features of the field induced transition can be successfully explained by including the effects of the local trigonal crystal field.

Biophysics #5: "Physics of biofilms: the initial stages of biofilm formation and dynamics." G. Lambert, A. Bergman, Q. Zhang, D. Bortz, and R. Austin, New Journal of Physics, 16(4):045005, April 2014.

One of the physiological responses of bacteria to external stress is to assemble into a biofilm. The formation of a biofilm greatly increases a bacterial population's resistance to a hostile environment by shielding cells, for example, from antibiotics. In this paper, we describe the conditions necessary for the emergence of biofilms in natural environments and relate them to the emergence of biofilm formation inside microfluidic devices. We show that competing species of Escherichia coli bacteria form biofilms to spatially segregate themselves in response to starvation stress, and use in situ methods to characterize the physical properties of the biofilms. Finally, we develop a microfluidic platform to study the inter-species interactions and show how biofilm-mediated genetic interactions can improve a species' resistance to external stress.

Key outcomes or Other achievements:

From excerpts of the exit reports of individual participants, we present evidence of the Center's continued success in achieving its specific objectives and more broadly in reaching its major goals.

(1) The Center is successful in freeing researchers from the distractions of their home institutions to concentrate on challenging scientific problems or major projects.

Giuseppina Fabbiano: I've had plenty of time to concentrate on my research and push forward a few papers. Somehow things that seem challenging when one has to juggle the many tasks of normal work life (science, management, committees, mentoring/teaching) seem to become clear in Aspen.

Sabine Kraml: It was very beneficial indeed to have plenty of "leisurely" time to discuss and develop new ideas--both, within our small working group and with other people--without being haunted by bureaucracy, administrative meetings, or the need of putting some paper out quickly. As the year before, I got plenty of ideas and new motivation in Aspen.

Alexander Grosberg: It was my first experience in Aspen as an individual researcher, and it turned out incredibly fruitful. Being essentially alone, I concentrated on the book project which otherwise progresses very slowly, and I made a big progress, if not a breakthrough, on writing the book; more than a half of it is now written and ready to go.

(2) The Center creates each week, in both summer and winter, a community of outstanding researchers with related interests and complementary expertise.

David Sept: This was once again the highlight of my year and one of the best scientific experiences I have ever had. I was able to interact with a very diverse group of scientists, including physicists, mathematicians, and biologists.

James Bosch: I came away from the meeting having held in-depth discussions (and/or

having gone on strenuous hikes!) with a lot of people who were only names to me before, and a lot of these people are doing work similar to mine. It's simply a lot easier to initiate new communication and collaboration with people after you've gotten to know each other, and Aspen was superb at facilitating that.

(3) The atmosphere and organization of the Center encourage free discussion within this community to identify the most important unsolved problems and to explore creative ideas;

Andrew Hearin:The discussions and interactions I had with the scientists here were invaluable, and because some of these discussions took place over many days I think my progress was dramatically enhanced by the extended format of the workshop.

Diederick Kruijssen: It was a real pleasure to see the vibrant interaction between the participants. All around new projects and collaborations were springing to life. This was facilitated by the unrivalled environment provided by the ACP. From the early morning to the late afternoon, the participants of our workshop could be found discussing their work in the alcoves, out in the patio, in the picknic area, around random blackboards, and in their offices.

Kevin Bundy: The conversations also turned more fantastic at times, evolving into brainstorming sessions about future instrumental capabilities and the ability to probe unexplored physics.

David Schaich: The fourth project was an unexpected and somewhat serendipitous development. George Fleming proposed a promising new technique for modeling topological charge fluctuations in lattice gauge theory calculations, which has proven to be a tricky issue for lattice studies of strongly-coupled physics beyond the standard model. I worked on this with George, Ethan Neil, Michael Cheng, Meifeng Lin and Rich Brower, who all put a lot of effort into developing this idea, and made significant progress in a short time. The serendipity was that George's initial proposal was inspired by some work of biophysicist Phil Nelson, with whom I shared at office at Aspen, by sheer coincidence.

(4) The Center is successful in strengthening existing collaborations between researchers from different institutions and in promoting the formation of new collaborations.

Eric Keto: We had not been able to put together the right scientific team for this project, until the Aspen meeting. There I found that Diederik Kruijssen and Steve Longmore have recently made the Galactic center the main topic of their own research. They joined our project. John Bally, also at the meeting, also joined, and we were able to formulate a list of the significant scientific questions that the observations with the SMA could address. This project is moving forward.

Scott Dodelson: The projects are spread around the world so require communication (and trust) among the collaboration members, especially those in leadership roles. I am convening working groups in both of those projects and need to interact frequently with other conveners, in this case Bhuv Jain and Sarah Bridle. The 3 of us spent long evenings together forging personal bonds that will help us work together in the future. There is absolutely no other place this could have happened, so yet another trophy that Aspen should add to its collection is its ability to help large collaborations work

efficiently.

Masahito Ueda: With Hiroshi Ooguri and Tetsuo Hatsuda, I have discussed the problem related to axions. The subject is not in my field, and such a scientific collaboration would not have been possible, if I did not come to Aspen. It is a fruitful collaboration of three people working in different fields.

(5) to choose summer colloquium speakers who can clearly convey the ideas and importance of the work in their area to their nonspecialist fellow participants at the Center.

Graeme Segal: The colloquium talk by Simon White on the latest experimental results in cosmology was outside the circle of things I usually think about, but it made me realize to what precision it is known that space-time is flat on the very largest scale, and I later had a very interesting conversation about this with Jacques Distler which fed into my interest in quantum gravity.

(6) The experience of working at the Center stimulates and energizes the passion for science that drives the most inspiring and successful researchers, mentors and teachers.

Matthew Benaquista: The Aspen Center is one of the ways that I can recover the simple joy of working on interesting physics problems without engaging in the administrative tasks that are required by the academic world.

Lee Armus: Most conferences and workshops these days are extremely tiring affairs, with jam-packed schedules and very little time to reflect on results and their implications. You move from one talk to the next, most in darkened rooms watching power-point presentations flash by endlessly. By the end I'm usually drained and in need of a long break. Aspen is exactly the opposite. In Aspen, the pressure and formality of a typical meeting is replaced with blackboard discussions, small gatherings under the trees, and hikes along the river. It's during those quiet moments, when my mind is free to wander, that I find I can get excited again about doing research.

The involvement of participants in public outreach activities adds to their positive experience at the Center. Exit reports include:

Jose Lorenzana: I also enjoyed very much a Kids talk I delivered on the difference between Complex and Complicated systems. A group of children telling me at the ice cream shop that they enjoyed the talk was a highly rewarding experience.

Karen Hallberg: I gave a talk at the Kid's BBQ on the passion of science, inspiration, lateral thinking for completely new concepts (with examples on counter intuitive ideas like magnetic monopoles and equal charge attraction like in superconductivity), and ethics in science to an overcrowded patio. I also encouraged students with Latin origin to discuss with me in Spanish and this was fun and introduced an international and multicultural component to the talk. Our common Spanish language also allowed me to meet Jose (one of the interns).

*** What opportunities for training and professional development has the project provided?**

The project does not include formal training or professional development activities. However, the ACP programs bring

together physicists at all stages of their careers. In particular, during the summer program, postdoctoral researchers and junior faculty interact with more experienced senior researchers in shared offices and at the lunch table as well as in the organized talks and discussions, benefiting from informal advice, and from the personal relationships and collaborations thus formed. This is described in more detail in the Impacts section on human resources. In summer 2013, 19% of the participants were postdocs, 13% were assistant professors and 30% of the participants were 'first-timers'.

*** How have the results been disseminated to communities of interest?**

The results of the research undertaken by visiting physicists at the ACP have been disseminated to the international physics community through the 385 peer-reviewed journal articles and 180 preprints, book chapters and conference proceedings listed in the pdf files under 'Products'. During the Summer program, the background and context of the physics problems being discussed at the workshops and progress made are disseminated to the other Summer participants through weekly colloquia held at the ACP. The list of colloquia from Summer 2013 is given in an attached pdf file (Colloquia2013.pdf).

The dissemination of activities at the Center through outreach has been described above in the Major Activities section, and in the attached file (outreach2013-2014.pdf). In addition to the live events, films of the public lectures and TV interviews with the public lecturers are made available in a video archive on the internet, and interviews with participating physicists are broadcast monthly on a local radio station KDNK and are available on the web and as free podcasts in iTunes.

This outreach included several activities involving local high school students, recently developed and initiated with the aim of strengthening their interest in learning and careers in physics. ACP asked teachers of advanced physics classes to recommend their students as possible 'go-fers' at the ACP, during the summer months. ACP hosted 12 such students in 2013. The students do not just undertake (paid) mundane tasks such as making coffee; the ACP also arranges one-on-one meetings for them with physicists who are working in an area of the student's special interest or who are from a university to which the student may apply. The high-school students leave the Center with greater enthusiasm for furthering their science education. We also continued our monthly radio program on physics, broadcast on KDNK, a local community access station. This broadcast is aimed at high school students, and consists of a participating physicist being interviewed by high-school students recommended by their physics teachers, including past or current "go-fers". The questioners are tasked with investigating the research undertaken by the physicist being interviewed and to base their questions on their findings. This format allows the student interviewers and audience to gain a deeper appreciation for who physicists are and what they do, with the hope that they can envisage themselves as physicists.

*** What do you plan to do during the next reporting period to accomplish the goals?**

ACP plans another summer of stimulating and topical workshops across many sub-fields of physics, complemented by cutting-edge winter conferences. The schedules of these are as follows:

Summer Workshops 2014
Dwarf Galaxies as Cosmological Probes, May 25 - June 15
Modern Trends in Quantum Magnetism, May 25 - June 22
Bacteria Meet Physics II, June 1 - June 22
Ultra-Compact Binaries as Laboratories for Fundamental Physics, June 8 - June 29
Fast and Furious: Understanding Exotic Astrophysical Transcients, June 15 - July 6
Connecting Flavor Physics with Naturalness: from Theory to Experiment, June 22- July 20
Emergent Spacetime in String Theory, July 6 - August 3
Combining Probes in Cosmological Surveys, July 20 - August 10
Model Building in the LHC Era, August 3 - August 31
Gauge Fields in Condensed Matter, Ultracold Atoms and Beyond, August 10 - September 7
Many-Body Quantum Systems Far from Equilibrium, August 10 - August 31
The Galaxy-Halo Connection Across Cosmic Time, August 24 - September 14
Radiation Driven Outflows in Stars and Quasars, August 31 - September 14

Winter Conferences 2015
Single-Molecule Biophysics, January 4-8
Microscale Ocean Biophysics, January 11-15
Black Holes in Dense Star Clusters, January 17-21
Exploring the Physics Frontier with Circular Colliders, January 24-28
Unifying Concepts in Glass Physics, February 1-5
Progress and Applications of Modern Quantum Field Theory, February 16-20
Closing in on the Cosmological Model, March 8-12
Non-Equilibrium Quantum Matter, March 23-27

The Aspen Center for Physics also plans to continue its established outreach activities.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
summerworkshops2013.pdf	List of summer 2013 workshops, including dates, organizers, and number of participants	Karin Rabe	06/22/2014
winterconf2014.pdf	List of winter 2014 conferences, including dates, organizers and number of participants	Karin Rabe	06/22/2014
Colloquia2013.pdf	List of summer 2013 colloquia, including dates, titles and speakers	Karin Rabe	06/24/2014
outreach2013-2014.pdf	List of outreach activities: public lectures, dialogs, Physics is for Kids, and Radio Physics	Karin Rabe	06/24/2014

Products

Books

Book Chapters

Conference Papers and Presentations

Inventions

Journals

Licenses

Other Products
Audio or Video Products.

All public lectures are videoed and shown on local television. Links to the videos are given on the ACP website next to the listing of the lecture. Radio Physics programs are available on the KDNK website and as free podcasts in iTunes.

Audio or Video Products.

Clifford Johnson, a General Member of the Aspen Center for Physics and Professor of Physics at the University of Southern California, created a short video describing the history and present activities of the ACP. This is available through the ACP website http://www.aspenphys.org/aboutus/index.html.

Other Publications

ACP Participants (2013). *Preprints, conference proceedings, and book chapters*. List of preprints, conference proceedings, and book chapters acknowledging the Aspen Center for Physics and federal support is provided in attached file. Status = SUBMITTED; Acknowledgement of Federal Support = Yes

ACP Participants (2013). *Published papers*. List of published papers acknowledging the Aspen Center for Physics and federal support is provided in attached file. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

Aspen Center for Physics website
http://www.aspenphys.org

This is the home page of the Aspen Center for Physics and contains links to all of the NSF-supported activities, both for the public and for physicists. The web pages were thoroughly revamped and updated in 2012 and are regularly updated and expanded.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
ref-v4.pdf	Published papers (attached file as described in list of products)	Karin Rabe	07/01/2014
nonref-v4.pdf	Preprints, conference proceedings, and book chapters (attached file as described in list of products)	Karin Rabe	07/01/2014

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Wyse, Rosemary	PD/PI	1
Rabe, Karin	Co PD/PI	1

Full details of individuals who have worked on the project:

Rosemary F Wyse

Email: wyse@pha.jhu.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: President of the Aspen Center for Physics through July 8, 2013; responsible for coordinating the activities of the Center and ensuring continuity in the transition to a new President

Funding Support: none

International Collaboration: No
International Travel: No

Karin Rabe
Email: rabe@physics.rutgers.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: President of the Aspen Center for Physics as of July 9, 2013, with the primary responsibility for coordinating the activities of the Center

Funding Support: none

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?
Nothing to report.

Have other collaborators or contacts been involved? Yes

Impacts

What is the impact on the development of the principal discipline(s) of the project?

The research and resulting findings of the participants in the ACP programs cover all subfields of physics, including high energy, astrophysics, condensed matter and biological physics. Thus the impacts on the discipline of physics, broadly defined, are many and varied. Arguably the most important impact made on the base of knowledge and technique in physics is the cross-fertilization of ideas achieved through the informal discussions fostered by the summer programs at ACP, with simultaneous workshops in diverse topics. Established techniques from one field of physics can, and do, find novel applications in another. Interinstitutional and international collaborations were created and/or strengthened during summer 2013, as described in participants' exit reports.

The fostering of interactions across subfields of physics was illustrated in summer 2013 by the workshop "Dark Matter in Galaxies, the LHC and Direct and Indirect Searches." The purpose of this workshop was to bring together theorists and experiments working on understanding the nature of dark matter from a variety of approaches, including direct, indirect, and collider searches, as well as using astrophysical observations and simulations. A notable characteristic of this workshop was the interdisciplinary attendance. Participant comments include:

Julio Navarro: The workshop was organized as an attempt to bring together specialists on three different (and sometimes divergent!) fields of research on the nature of dark matter. One group consisted mainly of astrophysicists/cosmologists, a

second group of particle physics phenomenologists, and a third included experimentalists and theorists working at CERN's Large Hadron Collider. I have seldom attended a workshop or conference where the same topic was addressed by such a diverse group of scientists with different expertise, all united by the same goal: to understand the nature of dark matter, that elusive glue that holds galaxies together and rules the clustering of matter in the Universe. The workshop contained, for me at least, a number of surprises. I was interested to learn how seriously results from one discipline are taken in another, although those same results might be considered to be on "shaky grounds" by experts of the former. At the same time, it was refreshing to see how keen people from one discipline were to learn from others.

Other workshops promote interactions between groups of researchers working on different aspects of a particularly important problem or set of problems in physics. Excerpts from summer 2013 exit reports follow:

Frank Bigiel ("Milky Way"): The participants represented an ideal mixture between astronomers studying star formation in the Milky Way and in other galaxies. Focusing on extragalactic studies myself, I had many fruitful conversations with Milky Way observers about how to reconcile latest results from studying individual star forming regions in our own galaxy and large-scale star formation in other galaxies.

Bradley Whitmore ("Stellar Clustering")
The galactic and extragalactic star clusters communities are largely disjoint. One of the primary goals of the workshop was to promote interaction between the two groups and I think this was very successful.

Tim Eifler ("The Next Decade of Weak Lensing Science"): The Weak Lensing community is currently preparing for several surveys that will observe different parts of the sky with different telescopes over the next 5 years. To conduct these surveys several large collaborations have formed, however cross-talk between these collaborations is, despite common challenges, rare. The ACP workshop was one of these rare opportunities to have in-depth discussions with the experts from other collaborations. I want to emphasize that these discussions enabled an information exchange that went far beyond the usual sketchy presentations/discussions at conferences.

Anton Vorontsov ("Many Body") This workshop brought together many researchers from close but not necessarily overlapping fields, and gave me opportunity to see new sides and new possible directions of my research too.

Another mode in which research interactions are developed is by sequencing or overlapping two or more workshops on topics with common threads. Three examples from summer 2013 are the overlapping of the "Quantum Condensed Matter" and "Superconformal Field Theory" workshops, the "Optical Lattice Emulators" and "LHC Higgs-like Signals" workshops and the "LHC Higgs-like Signals" and "Dark Matter" workshops. Three excerpts from relevant exit reports follow.

Michael Freedman: In July 2013 I was fortunate to be able to participate in both a condensed matter workshop and in the string theory/ higher category program. Astonishingly, Sergey Gukov from the string point of view had discovered a classification of abelian quantum Hall edge theories recently worked out on the condensed matter side by Chetan Nayak and Mike Mulligan. I had considerable fun linking the two approaches.

Tetsuo Hatsuda: The mixture of condensed matter physicists and high energy physicists at the same place at the same time was quite nice to learn many things with each other. I learned both the current status of the experiments in cold atoms and also the current status of Higgs boson from various workshop talks.

Antonio Masiero: During my stay I could take part in two workshops, one devoted to LHC physics and the prospects for new physics beyond the Standard Model, the other focused on direct and indirect searches of Dark Matter and its possible production at the LHC. My experience to have two workshops with various points in common overlapping for the whole two weeks of my stay at the ACP was very positive : frequent and fruitful discussions with participants to both workshops were even more stimulating than usual.

Another important impact of workshops is the bringing together of experimentalists and theorists to focus on cutting-edge problems in a particular field. observers and theorists in astrophysics, experimentalists and theorists in condensed matter,

and especially timely, high-energy experimentalists and phenomenologists for discussion of results from the LHC. Excerpts from exit reports follow.

Frank Bigiel ("Milky Way"): Another major advantage in my view was to bring together theorists and observers/experimentalists. I found it quite stimulating to see latest models and theories confronted with the observations, which triggered many very interesting discussions and ideas for new projects. This was triggered in particular by the discussion sessions, which were frequent enough to stimulate further, more detailed discussions while leaving enough room during the week to achieve progress with the actual data analysis I was working on at that time.

Ajay Gopinathan (organizer, "Functional Biological Assemblies"): Our aim was to bring together theoretical physicists, experimental biophysicists and cell biologists in an effort to jointly identify current theoretical and computational challenges in this area, as well as key questions that need to be addressed by quantitative, physics-based experiments.

Aurelio Juste ("Implications of LHC Higgs-like Signals"): I am personally quite interested in this type of workshops where a lot of interaction between experimentalists and theorists is possible, and this one has not disappointed me.

Matthew Bothwell ("Obscured Universe") The chance to sit down with a mixed group of theorists and observers was hugely useful, and has massively increased my knowledge of the field.

What is the impact on other disciplines?

Scientists whose primary disciplines are outside physics are increasingly participating in the programs at ACP. The 2014 winter conference program included "Active Fluids: Bridging Complex Fluids and Biofluids." The summer 2013 program included one workshop with an impact on biology, and one on physical mathematics. The purpose of the `Physics of Functional Biological Assemblies: Pushing, Pulling and Sensing' workshop was to bring together theoretical physicists, experimental biophysicists and cell biologists in an effort to jointly identify current theoretical and computational challenges in this area, as well as key questions that need to be addressed by quantitative, physics-based experiments. The participants came from diverse departments including Bioengineering, Biochemistry, Molecular Biology and Biophysics, Mechanical Engineering, Chemical Engineering, Molecular Biology, Materials Science, Chemistry, Biological Sciences, Cell Biology and Physiology as well as Physics. Indeed, fully 40% (16/40) of the participants in that workshop were from departments without `physics' in the name. The purpose of the "Mathematics of Superconformal Field Theory" workshop was to bring together people working on different approaches to superconformal field theory in diverse dimensions, which is a topic of current significant activity in both the math and physics communities. One quarter (12/48) of the participants were from mathematics departments.

Comments from exit reports relating to the impact of these programs include:

KC Huang: Many of the interesting interactions came from having this broad spectrum of scientists, covering experiment, theory, and computation… One of the great strengths of the Aspen Center workshops is the bringing together of such a diverse group (in our case, biophysicists and a microscopist) that can communicate on one topic.

Douglas Weibel
The Physics of Functional Biological Assemblies workshop consisted of a combination of experimentally and theoretically-oriented physical scientists studying the mechanics of cells. There was no single physical focal point in the workshop; instead a large group of scientists focused on describing the mechanics of eukaryotic cells and sub-cellular components. A separate group focused on related questions in the area of microbiology. The cross-pollination of concepts between the groups provided opportunities for integrating new theory and biophysical experiments, and the research discussed by participants focused on science that was particularly new and exciting.

Graeme Segal (mathematician)
The profit to me of all my visits to Aspen has come from what I learned of current thinking in various areas of physics, and of ideas for future work it has suggested to me, and this visit was no exception.

Nicholas Read (physicist)
The presence of mathematicians at the Center during this period made it particularly attractive for me.

What is the impact on the development of human resources?

The ACP programs bring together physicists at all levels and facilitate interactions between them, for example through shared offices. This can, and does, create new life-long collaborations and friendships. In summer 2013, 72/561 participants (13%) were assistant professors and 109/561 (19.4%) were postdoctoral fellows. We actively seek first-time applicants and in summer 2013, 167/561 (30%) had not participated in prior years. In addition, 39/561 participants were NOT faculty members at universities, but rather staff members at government laboratories, observatories and industrial laboratories, and thus the junior researchers could discuss non-university careers. We include three excerpts from the exit reports of junior summer 2013 participants :

Tim Linden: I believe the Aspen Center for Physics provided a great environment for my research endeavors. The ability to communicate with senior researchers across multiple fields was extremely helpful to me, as a young scientist [2013 PhD].

Alexandra Abate: I am a postdoc who was a first time attendee at Aspen. It was a unique workshop, a great opportunity to be able to interact people with a diverse set of interests from within a specific field of study and provided an invaluable, unrivaled amount of face-time with other experts. Strongly encouraging participants to stay for the full 3 weeks allowed plenty of time for discussion.

Michael Hirsch: I had the chance to give a short presentation of my ongoing research on shape measurement calibration. I outlined the key questions and goals of my research, and also my pursued approach in tackling them. It triggered a rich and fruitful discussion on the topic and as an early career scientist [PhD 2012] I was more than pleased with the positive feedback I received from prominent senior scientists in the field. It not only encouraged me in my approach but was also an important source of renewed motivation for my research project.

The ACP actively encourages women and under-represented minorities to participate, and indeed requires that one member of the organizing committee of each workshop or conference be identified as responsible for ensuring diversity in the applicant pool for that workshop/conference. In addition, there is a separate Diversity Committee of the governing body (the General Members) of the ACP. The percentage of women in summer 2013 (19.6%) represents an increase over summer 2012 (18.6%). It is hoped that the success in increasing participation at the Center will help to increase participation in the physics community. Many years ago, Bernice Durand, an Honorary Trustee of the ACP, started the custom of a weekly lunch for all the women participants. This is an ideal forum for networking, exchanging experiences, and discussing work-life balance. Comments from exit reports include:

Premi Chandra: I also enjoyed the Women’s Lunch where I had the opportunity to talk with women physicists in a broad range of fields and to discuss our common/different experiments.

Barbara Jones: Of additional note was a wonderful luncheon with the other physics women at the Center.

Dragana Popovic: I also went to lunch once with the other women physicists. We had the most interesting conversation covering a broad range of issues. I just wish there were more opportunities for such discussions!

The sense of community developed in the summer program at the ACP can encourage discussions of unusual depth and substance. As described in the article "The ethical grey zone" (Nature 503, 427 (2013)) by participants Caitlin Casey and Kartik Sheth, at the "Obscured Universe" workshop in May 2013, a group of astronomers "informally discussed how to build a positive, healthy work environment and make our community more inviting and inclusive of under-represented groups." This led to further discussion and action: "In a subsequent session at the same meeting, we conducted a "scenario-sorting activity in in which astronomers were invited to discuss realistic situations involving the ethical ambiguities that our community faces every day: plagiarism, sexual harassment, hostile work environments, bullying, cultural clashes, unconscious biases and simple misunderstandings. Each scenario was printed on a slip of paper and handed to a participant, making sure that

everyone had a different situation to contemplate. We asked everyone to stand up and work together to organize their assigned scenarios, from the most desirable through acceptable, undesirable and unacceptable, to unethical. Once they had decided on the relative ranking, we discussed the scenarios as a group, exploring how participants with different backgrounds had made different judgements." This work was then extended to the astronomy community through Astrobetter (www.astrobetter.com), a blog with roughly 3,000 readers, and the results from 481 astronomers who completed the survey were reported in the above-mentioned article in Nature.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?
Nothing to report.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?

The outreach activites of the ACP reach beyond the academic world and are aimed to improve public appreciation and knowledge of cutting-edge physics (Public Lectures) and of physicists and how they think and work (the informal Dialogues, the Physics Cafes and Radio Physics).

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.