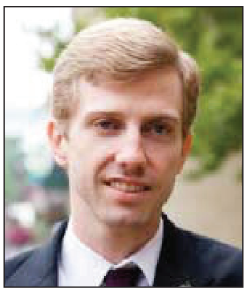
APS physics™

FECS

FORUM FOR Early Career Scientists

Spring 2019 AMERICAN PHYSICAL SOCIETY aps.org/units/fecs

Message from the Newsletter Editor



Greetings, FECS members! We are excited to present to you our newsletter for Spring 2019. We hope you find it informative and interesting. In these newsletters, in general, we aim to provide you with useful information about basic research in different fields of physics, information about our activities at conferences and elsewhere, opportunities to actively participate in FECS, and helpful guidelines toward furthering your career.

This issue includes a survey of machine learning and its utility, a review of the FECS activities and sessions that happened during the APS March and April Meetings in 2019, a reproduction of a unit profile of FECS from APS News, job search advice from the DFD meeting, an interview with a successful South Asian physicist who travelled a difficult path and succeeded, and an introduction to the newly elected FECS executives.

I offer my sincere gratitude to all the contributors for this issue of the FECS newsletter, who worked hard to provide useful and engaging content, and many thanks to all the FECS members for reading. Suggestions, comments about the newsletter, and article contributions are always very welcome, and you can reach me with these at kludwick@lagrange.edu or on our Facebook group (called "APS Forum for Early Career Scientists"). I hope to connect with you on our Facebook group and at upcoming APS meetings!

Sincerely,

Kevin

Kevin Ludwick

Kevin obtained his Ph.D. from the University of North Carolina at Chapel Hill. After a two-year postdoc at the University of Virginia, he became an assistant professor at LaGrange College in 2015. His research is in theoretical cosmology, pertaining to dark energy and dark matter models.

IN THIS ISSUE:

Views and opinions expressed in articles are those of the author and are not necessarily shared by the editor or the APS/FECS.

Message from the Chair

Jason S. Gardner

Welcome to this first issue of the 2019 FECS newsletter. I am looking forward to a very pro-active year on the forum business, especially in the international physics and young scientists front.

The APS staff from the president and CEO down recognise the importance of this critical group both for the good of global science and the vitality of the APS. Our membership represent the future leaders in science and are those who will have to live and work through some of the major changes that will happen over the next couple of decades. The APS has just released its Strategic Plan: 2019. As it clearly highlights, *APS IS HERE FOR YOU*. The APS deliberately sought out input from the FECS leadership for this document, recognising our importance. The CEO Kate Kirby, other members of the Board of Directors, senior members of the editorial staff and APS staff, and other unit leaders discussed the purpose and content of the Strategic Plan: 2019 before it was published. I recommend you read this short document.

A new slate of officers was installed in January, with the chair line moving one step forward. I welcome the new members of the Executive Committee: Ben Ueland (Chair-Elect), Ames Laboratory; Adam Iaizzi, National Taiwan University and Eric Sorte, Sandia National Laboratories (Members-at-Large). I thank Kevin Ludwick for stepping up and filling our Secretary/Treasurer position. As a team, the executive members hope to promote the issues of early career scientists, both in academia and industry, to the APS leadership and to assist the leadership in developing programs to retain members.

We are always looking for APS members to join our forum. In my year as chair, I am especially interested in finding more senior scientists in the world of industry and academia to join and help give back by advising and advocating for the younger scientist. Later in the summer we will be looking for candidates to run for up to 5 open positions on the executive. It is never too early to approach us, help at a meeting, and get your name out there. After all, those of us who live in America are already hearing of the big election in 2020.

As executives of our forum we continuously promote and defend the issues important to young scientists. This includes, but is not limited to, science in the international arena, open communication, safe and welcoming work environments, equal access to information and education, diversity, and gender equality. We are always open to suggestions for other areas of interest to members, topics to highlight at our annual meetings, and programs at the APS to support or start.

After obtaining his Ph.D. at Warwick University in the UK, Jason worked for several national laboratories in North America before moving to Sydney, Australia in 2013. From Sydney, he manages a group of five people performing neutron scattering at ANSTO, Australia, and around the world. He is currently a research Professor at Songshan Lake Material Laboratory, a new research laboratory in China. His scientific interests are primarily in frustrated magnets, but he's also performed research in many areas of condensed matter over thirty years of research. He has published over 140 papers and 4 book chapters. He was made a fellow of the Institute of Physics (UK) in 2008 and the APS in 2019.

NEWS

FECS Election Results Statement

Raju Prasad Ghimire, Past Secretary/Treasurer

Raju Prasad Ghimire

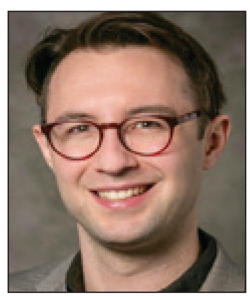
The first general election for the Forum for Early Carrier Scientist (FECS) began on December 18, 2018 and closed on January 18, 2019 and the results are in: Benjamin Ueland of Iowa State University has been elected as chair elect (3-year term), and Eric Sorte of Sandia National lab and Adam Iaizzi of National Taiwan University became members-at-large (2-year term). All began their new terms at the beginning of 2019. The executive committee wishes to thank the elected candidates all who helped to make this election successful.

Ben Ueland

Ben Ueland (Chair-elect) is an experimental condensed-matter physicist specializing in neutron and x-ray scattering studies of magnetic correlated-electron materials. He earned a Ph.D. in Physics from the Pennsylvania State University in 2007 for his work examining cooperative magnetic-relaxation effects in geometrically-frustrated magnetic oxides using various very-low-temperature thermodynamic measurements. He joined the NIST Center for Neutron Research in 2007 as an NRC Postdoctoral Associate to learn neutron scattering techniques and became a G. T. Seaborg Institute Postdoctoral Associate at Los Alamos National Laboratory in 2010. In 2012, he joined the Correlations & Competition between the Lattice, Electrons, & Magnetism group at Ames Laboratory located at Iowa State University and is currently a staff scientist there. Some of his recent work includes identifying emergent itinerant ferromagnetism in hole-doped $BaMn_2As_2$, examining magnetostructural coupling and itinerant magnetic excitations in various 122 pnictide superconductors and related compounds, and characterizing fragile antiferromagnetism in the heavy-fermion YbBiPt.

Eric Sorte

Eric Sorte (Member-at-large) graduated from the University of Utah with a B.S. in Finance in 2002. He spent 4 years working with various business consulting firms and investor groups in South America and the Eastern United States. After deciding to pursue science as a career, he attended Columbia University in New York City, pursuing a graduate degree in physics. He worked with the High Energy Cosmic Ray group developing software for the Telescope Array Project and received his Ph.D. in experimental condensed matter physics in 2011 studying manifestations of quantum chaos under the advisement of Dr. Brian Saam at the University of Utah. He then did postdocs at Washington University in St. Louis and Georgetown University before starting a job at Sandia National Lab where he is today. As a member of the Graduate School Advisory Committee (GSAC), Eric was instrumental in raising the levels of communication between graduate schools in the College of Science by spearheading interdepartmental activities. Eric has been very active in APS organizations, holding positions on the Executive Committees of the Forum on Graduate Student Affairs and of the Four Corners Section before becoming an APS Councilor. After leaving the Council. Eric worked with the Committee on Committees and more recently on the Committee on Informing the Public. As an active member of the APS, Eric has served on various panels both as panel member and host, including several APS webinars. He loves serving in the APS and looks forward to the next opportunity.



Adam Iaizzi

Adam Iaizzi (Member-at-large) is a postdoctoral research associate at National Taiwan University. He received a B.S. in physics from Ithaca College (2011) and a Ph.D. in computational condensed matter physics from Boston University (2018). During graduate school, Adam was active in student leadership, serving as treasurer and later president of the university-wide Graduate Student Organization, where he successfully advocated for a paid parental leave policy for Ph.D. students and a 75% budget increase for the organization. He also organized events for the women in science group. Within the physics department, Adam helped organize a graduate student peer mentoring program. Off campus, Adam served as a science consultant to Massachusetts State Senator William Brownsberger, where he wrote a report summarizing the latest projections of sea level rise along the Massachusetts coast. Since moving to Taiwan, Adam has gotten involved in science outreach, speaking to junior high school classes about careers in science.

Raju is a graduate student of Nanoscience and Microsystem Engineering at the University of New Mexico. He holds a master's degree in data science and electrical engineering from South Dakota State University (08/2015-08/2018), USA and graduate degree in physics from Tribhuvan University (01/2008-01/2011), Nepal. His research interests include, but are not limited to, ultra-conductors, composites, energy storage, semiconductor application, and renewable energy.

APS Membership Unit Profile: The Forum for Early Career Scientists

Abigail Dove

By the APS Forum for Early Career Scientists (FECS) provides support and mentorship to post-docs as they navigate through the early stages of their career, whether in academia or industry, in the US or abroad, or even a scientific field other than physics. This support spans from the professional—including networking opportunities with senior scientists in various physics careers, resources to help with successful grant writing, and funding for conference travel—to the practical—including support and advice around changes in geographical location, particularly for moving abroad.


Maria Longobardi

Established in 2016, FECS is a relative newcomer to APS, but the forum's fast-growing membership of nearly four thousand underscores the appetite for this kind of mentorship and support among early career scientists embarking on the next phase of their professional lives.

FECS was founded by Maria Longobardi (who has served as chair since 2016) with the help of Jason Gardner (chair-elect whose term will begin in 2019). Longobardi and Gardner met while serving in the APS Forum for International Physics (FIP), and the idea for FECS was born from the perceived shortcomings Longobardi observed in the mentorship and support she and her colleagues received while navigating twists and turns in their career trajectories and locations as young scientists. Longobardi is a gravitational wave theorist turned condensed matter experimentalist, now working at the intersection of material science and microbiology, and Gardner is an instrumental scientist whose career has taken him from his native England to the US and now to Australia.


Jason Gardner

The Forum on Graduate Student Affairs (FGSA) has existed since 2001 to provide support for physics graduate students, and Longobardi and Gardner emphasize that a counterpart to meet the unique needs of post-docs and early career scientists was long overdue. "Postdocs have different needs than the graduate student community," underscored Longobardi. Principally, many FECS members have families, which adds another dimension of complexity to the already challenging tasks of relocating and, if necessary, applying for visas. Added Gardner, many aspects of the professional landscape are unfamiliar to early-career scientists as they finish their postdoctoral fellowships. "Many early career scientists don't realize the different opportunities in front of them, what the competition in the job market looks like, what is involved in leaving the USA for work, or even what to ask when interviewing for a job," he said.

Importantly, the forum's support extends not only to early career scientists pursuing traditional paths in academia, but also the increasing number interested in joining industry and the private sector. This takes place in large part through events and receptions co-hosted with the Forum for Industrial & Applied Physics (FIAP) to promote dialogue and exchange between early career scientists and more senior members of industry. Beyond networking, this support also takes the form of actively educating early career scientists about the opportunities that exist beyond the sphere of academia, a domain that is likely quite unfamiliar, particularly for the majority of early career scientists whose mentors have been exclusively professors and academic researchers. For example, one of FECS' most well-attended APS Meeting sessions to-date was a symposium on data science featuring panelists from academia as well as companies like Netflix and Uber to discuss various applications of data mining and work with large data sets.

In this way, FECS could play an important role in keeping industrial and applied physicists involved in the APS community. Citing a drop-off in APS membership among physicists who transition out of academia, Gardner noted that FECS aspires to be a kind of bridge between the worlds of academia and industry: "People in industry may not think that APS has anything to offer them, but that's certainly not the case."

Beyond the emphasis on career development and network building, FECS is sharply focused on helping members hone their science communication skills. "Science is for all, and we have to learn how to communicate to a broad audience," noted Longobardi, herself a skilled science writer and a former editor at *Nature*, "I'm convinced this is one of the duties of a scientist." Currently this spirit of science communication is most evident in the forum's twice-yearly newsletter – a forum where, in Longobardi's words, "people from gravitational physics can explain their research to condensed matter physicists" and vice versa. To make science communication more accessible for FECS members who may not yet feel confident contributing to the newsletter, the forum is also in the process of organizing workshops and webinars to help early career scientists develop and practice this crucial skill.

Although FECS is geared toward meeting the needs of early career scientists, activities aren't restricted to this population. "We always get asked 'Am I too old to join FECS?'" noted Gardner, "and we want elders in the community to join and help guide these busy young minds." Longobardi echoed that her vision for the future of FECS involves a greater emphasis on guidance and mentorship from more senior scientists. As one example of how this intergenerational mentorship might come to fruition, FECS hopes to establish workshops at future APS meetings where early career scientists can get feedback on their CVs or resumes from experienced senior researchers and members of industry—especially those who have been involved in the hiring process.

Overall, FECS stands out as a forum with an incredibly bright future, and one that occupies an important niche for postdocs and early-career members in all their diversity. More information on this forum can be found on the FECS website.

The author is a freelance writer in Helsinki, Finland.

Forum For Early Career Scientists (FECS) Sessions at the APS March Meeting 2019

Jason S. Gardner, Chair

Jason Gardner

The Forum had several activities at both the March and April Meetings in 2019. These activities were organised to promote or encourage early career scientists to think outside the box and recognise the opportunities in front of them. Here I will highlight the March meeting events.

In March, we started off the week with the 2019 *Energy Research Workshop*, sponsored by GERA and FECS. This DOE supported meeting was held in Boston on Sunday, March 3, 2019. The workshop consisted of a series of talks by leading experts in the field, informal discussions during lunch and coffee breaks, and a panel discussion. Over 100 participants attended the daylong event, and every year we get great reviews.

On Wednesday the 6th at 8am, we co-sponsored a session entitled "Topology Matters: Structure-Property relationships on different length scales" with the Forum on International Physics (FIP). This session was in room 258A and our past-chair, to name one speaker, explained her work on STM and nanowires. This was an outstanding session highlighting a variety of science from around the world, with work at national laboratories and universities.

Three FECS executives (from left to right: Adam, Maria, and Ben) at a reception. IMAGE: ADAM IAIZZI

We also co-sponsored a session focused on industrial and applied research. This session, entitled "Physicists of Evolving

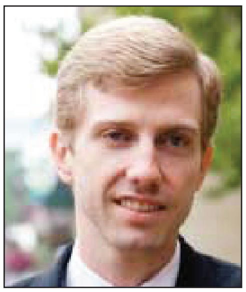
Careers Future" ends with the Distinguished Lectureship Award on the Applications of Physics given by Cynthia Keppel of the Thomas Jefferson National Accelerator Facility.

At the March Meeting the unit also co-hosted two receptions with our friends from FIP and FIAP. These were excellent opportunities for our members to interact with other members of the community, leaders in the field of physics, and perhaps future employers over light refreshments. On Tuesday evening, the FIP/FECS reception gave us an opportunity to acknowledge the distinguished student travel award winners.

As I mentioned before, the sessions we sponsor at the March and April meetings are put on to support the early career scientist community. We are always interested in hearing your ideas for sessions, whether it's a title or one or two key speakers. Please email the chair-elect with any suggestions you may have.

Overview of the APS April Meeting Sessions

Kevin Ludwick, Newsletter Editor and Secretary/Treasurer



Kevin Ludwick

The APS April Meeting in Denver, CO was an exciting meeting this year. The FECS sessions focused on science outreach to young people and publishing outside of academia.

FECS co-sponsored a session with the Forum on Physics and Society (FPS), chaired by myself. The session was entitled "Attracting Young People to Science and Science Policy", and all the speakers were engaging and passionate about what they do. The talks were about educating others in an engaging way and getting them excited about science and its applications to public policy. Brian Jones (Colorado State University) spoke about he effectively communicates to the general public and to his university students the science and facts behind climate change. His Little Shop of Physics tours around doing great science outreach work. David Mauillo (Rutgers University) excitedly spoke about his outreach work that takes him across the country, and he emphasized the effective use of physics demonstrations to get people thinking about science and applications to science policy. He also involved the audience with some live demonstrations. His has many successful outlets for outreach, and his NYC theater presentation *That Physics Show* is performed around the world. The third speaker, Meredith Drosback, talked about the important work she does with SciLine as its associate director. SciLine is affiliated with AAAS, and its purpose is to match up the journalist who is tasked with covering a story that has connections to a specific science field with an expert in that field, even if the journalist's deadline is only a few hours away. This effort to improve standards of science communication in journalism is important, and it has been fruitful.

FECS also co-sponsored a session with the Forum on Graduate Student Affairs (FGSA) entitled "Publishing in Areas Outside of Peer Reviewed Journals". The session was chaired by Tiffany Nichols from Harvard University. The talks highlighted various effective ways of communicating science

Q&A during the session on publishing outside academia. IMAGE: KEVIN LUDWICK

outside of academic journals to diverse audiences. Brian G. Keating (USC San Diego) talked about his book *Losing the Nobel Prize*, which is a memoir about the cosmological probe BICEP's cutting-edge observations of the polarization of the cosmic microwave background, its potential link to cosmic inflation, and its pursuit of the Nobel Prize. The second speaker, Nutsinee Kijbunchoo (Australian National University), spoke about her unique way of publishing science via comics, specifically on the work of the exquisitely precise gravitational interferometer LIGO. Afterward, Jermey N.A. Matthews (The MIT Press) gave a detailed overview of publishing books in the 21^{st} century. He went through strategies for different routes of publishing, whether as a single author or as a part of a collaboration. He also talked about different facets of open access publishing versus for-purchase publishing.

The sessions were entertaining as well as informative and useful. I am looking forward to seeing what future sessions FECS will sponsor at the APS April Meeting. Suggestions for topics and speakers from FECS members are always welcome!

Job Search Advice from the APS DFD Meeting

Mark Owkes, Member-at-Large

Mark Owkes

This year FECS made a splash at the APS Division of Fluid Dynamics Meeting by co-organizing an event aimed to help early career scientists navigate applying and interviewing for faculty and postdoc positions. The event featured four panelists: Lance Collins (Dean at Cornell), Anette (Peko) Hosoi (Dean at MIT), Bill Schultz (Professor at U. Michigan), and James Chen (Assistant Professor at U. Buffalo, SUNY). The panelists shared their thoughts on the process for securing a postdoc or faculty job in academia. Below is my attempt to organize the ideas the panelists shared.

Preparing for Success

Before you apply for positions, you need to prepare yourself to be successful. As a graduate student or a postdoc, you need to do good research and publish it in quality journals. The number of publications depends on where you are in your career (grad student, postdoc), but the consensus of the panel is that it is better to publish fewer high-quality papers than many low-quality papers, especially in the mature field of fluid dynamics. You should also work to build a network so that potential future employers know who you are. You can network by reaching out to people at conferences and making a point to interact with visitors to your university. Be sure to be involved in other activities such as outreach and teaching to prepare yourself for other aspects of a faculty position. These activities, when done thoughtfully, will help you distinguish yourself from other applicants.

Job Application

Your application is the first part of the job search process. A typical application consists of a cover letter, teaching statement, research statement, and CV. Your task is to differentiate your application from the hundreds of other applications for the position. Look closely at the job listing and think about how you would fit in at the institution, and express this in your cover letter. Customize your documents for each institution you apply to by including potential collaborators you could work with, research labs or equipment you can use, courses you can teach, and why the institution is a good fit for you. Pictures or other unique items that highlight your research, teaching, or skillset can help get the attention of the search committee.

Phone Interview

The phone interview is your chance for you to showcase why you are the person for this job. Preparing is very important, and you should have a clear plan for the future in terms of research and teaching activities (the balance depends on the focus of the institution you are applying to). For research-intensive positions, have a plan for the first few grants you will write, where you will submit them, and how they connect together to establish your research program. Put together a budget for a startup package that includes items that are essential, items that would be nice, and items that would really set you up for success. For teaching, reiterate how you have prepared yourself to be a successful teacher, and have a list of courses you can teach that includes one to two proposed courses (use the numbering system of the institution you are applying to).

Interview

The interview is your time to shine. At this point, your application has demonstrated your qualifications, and your phone interview has resonated with the search committee. Take this opportunity to learn as much as you can about research, labs, resources, and the overall culture at the institution you are applying to. Also, explore the area to see if it is a good fit for your life outside of work.

Your interview will likely involve talking with a lot of faculty, giving a research presentation, and potentially giving a chalk talk or teaching seminar. When meeting with faculty, you get the chance to share your work but also learn about the work faculty are currently doing at the institution. Think about future collaborations, how younger faculty are performing in the environment, and what it is like to live in the location of the institution.

The research presentation is an opportunity to share the research work you have been doing and plans for the future. The length is about 45 minutes. During this time, you should aim to inform the entire audience, not impress the one or two people in room that may be in your research area. The technical level should be appropriate for everyone, including undergraduates. If you feel you must impress, limit technical content to a few slides and explain it thoroughly.

Many interviews contain a chalk talk, which is an interactive discussion on your plans for the future. The panelists agreed that many people struggle here, and therefore encouraged applicants to prepare. Know your first three to five projects, including funding sources (specific programs) and thesis projects. Be ready to answer questions related to the proposed work. Keep in mind that you need to present a logical plan, but you will not be held to this plan as a faculty member.

General Advice

A faculty member needs to differentiate themselves from their advisors. Think about new directions (and funding sources) for your research. Doing a thorough literature review is one way to start a new direction. Reading many papers on a topic will allow you to learn about a topic and identify key researchers in the new area who you can network with. Consider a postdoc that gives you a unique combination of skills, some from your graduate work and some from your postdoc. Apply for fellowships to support your postdoc, which gives you latitude to create a postdoc experience that fits your goals. Keep in mind that the process of obtaining a postdoc can happen fast, so be prepared to accept opportunities. Once you start a postdoc, be sure you have an exit plan to move on to something new.

Securing a postdoc or a faculty position can be challenging. Good luck with the process!

Mark is an assistant professor at Montana State University in the department of Mechanical and Industrial Engineering. His research interests include developing numerical methods to study gas-liquid multiphase flows such as the atomization of a liquid fuel.

Stop Limiting Yourself

Raju Prasad Ghimire

Raju Prasad Ghimire

Stopping yourself from making achievements makes your life very uncomfortable and limited. Of course, every person can't be a genius, but every person can contribute something. New challenges are opportunities for us. Exploring opportunities within difficulties is one of the things that everyone can do. The more we can test our limits and capabilities, the more we will learn about ourselves. Not only can you grasp an opportunity, but also you can create opportunities that other people can grasp.

Of course, challenges are everywhere. Taking on such challenges is an important part of growing and developing as a person. It is a great challenge to become a scientist from a South Asian country due to limited opportunity. However, despite the difficulties, scientists from South Asia contributed to STEM fields and made some major discoveries, including but not limited to the Raman effect (Sir Chandrasekhara Raman), the statistical method of handling bosons (Satyendra Bose), the structure and evolution of stars (Subramanyam Chandrasekhar), the calculation of the cross section for elastic electron-positron scattering (Homi Jehangir Bhabha), and the gauge field theory of electroweak interactions (Abdus Salam).

Archana Sharma

Currently, Dr. Archana Sharma is one of the leading scientists from India, who has conceived and has been steering the GEM upgrade project over the last ten years at the CMS experiment as a principal scientist at CERN. She is also a role model inspiring young students in STEM fields and is paving the way by creating opportunities for others. Following a graduate degree in Nuclear Physics from BHU (Banaras Hindu University), Varanasi, India, Archana received her Ph.D. in particle physics from Delhi University in 1989 and the received her D.Sc. on instrumentation for high energy physics from the University of Geneva in 1996. Dr. Sharma also earned an executive MBA degree from the International University in Geneva in 2001. She is an internationally recognized expert for her experimental work on gaseous detectors for research in high energy physics.

Many scientists throughout the world want to be involved in a world-renowned, successful, and amazing project by any means, and experiments at CERN are flagship projects of the 21st century. Dr. Sharma made it to CERN from India, coming from a humble background, and is now at the pinnacle of her career within one of the largest scientific communities of high energy physicists. However, she started her journey through CERN as a summer intern. But the big question is what drove Dr. Sharma to get there, and the easy answer is her interest, passion, and hard work, and in our conversation, she explained in detail.

1. **How was your family background and school life?**

   I was born in Jhansi (Uttar Pradesh, India), and both of my parents were teachers. I grew up like any other middle-class kid in India. I was always an average student during my school. But the support from my parents, close family, and teachers was enormous and enabled me to overcome any challenges, and my family was the backbone for all my success.

2. **Why science (physics)? Why not another field?**

   Given encouragement all the time from mentors, I was always passionate to do something meaningful and impactful in life, and I thought physics could be the means, and it made me who I am today. I chose nuclear physics against electronics and solid-state physics at BHU simply due to the "outstanding" set of teachers at the physics department.

3. **During school, what did you want to be in the future?**

   During school, I didn't know what I wanted to do and never thought I would end up at the Mecca of particle physics. However, as I mentioned before, I was ambitious to contribute something to the society by following the footsteps of role models.

4. **Did you really want to work at CERN?**

   Just like everyone else, I wanted to be a part of the world-renowned project or a similar place where I can use my ability and knowledge for fruitful outcomes. I found that CERN is one of those projects and I was passionate about it. It is not easy, but not impossible either.

5. **Was it chance or passion?**

   Honestly, success by chance is very rare and of course, luck can be lured by hard work and grit of overcoming all challenges one faces.

6. **When and how did you join CERN?**

   In 1987 I started to work at CERN as a summer intern for a few months and in that framework, I participated in an instrumentation school, where I received one of the awards, which was to spend a year at CERN. I worked on R&D for 12 subsequent years and then joined the CMS collaboration.

7. **What were the difficulties?**

   I was still completing studies and working at CERN on detector development, and this was quite challenging, especially because I was in a foreign country with very few Indians. It was also daunting partly because of the complexity of instrumentation and the experiments. The day-to-day challenges of information management, laboratory schedules, learning, and progressing in a foreign land were massive. There was no scope of being employed as an Indian by CERN as it employs only member state nationals. But in certain exceptional cases this rule can be exempted, and in my case, the requirements of the job did not yield at that point of time an equivalently qualified member state national applicant.

8. **How did you make it through other difficulties?**

   Self-commitment to deliver and family support are the keys. Besides that, I grew up in a society where education and emphasis on career was the only way to success, and that pushed me towards my achievement. As one example, when I was close to submitting my doctoral thesis at Geneva University, I was told about a new rule that I must complete certain courses in theoretical particle physics (in French) and that there would be an examination at the end. It was a great challenge since my master studies were already many years behind me, and I was fully immersed in the technology R&D. But working day and night, I managed it, eventually passing the exam with honors. With these small successes, I became confident that all challenges could be overcome if we believe we can do it. It is we who set the limits!

9. **Are you the only one from South Asia who works as a principal scientist?**

   To my knowledge, I am the first permanent staff from South Asia, and I am privileged. Recently, more Indians are being employed since India has become an associate member. In addition, there are a number of institutions and physicists from South Asia collaborating with CERN projects.

10. **What is your suggestion to the high school, undergraduate, & graduate student, and even the young scientist, for being successful in STEM?**

    Every person has a hidden Einstein inside with huge potential. Failures are stepping stones and obstacles are the first steps towards achievement. Youngsters should not give in to the allure of "fast job and big money", a common trend. Please keep in mind that if anyone can do it, you can do it too. Of course, the first thing to examine is if you wish to follow the path of a scientist. If you wish to go for "fast job and big money", it's totally honorable since the choice is made by yourself. It's your happiness eventually that counts!

11. **Any other suggestions for success?**

    Start building your "career capital", your experience in the field where you want to work. The path will open up automatically if you will not stop doing everything in your power towards achieving your goals. Make yearly goals, make daily goals, and review them every few months. Success cannot be far away!

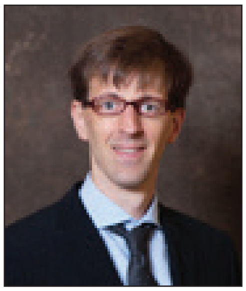
Archana is the founder and leader of CMS GEM collaboration, which exploits one of the most sensitive detectors for trigger and tracking in the CMS experiment at LHC with very high discovery potential. The author and co-author of over 1000 publications, Ms. Sharma is invited regularly for talks in international conferences and public addresses in various science and technology events. Recently nominated as a Distinguished Lecturer at the US-based IEEE, she has collaborated at events at the ILO Geneva and World Communication Forum at Davos as spokesperson for diversity and excellence in scientific communication.

In summary, as Dr. Sharma thinks positively and keeps working with diligence in her field, she has been able to set an example for us to make a difference. If you're unsuccessful, you're not pushing your abilities, and if you're not pushing your abilities, you're not improving! Achievements come by accumulating daily tiny doses of failures and overcoming them.

SCIENCE

How Can Machine Learning Help Your Research Forward?

Wouter Deconinck, William & Mary



Wouter Deconinck

The excitement about machine learning, deep learning, and artificial intelligence is everywhere. What is behind these terms, and can you take advantage of their development to advance your career or research? Since we can only scratch the surface in this short and necessarily incomplete discussion, consider it a starting point for further exploration.

Let us start by defining artificial intelligence, the ultimate goal of developing systems that mimic "human intelligence," *i.e.,* learning and problem solving. Formally, an artificially intelligent system independently takes actions based on measured inputs to maximize the probability to achieve its goals. To do so it relies on several subfields to derive meaning from inputs (computer vision, natural language processing) or to learn implicitly what to base decisions on (deep learning).

Machine learning is the subfield of artificial intelligence that uses statistical techniques to allow computer systems to progressively improve performance on specified tasks, *i.e.,* learn, without explicitly programmed algorithms to perform those tasks. Perhaps the most common machine learning algorithm is the artificial neural network which forms the basis for the field of deep learning.

The "hello world" example of machine learning is handwritten digit recognition based on the standard MNIST data set. A traditional rules-based algorithm to classify the 28x28 pixel images into one of 10 digits would need to take into account whether the '7' has a horizontal cross bar through the middle, and whether the '1' is a simple vertical bar or has an ear and bottom serif. For every exception the algorithm becomes more involved. Machine learning takes a different approach and avoids the need to enumerate all possible cases.

We should not think of machine learning as a magic black box. It is a field founded on mathematical and statistical techniques that are familiar to many physicists (from linear tensor algebra and multidimensional calculus to Bayesian probability). It is not a universal solution to every problem, but it may help to automate certain classes of common problems in physics, leaving you with time to spend on problems not solved by artificial intelligence (yet).

Andrew Ng, a thought leader in the artificial intelligence community and the author of a popular online course on machine learning, summarized the set of problems where artificial intelligence can be useful as follows: If you can perform a mental task in less than a second, then an artificial intelligence algorithm can be used to automate the task now or in the near future. This turns out to be a useful test when assessing where you may be able to use machine learning algorithms. Start by focusing on the problems where you can quickly tell what the answer is but where it is hard to write down a traditional rules-based algorithm.

At the risk of oversimplifying, there are two broad classes of machine learning: supervised and unsupervised learning. In supervised learning, the data scientist has access to a representative training data set, perhaps painstakingly verified by hand. Using this training set of input values (*features*) and the corresponding output values (*targets*), the training process determines the parameters of the algorithm such that a *loss* function is minimized.

Two classes of problems lend themselves well to supervised machine learning. We discussed classification of handwritten digits, which is similar to the separation of signal from background based on detected signals in physics. In regression problems we wish to determine the relationship between input values and the expected mean of the output value, even when that output value is affected by measurement noise as is commonly the case in experimental physics.

The loss function to be optimized is often the sum of quadratic differences between predicted and actual targets, similar to a least squares method. For classification problems, where the algorithm determines probabilities for each possible class, we use loss functions based on log likelihood or information entropy.

The loss minimization during the training process often uses a variation of the gradient descent minimization algorithm, repeatedly applied on a subset of the potentially large training data set and with a specified learning rate. As with the fitting of a polynomial to a set of data points, overfitting can occur when the number of algorithm parameters is large, a common occurrence in large artificial neural networks. In order to minimize overfitting we set aside two parts of the training data set: for validation and for testing. After training an algorithm on the training data set, we assess the performance on the validation data set. When overtraining, the cost for the training set will continue to decrease but the cost for the validation set will start to rise indicating that we are now describing the training set at the cost of generality. After we determine the network parameters and learning rate through repeated training and validation cycles, we can assess the quality of the trained algorithm with one final evaluation of the as-of-yet-unseen test data set.

The strength of machine learning often derives from non-linear elements, for example, as activation function f in each of the nodes of a neural network that project their input $\vec{x}$ onto their output $y = f(\vec{w} \cdot \vec{x} + b)$. Training determines the weights $\vec{w}$ and bias b for all network nodes. The S-shaped sigmoid curve ensures that the projection is continuous, differentiable, and bounded to the unit interval.

In unsupervised learning, we do not use a training data set. Clustering algorithms can find structure in high dimensional data sets based solely on the data set under study. Anomaly detection algorithms on measurement data may use autoencoder networks to reduce the data dimensionality, *i.e.*, the network learns to ignore noise but recognizes when new data deviates regardless. This in turn can be exploited in generative adversarial networks to produce data sets that behave superficially as identical to an original data set, and this process is a fast and inexpensive way to produce additional simulated data.

If you are interested in exploring machine learning, you will find that nearly all common programming languages and physics analysis tools have support for some aspects of machine learning (including MatLab and Mathematica). Nevertheless, the most widely used and feature-rich tools (tensorflow and pytorch) have their best supported interfaces in Python. Interactive notebooks in Google's Colaboratory platform are cloud-based and present several tutorials to get started. The interactivity and ease of visualization in these notebooks facilitates the frequent training/validation cycles in machine learning.

As with any new approach, starting with modest ambitions on a simplified model of your problem will help you develop an intuition for the effects of your choices of algorithm and parameters. You are entering an exciting world of applied mathematics and statistics!

After obtaining a M.S. in Engineering Physics from Ghent University (Belgium), a Ph.D. in Physics from the University of Michigan, and a postdoc position at MIT, Wouter Deconinck has been on the physics faculty at William & Mary since 2010. In fall 2019, he will be joining the faculty at the University of Manitoba. His research interests are precision searches for physics beyond the Standard Model, in particular through parity-violating electron scattering. This article is based on a talk at the 2018 SESAPS Meeting in Knoxville, TN.

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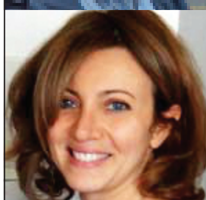
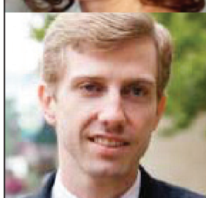
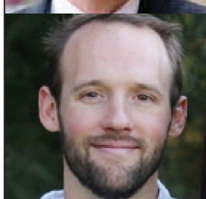
	**Past Chair:** Maria Longobardi *University of Geneva*
	**Secretary/Treasurer:** Kevin Ludwick *LaGrange College*
	**Member-at-Large:** Eric Sorte *Sandia National Laboratory*
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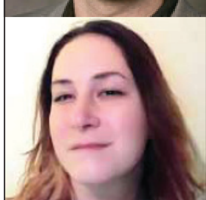
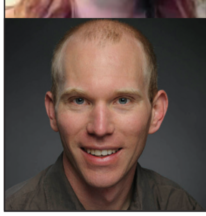
	**Member-at-Large:** Sara Clements *United Healthcare, California*
	**Member-at-Large:** Mark Owkes *Montana State University*

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