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Preview of Award 1066293 - Annual Project Report

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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:	Karin Rabe, Principal Investigator Joshua A Frieman, Co-Principal Investigator
Recipient Organization:	Aspen Center For Physics
Project/Grant Period:	10/01/2011 - 09/30/2016
Reporting Period:	10/01/2014 - 09/30/2015
Submitting Official (if other than PD\PI):	Karin Rabe Principal Investigator
Submission Date:	07/08/2015
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 2014, the Aspen Center for Physics hosted 543 leading international researchers from a broad range of institutions around the world. A total of 620 researchers participated in the winter 2015 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 cross-fertilization 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 2014 Summer Workshops are listed in an attached file (summer2014.pdf); topics included high-energy physics beyond the Standard Model, string theory, quantum magnetism, ultra-cold atoms, ultra-compact binary stars, and cosmological surveys. The quality of the researchers in the summer programs at the Center is ensured by a competitive admissions process. For summer 2014, 615 of 1048 applicants were offered admission, yielding 543 participants. Special attention was paid to including junior researchers (73 assistant professors, 121 postdocs, and eight 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 18 were from small universities (fewer than 3 physics PhDs annually). Participants need not be affiliated with a specific workshop: 12 different small working groups (62 physicists in total) were hosted, together with 35 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 2014 colloquia are reported in an attached file (summer2014.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 2015 is included in an attached file (winterconf2015.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 2015 winter participants, 115 (18.5%) were women.

The research activities of the Center spanned the fields of high energy physics, astrophysics, condensed matter physics, biological physics and related disciplines. In summer 2014, of a total of 43 workshop weeks, 12 weeks were in high energy physics, 17 weeks were in astrophysics (6 workshops), 11 weeks were in condensed matter physics (3 workshops), and 3 in biological physics (1 workshop). Of the eight winter conferences, one was in high energy physics, one was interdisciplinary, two were in condensed matter physics, two were in astrophysics and two were in biophysics. Of the 543 summer program participants, 160 (30%) were in high energy physics, 74 (14%) in strings and physical mathematics, 138 (25%) in astrophysics, 134 (25%) in condensed matter physics and 33 (6%) in biological physics. Of the 590 papers, conference proceedings, and book chapters citing the Center in the year starting July 1, 2014, 217 (37%) were in high energy physics/strings/physical mathematics, 200 (34%) were in astrophysics, 149 (25%) were in condensed matter physics and 24 (4%) were in biophysics.

In both summer 2014 and winter 2015, 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. The lectures 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 (outreach2014-2015.pdf). The Summer 'Physics is for Kids' Family Barbeques and the Physics Cafes are cohosted by the Aspen Science Center. 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 high-school student 'go-fer' program. ACP hosted 13 such students, recommended by their physics teachers, in summer 2014. 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. An additional outreach activity 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 76 general members, mostly senior scientists who volunteer their efforts to the Center for five-year terms (generalmembers.pdf). 18 (24%) 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: 5 of the 49 workshop organizers in summer 2014 and 4 of the 28 conference organizers in winter 2015 were general members, with 47 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 439 published research papers and 151 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 and Physical Mathematics #45: "Complementarity between nonstandard Higgs boson searches and precision Higgs boson measurements in the MSSM," M. Carena, H. E. Haber, I. Low, N. R. Shah, and C. E. M. Wagner. Phys. Rev. D 91, 035003 (2015).

Precision measurements of the Higgs boson properties at the LHC provide relevant constraints on possible weak-scale extensions of the Standard Model (SM). In the context of the minimal supersymmetric Standard Model (MSSM) these constraints seem to suggest that all the additional, non-SM-like Higgs bosons should be heavy, with masses larger than about 400 GeV. This article shows that such results do not hold when the theory approaches the conditions for "alignment independent of decoupling," where the lightest CP-even Higgs boson

has SM-like tree-level couplings to fermions and gauge bosons, independently of the nonstandard Higgs boson masses.

High Energy Physics and Physical Mathematics #30: "Elliptic Genera of 2d=2 Gauge Theories," F. Benini, R. Eager, K. Hori, and Y. Tachikawa, *Comm. Math. Phys.* 333, 1241 (2015).

We compute the elliptic genera of general two-dimensional and gauge theories. We find that the elliptic genus is given by the sum of Jeffrey-Kirwan residues of a meromorphic form, representing the one-loop determinant of fields, on the moduli space of flat connections on $T(2)$. We give several examples illustrating our formula, with both Abelian and non-Abelian gauge groups, and discuss some dualities for $U(k)$ and $SU(k)$ theories.

Astrophysics #19: "Simulations of Ion Acceleration at Non-relativistic Shocks. II. Magnetic Field Amplification." D. Caprioli and A. Spitkovsky. *ApJ*, 794, 46 (2014).

We use large hybrid simulations to study ion acceleration and generation of magnetic turbulence due to the streaming of particles that are self-consistently accelerated at non-relativistic shocks. When acceleration is efficient, we find that the upstream magnetic field is significantly amplified. The total amplification factor is larger than 10 for shocks with Alfvénic Mach number $M = 100$, and scales with the square root of M . The spectral energy density of excited magnetic turbulence is determined by the energy distribution of accelerated particles, and for moderately strong shocks ($M < 30$) agrees well with the prediction of resonant streaming instability, in the framework of quasilinear theory of diffusive shock acceleration.

Astrophysics #68: "Galactic Center Excess in Gamma Rays from Annihilation of Self-Interacting Dark Matter," M. Kaplinghat, T. Linden, and H.-B. Yu. *Phys. Rev. Lett.*, 114, 211303 (2015).

Observations by the Fermi Large-Area Telescope have uncovered a significant gamma-ray excess directed toward the Milky Way Galactic Center. There has been no detection of a similar signal in the stacked population of Milky Way dwarf spheroidal galaxies. Additionally, astronomical observations indicate that dwarf galaxies and other faint galaxies are less dense than predicted by the simplest cold dark matter models. We show that a self-interacting dark matter model with a particle mass of roughly 50 GeV annihilating to the mediator responsible for the strong self-interaction can simultaneously explain all three observations.

Condensed Matter Physics #56: "Observation of Majorana fermions in ferromagnetic atomic chains on a superconductor.," S. Nadj-Perge, I. K. Drozdov, J. Li, H. Chen, S. Jeon, J. Seo, A. H. MacDonald, B. A. Bernevig, and A. Yazdani, *Science* 346, 602 (2014).

Majorana fermions are predicted to localize at the edge of a topological superconductor, a state of matter that can form when a ferromagnetic system is placed in proximity to a conventional superconductor with strong spin-orbit interaction. With the goal of realizing a one-dimensional topological superconductor, we have fabricated ferromagnetic iron (Fe) atomic chains on the surface of superconducting lead (Pb). Using high-resolution spectroscopic imaging techniques, we show that the onset of superconductivity, which gaps the electronic density of states in the bulk of the Fe chains, is accompanied by the appearance of zero-energy end-states. This spatially resolved signature provides strong

evidence, corroborated by other observations, for the formation of a topological phase and edge-bound Majorana fermions in our atomic chains.

Condensed Matter Physics #79: "Defining and detecting quantum speedup," T. F. Ronnow, Z. Wang, J. Job, S. Boixo, S. V. Isakov, D. Wecker, J. M. Martinis, D. A. Lidar and M. Troyer, *Science* 345, 420 (2014).

The development of small-scale quantum devices raises the question of how to fairly assess and detect quantum speedup. Here, we show how to define and measure quantum speedup and how to avoid pitfalls that might mask or fake such a speedup. We illustrate our discussion with data from tests run on a D-Wave Two device with up to 503 qubits. By using random spin glass instances as a benchmark, we found no evidence of quantum speedup when the entire data set is considered and obtained inconclusive results when comparing subsets of instances on an instance-by-instance basis. Our results do not rule out the possibility of speedup for other classes of problems and illustrate the subtle nature of the quantum speedup question.

Biological Physics #11: "How a well adapted immune system is organized," A. Mayer, V. Balasubramanian, T. Mora and A. M. Walczak, *PNAS* 112, 5950 (2015).

The repertoire of lymphocyte receptors in the adaptive immune system protects organisms from diverse pathogens. A well-adapted repertoire should be tuned to the pathogenic environment to reduce the cost of infections. We develop a general framework for predicting the optimal repertoire that minimizes the cost of infections contracted from a given distribution of pathogens. The theory predicts that the immune system will have more receptors for rare antigens than expected from the frequency of encounters; individuals exposed to the same infections will have sparse repertoires that are largely different, but nevertheless exploit cross-reactivity to provide the same coverage of antigens; and the optimal repertoires can be reached via the dynamics of competitive binding of antigens by receptors and selective amplification of stimulated receptors. Our results follow from a tension between the statistics of pathogen detection, which favor a broader receptor distribution, and the effects of cross-reactivity, which tend to concentrate the optimal repertoire onto a few highly abundant clones. Our predictions can be tested in high-throughput surveys of receptor and pathogen diversity.

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.

T. Prince

For a person like me who has significant administrative responsibilities at my home institution, I highly value the Aspen experience. It is one of the few times that I can dedicate myself to my research and take the time to think in depth about various aspects.

C. Heymans

The Aspen Centre for Physics is an oasis of calm in the otherwise busy life of an academic. My stay this summer has been the first time in a long while that I've

had the space to think and dream up new ideas, stimulated by enlightening conversations with my colleagues. This is in contrast to the day-to-day university life where thoughts are constantly interrupted by admin and teaching etc etc!

J. Xavier

The Center for Physics provides a rare solace to academics who these days seem to spend most time rushing to make the next grant deadline. I could hear myself think there, which is something I had forgotten was possible.

A. Adams

This summer I focussed on finishing a series of projects which each needed a large chunk of uninterrupted attention and effort (something nearly impossible to arrange at home).

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

S. Raju

This workshop [Emergent Spacetime] was extremely useful since it got together a collection of participants with diverse interests, all of whom had interesting perspectives on this problem.

F. Mila

Thanks to the relaxed atmosphere and to the presence of many colleagues also interested in quantum magnetism, I have been able to achieve much more than I expected, and I came back home full of ideas and enthusiasm.

S. Mukerjee

My primary motivation for attending the workshop was to have discussions and possibly strike up collaborations with experts from around the world working in the broad field of gauge fields in many body systems. I could not have asked for a better roster of participants than the one during my three weeks in Aspen.

(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;

M. Kilic

The informal discussions in these workshops [Ultra-Compact Binaries and Fast and Furious] were excellent. I liked how ~20 people got together and brainstormed on the latest questions in the field to try to make progress. I liked the level of the discussion, as it was made accessible to all the participants. It was the most intellectually satisfying workshop that I have ever attended.

J. Xiao

The talk is very informal, and the small audience allows intimate and most direct discussions. The number, breadth, and depth of questions being asked at these sessions far exceeded any other meetings or seminars I have attended to. It is highly stimulating.

M. Watson

Each individual contributed a unique perspective that collectively enhanced the supportive culture of the Center's work environment. I am particularly appreciative of the manner in which relevant feedback was sought and given. Everyone was encouraging to each other, and I felt comfortable sharing my thoughts and opinions.

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

E. Tollerud

This visit to Aspen was useful for accomplishing one of my primary goals: cementing a collaboration with A. Wetzels and D. Weisz.

E. Murphy

By having actual face-to-face time with my collaborators in this group, I was able to learn about a number of interesting projects that they have started to work on. Consequently, we were able to spearhead a number of new and exciting science projects that otherwise would have been missed.

K. Spekkens

The biggest benefit of the workshop for me, however, were the new collaborations that I forged with colleagues that I had not previously met.

B. Czech

This interaction with a knowledgeable mathematician (Michael Freedman) who was able to identify and explain the branch of formal mathematics underlying my current work would have been unlikely anywhere other than the Aspen Center for Physics.

N. Liebeskind

My time in Aspen was spent discussing with various people I had never had the opportunity to converse with before. These conversations led to three completely new projects with scientists I had never worked with, on three wholly different projects.

(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.

M. Oshikawa

As it is always the case in Aspen, colloquia gave me unique opportunities to learn about the frontiers in different fields of physics. I enjoyed both "Solving the 'Small Scale Crisis' of Cold Dark Matter" by Alyson Brooks, and "Life at High Reynolds Number" by David Nelson, which were excellent and informative.

A. Castro

I enjoyed very much the two colloquium that I attend while there. The speakers

were C. Heymans and H. Peiris. Both speakers were exceptional!

M. Cazalilla

I greatly enjoyed the Colloquia that I attended, including the one given by Pepi Fabbiano on the Chandra X-ray observatory, which was full of amazing images and impressive data about the high-energy phenomena occurring in our universe.

P. Nelson

I was totally overwhelmed by Murname's colloquium, which introduced me to an entire continent of physics I did not know existed.

(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.

Rachael Beaton

Moreover, the opportunity to discuss -- over an extended period of time! -- ideas with scientists studying similar projects was invaluable for renewing my excitement for my chosen field. As an advanced graduate student, I desperately needed the peace and quiet provided by the Aspen Center for Physics to just think and reflect. This opportunity has been very powerful to remind me what I value about my field -- discussion, interactions, and ideas! -- and how rewarding it is to be surrounded by smart and stimulating individuals!

Adrian Bevan

This workshop has helped energise me, generate a number of new ideas that I need to explore more fully, and organise a number of loose strands of thought that I have been gathering the past few years.

Matthew Benaquista

The Aspen Center is one of the ways I maintain my joyous curiosity about the universe. I love learning new things or learning new ways of understanding things I already know. Nearly everyone at the ACP is also happy to be there, and being surrounded by people who are curious to learn new things and passionate about explaining what they have learned is a way to keep up the enthusiasm for physics during the rest of the year.

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

S. Su

On June 24, Tuesday, I had a radio interview with high school gofers at radio KDNK in Carbondale, discussing my research area as well as my research career with 3 high school students. I enjoyed it quite a lot.

R. Harnik

I also enjoyed leading a lecture on dark matter as part of the physics for kids series. I particularly enjoyed getting questions from the kids and the excellent interns. This was my first experience with this activity and I look forward to doing it again in the future.

F. Cordero

I dearly enjoyed the Scientific Street Fair in which I volunteered for a couple of hours in the ACP stand.

*** 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 housing 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 on Human Resources section. In summer 2014, 22% of the participants were postdocs, 13% were assistant professors and 38% of the participants were 'first-timers'.

POSTDOC MENTORING: The Center works to further the career development of postdoctoral researcher participants by encouraging workshop and conference organizers to give opportunities to junior researchers to present their work. As described above, during the summer program, postdoctoral researchers interact with more experienced senior researchers in shared offices and housing 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 on Human Resources section. These efforts by the Center are intended to complement and enhance the mentoring received by each individual postdoctoral researcher from his/her supervisor at the home institution.

*** 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 439 peer-reviewed journal articles and 151 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 2014 is given in an attached pdf file (Colloquia2014.pdf).

The dissemination of activities at the Center through outreach has been described above in the Major Activities section, and in the attached file (outreach2014-2015.pdf). In addition to the live events, the public lectures are filmed and made available in a video archive on the internet.

This outreach included several ongoing activities involving local high school students, developed with the aim of strengthening their interest in learning and careers in physics. ACP asks teachers of advanced physics classes to recommend their students as possible 'go-fers' at the ACP during the summer months. ACP hosted 13 such students in 2014. 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?**

The Aspen Center for Physics 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 2015

- Understanding Strongly Coupled Systems in High Energy and Condensed Matter Physics, May 24 - June 14
- The Dynamic Universe; Understanding ExaScale Astronomical Synoptic Surveys, May 24 - June 14
- CSI PTA: Computation, Systematics, and Inference for Pulsar-Timing Arrays, and Beyond, May 24 - June 21
- Primordial Physics, June 7 - July 5
- Physics and Mathematics of Viral Assembly, June 14 - July 5
- The Physics of Accretion and Feedback in the Circum-Galactic Medium, June 21- July 12
- From Scattering Amplitudes to the Conformal Bootstrap, July 5 - July 26
- Ultra-Cold Quantum Matter with Atoms and Molecules, July 12 - August 9
- Neutrinos from Space and on Earth, July 26 - August 16
- New Directions to Shed Light on Dark Matter, August 9 - September 13
- Beyond Quasiparticles: New Paradigms for Quantum Fluids, August 16 - September 13
- F-Theory at the Interface of Particle Physics and Mathematics, August 16 - September 13

Winter Conferences 2016

- Populations, Evolution and Physics, January 3 - 9
- Particle Physics at the Verge of Another Discovery? January 10 - 16
- Dynamics and Accretion at the Galactic Center, February 6-12
- Topological Quantum Matter: Progress and Applications, February 15 - 21
- The Re-ionization Epoch: New Insights and Future Prospects, March 6 - 12
- Advances in Quantum Algorithms and Computation, March 20 - 26
- Physics of Development and Disease, March 27 - April 2

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

Supporting Files

Filename	Description	Uploaded By	Uploaded On
summer2014.pdf	List of summer 2014 workshops and colloquia	Karin Rabe	07/08/2015
winterconf2015.pdf	List of Winter 2015 conferences	Karin Rabe	07/08/2015
outreach2014-2015.pdf	Details of outreach activities 2014-2015	Karin Rabe	07/08/2015
generalmembers.pdf	List of current "general members" of the Aspen Center for Physics	Karin Rabe	07/08/2015

Products

Books

Book Chapters

Conference Papers and Presentations

Inventions

Journals

ACP participants (2015). Papers in refereed journals. *see attached file: papers-2015-ref.pdf*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Products

Other Publications

ACP participants (). *Preprints, conference papers, books and book chapters*. *see attached file: papers-2015-nonref.pdf*. Status = OTHER; 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
papers-2015-ref.pdf	Papers published 7/1/2014-6/30/2015 in refereed journals citing the Aspen Center for Physics	Karin Rabe	07/08/2015
papers-2015-nonref.pdf	Preprints, conference proceedings, books and book chapters posted or published 7/1/2014-6/30/2015 citing the Aspen Center for Physics	Karin Rabe	07/08/2015

Participants/Organizations

What individuals have worked on the project?

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

Full details of individuals who have worked on the project:

Karin M Rabe

Email: rabe@physics.rutgers.edu

Most Senior Project Role: 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

Joshua A Frieman

Email: frieman@oddjob.uchicago.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Vice President of the Aspen Center for Physics as of July 9, 2013, responsible for assisting the President in 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.

What other collaborators or contacts have been involved?

Nothing to report

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 2014, as described in participants' exit reports.

The fostering of interactions across subfields of physics was illustrated in summer 2014 not only by the spontaneous cross-fertilization resulting from concurrent workshops, working groups and independent researchers in different subfields, but more formally by the summer workshop "Gauge Fields in Condensed Matter, Ultracold Atoms and Beyond." The goal of this workshop was to bring together researchers working on the latest developments concerning gauge fields from the diverse fields of condensed matter, cold atoms, and more. There were several interdisciplinary interactions as well as those within subfields, and the workshop was all the more enriched for having a non-equilibrium workshop running in parallel with several people attending activities of both workshops. Participant comments include:

Stefan Natu

A second advantage of Aspen over typical programs is the diversity of the participants, even within a given program. The Gauge fields program in particular, brought together researchers in cold atom physics (such as myself), condensed matter, non-equilibrium physics, experts on numerical techniques etc. So in addition to learning in depth

about a given topic, one gets a sense of how one's research fits into a bigger picture, which is extremely useful.

Ajay Gopinathan (Bacteria Meet Physics II)

One of the most significant conversations was in fact with someone from a different program [Quantum Magnetism] - Paul Goldbart - about the possibility of adapting his analytic model for directed polymers to understand swarming with disorder that we are studying computationally. This work is in progress currently.

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 2014 exit reports follow:

Benjamin Safdi

The Emergent Spacetime workshop brought together a mix of researchers from different sub-fields. For example, while many participants debated the recent firewall paradox, others discussed fundamental problems in QFT, some of which potentially have applications to real critical points in nature. But a unifying theme among all participants was the idea of quantum entanglement as a probe of these systems.

Sabrina Stierwalt

At Aspen, I got the idea for a new paper connecting two very separate aspects of dwarf galaxy studies. This is truly a project that would never have come to be without my trip to ACP. In my most recent work, I study mergers between dwarf galaxies in the local universe which I believe were even more important at high redshift. Not being in the high redshift community myself, the path toward making our work known to them has not been straightforward. Through several meetings with a high redshift astronomer, we were able to compare notes/summarize literature for each other on what is observed for dwarf-dwarf mergers at low redshift to what is observed for higher redshift systems and come up with quantities that are directly comparable. We have since remained in frequent contact and hope to publish our paper in the fall.

Knox Long

At the Radiation Driven Outflows in Stars and Quasars workshop, the cross-fertilization between stars and AGN was very useful, in part because it forced both groups to talk to one another with less jargon than normal, and to explain (more than once) what they meant in terms that non-experts in a subfield could understand.

Brian Shuve

I think the workshop was very successful, since there was a very wide range of participants from LHC experimentalists to experts on flavour and neutrino physics and those that work on more conventional theories such as supersymmetry or composite Higgs models.

Another mode in which research interactions are developed is by sequencing or overlapping two or more workshops on topics with common threads. Two examples from summer 2014 are the overlap of the two workshops "Ultra-Compact Binaries as Laboratories for Fundamental Physics" and "Fast and Furious: Understanding Exotic Astrophysical Transients," and of the three workshops "Combining Probes in Cosmological Surveys", 'Emergent Spacetime in String Theory' and 'Connecting Flavor Physics with Naturalness: from Theory to Experiment.' Four relevant excerpts from exit reports follow.

Raffaella Margutti (Fast and Furious workshop participant)

The partial overlap with the workshop dedicated to compact objects gave me the opportunity to meet with other people as well (my research concentrates on both subjects). It is a rare opportunity to find most of the relevant people in the very same place.

Rosemary Wyse

The joint session of the 'Combining Probes in Cosmological Surveys' workshop and the 'Emergent Spacetime in

String Theory' workshop was a highlight - this was just the sort of wide-ranging discussion that encourages free-thinking across disciplines.

Don Marolf (organizer, Emergent Spacetime)

There were significant interactions with the combined probes in cosmology workshop, including sessions on early universe cosmology and a lunch in which our workshop described our struggles with formal black hole puzzles. Several of our participants also interacted significantly with the flavor workshop.

Bulbul Chakraborty (independent researcher)

The interactions with workshop participants, and the ideas that I got from the Gauge Fields and Nonequilibrium Processes workshops, which are very far from being directly related to my research interests, helped me make significant advances in my own research. It was precisely the fact that I was hearing from a completely different community that helped me achieve these breakthroughs. To me, this is why the center is special!

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 of physics beyond the Standard Model. Excerpts from exit reports follow.

Daniel Perley

It was an excellent opportunity to discuss the nature of unusual optical transients with other people working in similar areas - in particular, groups operating from different optical surveys, and with theorists working to model these events.

Joshua Shaevitz

Talking to theorists about our experimental projects is probably the number one reason I love the ACP. It is rare to find real experiment-theory intellectual engagement elsewhere but it always seems to happen organically at the ACP.

What is the impact on other disciplines?

Scientists whose primary disciplines are outside physics are increasingly participating in the programs at ACP. The 2015 winter conference program included conferences on "Single Molecule Biophysics" and "Microscale Ocean Biophysics." The summer 2014 program included one workshop with an impact on biology. The goal of that workshop, "Bacteria Meet Physics II", was to bring together biologists and physicists to promote discussion, foster collaborations, and inspire new ideas in areas at the interface of biology and physics.. The participants came from diverse departments including Bioengineering, Biomedical Engineering, Biochemistry, Biology, Mechanical Engineering, Chemical Engineering, Molecular Biology, Chemistry, Systems and Synthetic Microbiology as well as Physics. Indeed, fully 50% (16/32) of the participants in that workshop were from departments without 'physics' in the name. Comments from exit reports relating to the impact of this workshop include:

James Weishaar

As a biophysical chemist who works in a chemistry department, I was somewhat of an outsider at this workshop. I benefited greatly from the incisive thinking of the physicists, and I learned a lot about the kinds of collective behavior they are studying in live bacterial cultures. Informal conversations on long hikes were excellent. I feel more connected to this community as a result of the meeting.

Katherine Freese (astrophysicist)

I attended Bacteria meets Physics because of my recent work on Dark Matter detectors using DNA. I gave an hour and a half talk on the subject to a biophysics audience on this interdisciplinary topic.

Christoph Haselwandter

I would like to emphasize how important interdisciplinary workshops such as Bacteria Meet Physics II are for the biological physics research community. As illustrated nicely by the affiliations of the workshop participants, the biological physics research community is scattered among a variety of different departments and schools from physics to molecular biology to bioengineering to mechanical engineering to applied science to medicine, and beyond. Thus, the biophysics workshops at Aspen are not only very important for the research of the individual workshop participants, but are also pivotal for the emergence of biological physics as a new discipline and for the building of a community of researchers working at this exciting new frontier of physics.

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 and housing. This can, and does, create new life-long collaborations and friendships. In summer 2014, 73/543 participants (13%) were assistant professors and 121/543 (22%) were postdoctoral fellows. We actively seek first-time applicants and in summer 2014, 207/543 (38%) had not participated in prior years. In addition, 66/543 participants were NOT faculty members at universities, but rather staff members at government laboratories, observatories and industrial laboratories. This can be especially valuable for junior participants, as illustrated in the following excerpts from exit reports:

Jie Xiao

The casual, relaxed atmosphere at the center encourages frequent conversations between scientists. Young and well established, experimentalists and theoreticians, all of them can easily engage in discussions without much effort.

Jeffrey Silverman (PhD 2011)

Being able to chat with these experts in their fields both in the formal environment of the Center and in the less formal condo was something I have never experienced before at a scientific workshop or conference.

Roni Harnik (workshop organizer)

We were very fortunate to have a vibrant group of participants, which was dominated by postdocs and young faculty. With very few exceptions we had talks only by postdocs. We've gotten quite a bit of positive feedback from participants about the relatively young crowd and the choice of young speakers.

Phillip Tanedo (PhD 2013)

It's sometimes difficult for young postdocs to feel for how to find new ideas---but what's really magical about the ACP is that sometimes you can sit at the picnic tables and new ideas and collaborations can just fall into your lap.

Phillip Tanedo (PhD 2013)

The hiking trips included free flowing discussions that included interesting physics ideas, career advice, and non-physics topics that led to new friendships and connections. One of these discussions led to the identification of a fellowship opportunity that may turn into my next academic position down the road.

Brian Shuve (PhD 2012)

I think that my stay here helped with my career development. As a direct result of conversations here, I've received invitations to visit and give seminars at two institutions that I'm interested in applying to for future postdoctoral work. I also met and interacted with some faculty members that I had not previously met.

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 2014 (20.2%) represents an increase over summer 2013 (19.6%). 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:

Marika Taylor

I attended a couple of womens' lunches organised by Bernice Durand. These provided a nice opportunity to meet physicists from other fields and I also benefited from hearing about Bernice's experiences leading diversity initiatives at her previous university, since I lead a diversity program at my home institution.

Clare Yu

I attended the women's luncheons at Bernice Durand's home on Thursdays. It's a good way to meet and network with other women physicists, and learn about other fields of physics.

Manuela Kulaxizi

I would also like to mention one special event in particular: the Women's Lunch, hosted by Bernice Durand every year. It is always a very warm gathering and Bernice is an amazing host. It gives us (women) the opportunity to meet each other and learn from each other's experience. I love taking part in these lunches.

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 activities 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.

