

the high points of my undergraduate days at Caltech.

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Mavericks who failed

I enjoyed Tomasz Durakiewicz's commentary in the November 2022 issue of *PHYSICS TODAY* (page 10) about the benefits of being a maverick. He gave some wonderful examples of mavericks who succeeded, but what about those who failed? Some failed for bad reasons, such as trying to create perpetual motion machines. But some—such as Albert Michelson and Edward Morley in their famous experiment—failed for good reasons, and the world learned something from their failure.

I spent the bulk of my career doing research in industry. A director of research at one lab used to say, "If we're succeeding all the time, we're not trying hard enough." The question then becomes how does one reward the "good" failures. I don't think he ever figured that out. Has physics?

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Hubble has more time

In the article "Electric propulsion of spacecraft" by Igor Levchenko, Dan Goebel, and Katia Bazaka (*PHYSICS TODAY*, September 2022, page 38), the authors mistakenly refer to the *Hubble Space Telescope's* "hydrazine thrusters."

As project scientist for *Hubble* from 1972 to 1983—the period of its creation as a real piece of hardware, its design, and its early phases of construction—I clearly recall

that thrusters of any sort were not incorporated. That was because UV performance could potentially be lost through contamination by any gas used in thrusters.

Levchenko, Goebel, and Bazaka mention that "the telescope could potentially spiral back to Earth by 2028." Without a dedicated mission of another spacecraft to raise the orbital altitude of *Hubble*, the telescope will eventually decay into the upper atmosphere of Earth. That will cause *Hubble* to lose control of its pointing before finally making a fiery return. That is well in the future, with project leaders now estimating that there is a 10% chance that reentry will occur by October 2034, a 50% chance by July 2037, and a 90% chance by October 2045.

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Superdeterministic loophole

In her excellent *PHYSICS TODAY* report "Physics Nobel honors foundational quantum entanglement experiments" (December 2022, page 14), Heather Hill discusses how the laureates closed loopholes in the interpretation of entanglement. She rightly concludes that the freedom-of-choice loophole remains open, but she describes it incorrectly, writing, "Taken to an extreme, the loophole can suggest that every event in all spacetime was determined by the initial conditions at the Big Bang, an idea called superdeterminism."

Actually, that idea—that later events can be determined by earlier ones, and vice versa—is simply called determinism. There is a centuries-old philosophical tradition called compatibilism, which holds that even in a deterministic world we are free agents if we can do as we like without constraint. In the context of the Bell experiment, a compatibilist would say that experimenters are free to choose how to set their polarizers (for example, using the birthday of their grandparents or light from distant quasars), determinism notwithstanding.

Superdeterminism is much more subtle than that (and as a result is typically misunderstood or grossly oversimplified

in the media). It is based around the following question: Do the laws of physics allow us to vary the Big Bang initial conditions in such a way that we could describe a hypothetical universe where the same pair of entangled particles—that is, with the same hidden variables—are measured with differently set polarizers? Such a universe is counterfactual, and superdeterminism describes an emergent restriction on such counterfactual measurements imposed by suitably formulated putative laws of quantum physics.^{1,2}

No experiment to date has closed the superdeterministic "loophole." Indeed, we are still searching for a realistic experimental protocol that can test it. We will get there one day, hopefully in the not too distant future, but it will likely not be via a Bell experiment.

References

1. T. N. Palmer, *Proc. R. Soc. A* **476**, 20190350 (2020).
2. S. Hossenfelder, T. Palmer, *Front. Phys.* (2020), doi:10.3389/fphy.2020.00139.

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