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Sex, gender, and physics, and the introductory physics classroom FREE

Special Collection: Sex, Gender, and Physics Teaching

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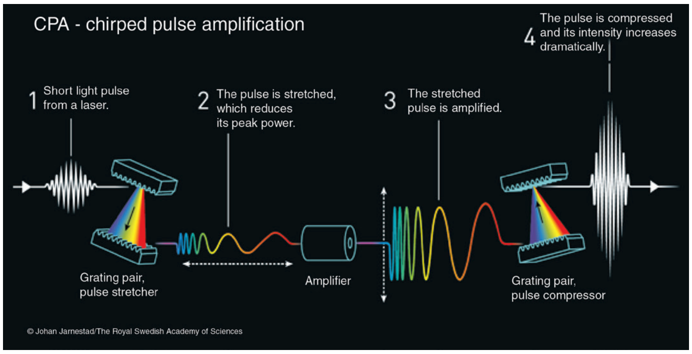
Congratulations to Dr. Donna Strickland! As I am sure you have heard by now, she was awarded ¼ of the Nobel Prize in Physics for her contributions to "groundbreaking inventions in the field of laser physics" and the "method of generating high-intensity, ultra short optical pulses."[1] Another ¼ of the prize went to Gérard Mourou, and the remaining ½ of the prize went to Arthur Ashkin for his work on "optical tweezers and their application to biological systems." On the occasion of the announcement of the Nobel Prize for this ground-breaking work, I invite you to join me in a celebratory reflection about the physics of chirped pulse amplification (CPA), along with some related metaphors for the classroom, some opinionated and personal remarks about the importance of eradicating sexual harassment in the discipline, and finally, a new call for papers on related issues.



This graphic shows a more modern version of chirped pulse amplification wherein diffraction gratings are used both to spread out the initial pulse and to compress the amplified pulse; the text describes Dr. Strickland's original experiment wherein a special optical cable was used for the initial "chirp" production. (Photo courtesy Johan Jarnestad/The Royal Swedish Academy of Sciences)

First, this is some exciting physics! Dr. Strickland's dramatic implementation of CPA resulted in extremely high intensity, very short pulses of laser light, and was part of her thesis work with her advisor, Dr. Mourou. It is a technique that was inspired by similar success in radar and is now used in a wide swath of applications, from eye surgeries and medical stents to observing and controlling chemical reactions to creating more efficient electronic data storage and exploring novel non-linear optical effects in various media. Here is the abstract of their Nobel-worthy paper,[2] artfully and stunningly succinct:

> "We have demonstrated the amplification and subsequent recompression of optical chirped pulses. A system which produces 1.06 μm laser pulses with pulse widths of 2 ps and energies at the millijoule level is presented."

Dr. Strickland started by first sending infrared light pulses from a Nd:YAG laser into one end of a special 1.4-km optical cable. Unlike in most materials, higher frequencies slightly outpace the lower frequencies in this cable, resulting in a "chirped" pulse exiting the other end. Next, she injected these stretched, chirped pulses into an amplifier, but because the pulse had been spread out, this process could proceed without damage to the amplifying medium. Finally, she extracted an amplified, chirped pulse and sent it to a special diffraction grating arrangement, which allowed the longer wavelengths to catch up to the shorter wavelengths, compressing the amplified pulse into a much more intense packet of light with more than 30,000 times the energy of the original pulses and about 1/100th the duration.[3]

What's good about having more intense, shorter pulses of light? For one thing, short powerful pulses do less damage when used on biological samples; for another, they allow much higher precision and efficiency in developing electronic storage media; for a third, they allow a much richer exploration of various strong field non-linear effects and time-dependence of electron dynamics within molecules.[4,5] Nowadays, these ideas and techniques are used by scientists in virtually all of the highest powered lasers in the world, and by doctors in thousands of eye surgeries each day, to name two of the most visible applications.

What else is good about this? Well, it's Dr. Strickland herself; I was struck by how enthusiastically she talks about her work and how gracious she is in acknowledging her colleagues in this 2014 celebration honoring Mourou.[6] Especially fascinating is her story about acquiring a 2.5-km optical cable from Corning and discovering that only one end of the cable was free—the other end was wrapped up on the spool, inaccessible until the entire cable was unspooled! She tells of hours spent unspooling the full length of cable and, when the other end was finally reached, of her disappointment upon inputting a test signal and finding that no corresponding output signal emerged. After some scrutiny, she discovered a flaw in the cable near the midpoint, and thus had to settle for 1.4 km instead of the 2.5 km that she hoped to use, barely enough for her purposes.

I know what you are thinking—this is terrific stuff for my physics class this semester! It certainly speaks to me as I teach E&M this week, gearing up for the subtleties of optics after the seeming abstractness of Maxwell's equations. After all, it is a great story about how a physics graduate student changed the world, about how science progress happens when the community builds on each other's work, and how science can benefit humanity, and—this is a real bonus—the physics is quite accessible.

But, as I consider how I am going to introduce the topic, how much to cover and at what level, it also occurs to me that this is a clear opportunity to give my students a fuller picture of physics—of gender issues and beyond, in fact. After all, Dr. Strickland is a woman, the first person of her gender[7,8] to win the Nobel Prize in Physics in 55 years. It is also telling that she did not have a Wikipedia entry,[9] nor was she a full professor when the prize was announced; both oversights have apparently since been addressed. Perhaps I ought to introduce a little more than just the "pure" physics alone; perhaps my students should learn a little more about the culture of physics—the good, the bad, and the ugly.

Hear me out. As a physics educator, I want my students to learn more physics and to be able to use what they learn in physics to improve their understanding of the world around

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them and contribute to the betterment of that world, among other things. Yet I know that there are hurdles and barriers to their learning, such as stereotype threat[10] and implicit bias[11] and sexism[12] and sexual harassment,[13] to name a few. Furthermore, I am convinced by the data[12,14-16] that one way to mitigate some of these barriers and hurdles, ***to improve the performance and learning of my students***, is for learners to become more aware of the nature of these barriers and hurdles, and how they are manifested and how they can be dismantled, at least partially. This is reason enough for me to engage this topic in my physics class.

So, to be sure, my students will learn about how a special diffraction grating arrangement can be used to create an environment where certain colors of light catch up with the other colors of light—colors that got a head start—and how this seemingly abstract and impractical idea is being leveraged to help millions of people see better each year. But my students are also going to get a better view of how society in general, and the culture of physics particularly, gives certain people (read: male, White, straight, gender-conforming, able-bodied) a substantial head start on average, but has yet to produce a classroom environment where everyone is uplifted and unimpeded, while allowing those in the marginalized classes (read: female, non-White, LGBTQ+, disabled) to readily catch up, on average. This kind of asymmetry—in physics particularly—might well be part of the reason why only 20% of the bachelor's degrees in physics in this country go to women,[17] while in disciplines like math and chemistry the percentages are much closer to 50% and have been so for years.[18]

Similarly, my students will discover how attending to the different wavelengths within a pulse with some care and sensitivity, that is, chirping a pulse, will allow you to amplify it more, and explore and leverage non-linear effects without damaging the medium. (Sorry, the metaphors are a bit clumsy, but I couldn't resist; they are thought provoking, at least for me!) Likewise, we will explore the potential upside to having different views and a diverse representation of folks in a physics collaboration.[19] But they will also be introduced to some of the negative non-linear effects that a scientist at the intersection of multiple marginalized identities must endure to succeed in physics,[20] where the cultural biases (and as the data show, even scientists' perceptions [21]) are largely skewed to favor (White, straight, cisgendered) men such as myself.

However, some of the barriers are more sinister than mere hindrances, and perhaps even more radical action is called for in those cases. I am referring to overt sexual harassment and even sexual abuse that many of our students and colleagues experience, and have experienced over the years, within the academic setting. While I was writing this editorial, in the wake of the announcement of only the third female Nobel Prize winner in physics, a number of other recent events reminded me how important it is for us within the physics classroom to address the subject of gender and physics, particularly sexual harassment, and not to leave it only to those outside, including:

- The National Academy of Sciences released an extensive report[13] in summer 2018 entitled *Sexual Harassment of Women* suggesting that almost 1 out of 3 undergraduates in STEM and about 1 out of 2 medical school students are subjected to sexual harassment from faculty/staff, with even higher incidence rates "among women and those who endorsed a gender other than male or female."
- Physicist Lawrence Krauss announced his retirement from Arizona State after sexual misconduct investigations.[22]
- Prominent physicist Alessandro Strumia delivered a sexist rant, misrepresenting the nature of his talk to the organizers, at CERN, and was suspended.[23, 24]

Furthermore, I have some direct experience with the subject. Thirty-three years ago, I was sexually harassed by a graduate school mentor. While I told a few friends at the time, I didn't acknowledge fully what was happening. I was an open-minded guy and could understand a momentary lapse in judgment, right? Yet, after this happened, I was still a little shocked and a little confused—I began to question why I had been welcomed into the research group, and I began to doubt my ability to succeed in the nuclear physics research, even while I finished my thesis, and graduated, and began interviewing. Meanwhile the perpetrator, having moved exclusively to the employer role, continued to let me know that the door was not closed, every few months slipping little asides into the conversation like, "Student/faculty relationships are a tradition in physics" or "You should loosen up and have more fun" or "Now that you've graduated, perhaps we can revisit the issue of our relationship." A few months later, in what I always considered to be an unrelated move, I decided to take a job at a rural Louisiana college near my home, as the only physicist on campus. After all, I was a grown man who made decisions independently of "tiny" side issues like this—but secretly, I was relieved to be far removed from the sexual harassment inflicted upon me by my mentor (not a phrase I would have ever thought to assign to the situation at the time). Some 30 years later, upon reading about Geoffrey Marcy's sexual harassment of his students, it dawned on me that I probably hadn't fully recognized all of the forces at play in my trajectory, and how fortunate I was to be able to carve out a path that I was happy with, despite being subjected to sexual harassment. It helped of course that I was male (and White and straight and cisgendered) and that my perpetrator was not terribly vindictive.

I don't mean to suggest that my experience is equivalent to what is experienced by many women in a sexual harassment or sexually abusive situation, but I am telling the story largely to amplify that the effects are long term and real, at least they were in my situation and, as I understand it, in many similar situations. Also I want to reinforce how hard it can be to recognize that what is happening is intrinsically wrong, and that it is the fault of the perpetrator, not the recipient, and that the ripples of the bad behavior can cause loss of confidence and questioning of abilities for years. So, by telling some of my story, I hope that others who find themselves in such a situation can recognize it more readily and thus be more cognizant of all the factors driving a particular career decision. Finally, I should add that telling this story is somewhat cathartic, and therefore a bit self-serving, even if it is difficult and painful for me to revisit this time in my life.

If the recent National Academies report[13] is anywhere close to the mark, then it is likely that several of your current students and colleagues have experienced some kind of sexual harassment, and, I would claim, are still dealing with the repercussions of this harassment in some respect. This reality, even more than the celebration of Dr. Strickland's Nobel Prize, compels me therefore to deliver a further call for new thinking about the issues of gender and physics, a call for more research and especially more practical advice—advice about how to tear down and/or overcome the barriers to success that the world, and science, and academia, and the culture of physics put in the way of those who are not White and not male. I am hoping for some help from those of you who have studied this issue, or who have lots of experience with it over the years, and from those who can help bridge the gap between what is known in the expert communities that study these topics and what physics teachers tend to know. Please consider writing about what you have learned over the years for the introductory physics teacher audience, and submit your ideas as potential articles for *The Physics Teacher*; we need your help to diminish the impact of these hindrances to equity and fairness in physics. In addition, I hope to receive manuscripts celebrating even more explicitly contributions to physics from outside the usual stereotypical circles, works that elevate the strengths and creative contributions by women. (I think immediately of the truly profound, but largely-uncelebrated-by-the-textbooks, work by Emmy Noether in linking two of the most important ideas in all of the history of physics—symmetry and conservation laws[25]). I am also calling for more work that celebrates what it is that we can do as physics teachers to encourage, nurture, and support students in the classroom to be more successful as learners, work like the recent article[26] by Zahra Hazari and Cheryl Cass about what teachers can do in the classroom to help students feel recognized as a physics person. Finally, I am calling for more advice and more concrete action against those who perpetrate, and more work to re-educate those who perhaps inadvertently reinforce sexual discrimination in its more and less subtle forms.

I am hopeful that this advice and action will come in the way of more manuscripts that can be published in *The Physics Teacher*, manuscripts that speak directly to the teachers of the introductory physics course, as that is a sure way to get it into the hands of the educators that can change the world. There, I have said it—I have that kind of faith in you, and that expectation of you, dear readers. I look forward to reading, and learning from, your submissions.

Sincerely, *Gary White*

Acknowledgments

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