introduction to astronomy at that level—seems to have been overlooked. The only such general introduction that my colleagues and I were able to find at that time was an excellent textbook by Jay Pasachoff[2] that wasn't available anymore, although a revised edition has since appeared. An experienced teacher working with me commented that the currently popular emphasis of Web-based resources for teachers and students on relatively narrow topics makes it difficult to present a subject like astronomy cohesively.

Another concern is the impact of too many curriculum changes on teachers. Our daughter teaches third grade, and one wonders how many enthusiasts of frequently revamping STEM curricula understand how much work goes into handling 25 rambunctious kids and their sometimes-difficult parents. Attrition of experienced teachers is a serious problem, and finding out that they need to master yet another way to teach math or science could be the last straw for some.

It would be interesting to hear from the authors whether such concerns have been covered in past evaluations or how they might be addressed in the future.

References

1. P. Foukal, *Eos Trans. AGU* **95**, 63 (2014).
2. J. Pasachoff, *Science Explorer: Astronomy*, Prentice-Hall (2000).

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It doesn't take a rocket engineer to recognize the widely used and unfortunately misleading technoscience cliché in the subtitle of the worthy September 2021 article "Improving science education: It's not rocket science—it's harder!" (page 26).

In the NASA History Series book *Remembering the Space Age*, Monique Laney, a historian at Auburn University, declares the term "rocket scientist" a "misnomer used by the media and in popular culture."[1] She points to the condemnation of the term by former National Air and Space Museum space history chair Michael Neufeld, who associates it with "a deep-rooted failure in the English-speaking media and popular culture to grapple with the distinction between science and engineering." Neufeld acknowledges that "the boundaries are fuzzy," but he asserts that "the correct term is 'rocket engineer.'"[2]

Most who mastermind and shepherd spaceflight to serve science—and maybe commerce—are engineers.

References

1. M. Laney, in *Remembering the Space Age*, S. J. Dick, ed., NASA Office of External Relations, History Division (2008), p. 92.
2. M. J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War*, Vintage Books (2008), p. xv.

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▶**Pompea and Russo reply:** We agree with Steven Corneliussen that the term "rocket science" is a poor overall descriptor of the scope of aerospace engineering. However, the term resonates with the public in describing endeavors that it views as difficult and complex or where failure would be highly visible (for example, the efforts to bring back *Apollo 13*).

When the astronaut, scientist, and educator George "Pinky" Nelson observes that education is harder than "rocket science," he accurately describes the complexities and difficulties in advancing STEM (science, technology, engineering, and mathematics) education. Just getting a rocket off the launchpad is much easier than getting the payload into the specific orbit desired. STEM education undertakings also benefit greatly from well-designed, intentional efforts from teams that use a systems-based approach.[1]

We also agree that effective classroom science education, especially at the elementary school level, is difficult for the reasons outlined by Peter Foukal. Science teachers are challenged by curriculum changes, poor textbooks, a paucity of computers and other equipment, and inadequate training in pedagogical content knowledge for the subjects they teach. From our experience, teaching is one of the most challenging professions; its difficulty is significantly underappreciated by other professionals. It is no wonder that there is currently a critical shortage of science teachers in the US (see Physics Today, March 2022, page 25).

Most concerning to us is that public education in the US has been under attack for decades, a topic well explored by Diane Ravitch, a former US assistant secretary of education. Public funding for education is increasingly being diverted to private and religious schools, which weakens the public school system. STEM professionals and their organizations need to take a more active role as stewards of local public STEM education in order to preserve the rapidly deteriorating educational ecosystem.[2]

References

1. S. M. Pompea, P. Russo, *Annu. Rev. Astron. Astrophys.* **58**, 313 (2020).
2. D. Basler, B. Bartel, "Fostering Stewardship in Science Education," 23 May 2022, in *Lab Out Loud*, podcast, https://laboutloud.com/2022/05/episode-267-fostering-educational-stewardship.

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Lesson from a lost radioactive source

I appreciated the item "Replacing high-risk radioactive materials remains a challenge" in the September 2021 issue of Physics Today (page 23). In 1972 my career at the University of Rochester started with periodic source replacements in the Tandem Van de Graaff accelerator, which used iridium-192. My colleagues and I also used the same nuclide in radiation-therapy breast implants. I had to assist in the operating room to ensure no iridium seeds were lost. Over the years we dealt with blood irradiators and several cobalt and cesium therapy machines and with many smaller sealed sources.

The only "lost" source that I can recall is a cesium-137 capsule used for a three-day cervical implant. It was removed from the patient on a weekend, and procedures were not followed. An inventory on Monday morning revealed that one source was missing. We found it under a conveyor belt that workers used to sort laundry by hand. The source was not damaged, and none of the workers received a significant radiation dose. The incident does, however, support the challenge referenced in the article—a challenge that is easily met by following procedure.

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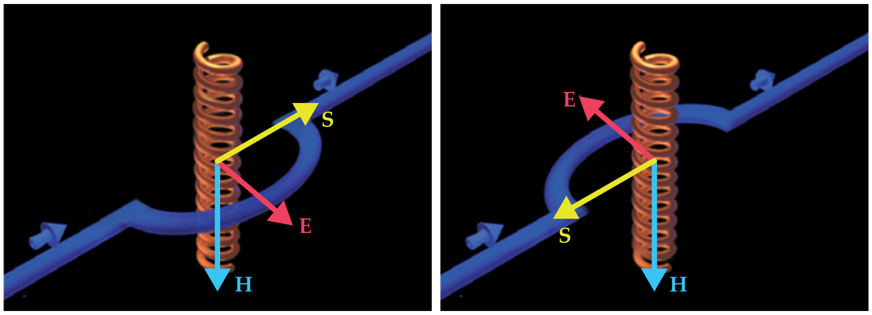

Revisiting the electric potential

In the Quick Study by Eve Vavagiakis, Thomas Bachlechner, and Matthew Kleban (PHYSICS TODAY, August 2021, page 62), the authors' claim about the ontology of the electromagnetic vector fields seems too simple. As indicated in the figure above (adapted from the authors'), an electron taking either of the paths around the solenoid has an electric field **E** extending into the solenoid, where there is a nonzero magnetic field **H**. For a short time, the electron creates a Poynting vector **S** carrying momentum. That momentum has to be taken away from the initial momenta and thus affects the phase difference between the paths. That quantum mechanical phenomenon, called the magnetic Aharonov–Bohm effect, depends on only the magnetic flux. The obtained phase change does not depend on the distance to the solenoid. Its size is easy to calculate for an infinite solenoid.

Usually, a properly renormalized electron can be thought of in quantum mechanics without considering the constantly emitted and absorbed photons building up the electric field. But for an electron passing around a solenoid, there is an exception, as noted by Lev Vaidman.[1]

The electrostatic version nicely described by J. J. Sakurai and Jim Napolitano is more straightforward.[2] At some point, the electrostatic potential has to be switched on, which, independent of the geometric details, has to involve an electric field. That electric field crosses the particle path and takes away or adds momentum, resulting in the observed phase difference between both paths.

References

1. L. Vaidman, *Phys. Rev. A* **86**, 040101(R) (2012).
2. J. J. Sakurai, J. Napolitano, *Modern Quantum Mechanics*, 2nd ed., Addison-Wesley (2011).

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▶Vavagiakis, Bachlechner, and Kleban reply: Fritz Bopp correctly points out that creating a potential difference necessitates a nonzero electric field. He goes on to assert that the field must cross the particles' paths, differentially accelerating them. If that were the case, the difference in phase could indeed be explained by the interaction of the particles with the electric field. As we describe in our Quick Study, however, the field could be switched on for a while and then off again while the particles are deep inside two long, tubular Faraday cages. Those cages shield the particles from contact with the nonzero field, yet while the field is on, there is a potential difference between the interiors of the two cages. That potential difference is therefore responsible for the difference in phase.

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Correction

July 2022, page 5—The last sentence of the "On the cover" description should read "the world's largest cryogenic particle detector." PT