Clarifications on the Chien-Shiung Wu feature

The article "Chien-Shiung Wu's trailblazing experiments in particle physics" (Physics Today, December 2024, page 28) says Elena Aprile "was the second woman to join the [Columbia University physics] department, more than four decades after Wu." Many former Columbia physics students, however, know this to be untrue, having taken the class we affectionately called "Lucy Lab," designed and supervised by Lucy J. Hayner. Her Physics Today obituary (January 1972, page 97) describes Hayner as "a professor emeritus of physics at Columbia University." It says she received a master's degree at Columbia in 1920 and that "after returning to Columbia in 1929, she taught in and later headed the Ernest Kempton Adams Laboratory." As a Columbia undergraduate in the early 1960s, I took Hayner's lab class and Wu's course in nuclear physics. Thus, I experienced the teaching of two women on the Columbia physics faculty at a time when Aprile—who was born in 1954—was not even 10 years old.

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CHIEN-SHIUNG WU at Columbia University, sometime around 1975. (Photo from American Association of Physics Teachers [AAPT], courtesy of the AIP Emilio Segrè Visual Archives.)

"Chien-Shiung Wu's trailblazing experiments in particle physics" by Chon-Fai Kam, Cheng-Ning Zhang, and Da Hsuan Feng (Physics Today, December 2024, page 28) helps to correct the scientific community's failure to give appropriately enormous credit to Wu for her many accomplishments, especially her leadership of what may well be described as the most important experiment in the history of particle physics: the demonstration that the weak interaction violates parity conservation. The article's brief mention of the test of hidden-variable theories, however, needs more complete referencing.

Following John Bell's celebrated 1964 work in which he derived an inequality that must be satisfied by local hidden-variable theories, it was a paper by John Clauser, Michael Horne, Abner Shimony, and Richard Holt that proposed a practicable experiment that could test the Bell inequalities.[1] As a postdoc at the University of California, Berkeley, Clauser brought that idea to Stuart Freedman, who was then a UC Berkeley graduate student under the guidance of Eugene Commins. It was Freedman who conducted the experiment as his thesis, and the work was published in *Physical Review Letters* in 1972.[2] The experiment provided compelling evidence that local hidden-variable theories were wrong.

As Kam, Zhang, and Feng note in their article, Alain Aspect, Clauser, and Anton Zeilinger received the 2022 Nobel Prize in Physics "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science." (For additional information, see Physics Today, December 2022, page 14.) Just as Wu died without receiving a Nobel Prize

for her early photon entanglement experiment, Bell and Freedman died without receiving a Nobel Prize for their work whose significance was indicated by the awarding of the prize to Aspect, Clauser, and Zeilinger.

References

1. J. F. Clauser, M. A. Horne, A. Shimony, R. A. Holt, *Phys. Rev. Lett.* **23**, 880 (1969).
2. S. J. Freedman, J. F. Clauser, *Phys. Rev. Lett.* **28**, 938 (1972).

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In the fascinating article "Chien-Shiung Wu's trailblazing experiments in particle physics" (PHYSICS TODAY, December 2024, page 28), the authors incorrectly describe the result of an experiment testing a prediction by John Wheeler.[1] They report that Ernst Bleuler and Helmut Bradt at Purdue University measured the ratio of perpendicular to parallel polarization of gamma rays emitted from the decay of an electron–positron pair as 2.1 ± 0.64, a relatively large uncertainty. That ratio was for one run; the published result combining all of their measurements was actually a much more respectable 1.9 ± 0.3.[2] Given that Wheeler predicted a maximum ratio of 1.100 and later theorists[3,4] fixed the error and calculated a ratio of 1.7 for the configuration used by Bleuler and Bradt, the two could at least be given credit for showing that Wheeler's math was wrong and that the new predictions were pretty good.

By adroitly utilizing the latest in scintillation detector technology instead of Geiger counters, Wu and her graduate student Irving Shaknov[5] obtained 2.04 ± 0.08, where the improved theory predicted 2.00 for their configuration. The scientific community accepted this as confirmation of Wheeler's suggestion that the electron–positron pairs decay from a state with zero angular momentum. Wheeler makes no mention of entanglement, whose significance became apparent much later.

References

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5. C. S. Wu, I. Shaknov, *Phys. Rev.* **77**, 136 (1950).

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► **Kam, Zhang, and Feng reply:** With respect to Robert Cahn's comments, we agree that John Bell and Stuart Freedman should be acknowledged, just as Chien-Shiung Wu should be, for their contributions to the body of work that eventually earned Alain Aspect, John Clauser, and Anton Zeilinger a Nobel Prize. We wanted to draw attention to Wu and Irving Shaknov being the first to conclusively verify photon entanglement. Considering that Wu and Shaknov's experiment was done only about 15 years after Albert Einstein, Boris Podolsky, and Nathan Rosen first brought the concept of quantum entanglement to light in what's known as the EPR paper, our personal perspective is that it was worthy of a Nobel Prize.

With respect to Stephen Durbin's comments, we agree that the experimental efforts made by Ernst Bleuler and Helmut Bradt should not be dismissed. John Wheeler made no mention of "entanglement" in his paper, and neither did Wu and Shaknov in their letter. When the latter published their results in 1950, the word was not yet a common scientific term. To perform an experiment like that 75 years ago required Wu to be well ahead of her time. We think that she had the concept of entanglement in her mind.

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Comments on "Careers by the numbers"

The October 2024 careers issue of PHYSICS TODAY missed the mark in more than one way. In Richard Fitzgerald's otherwise excellent article "Careers by the numbers" (page 30), the figure showing new physics PhDs' starting salaries (page 35) confusingly has federally funded R&D centers (FFRDCs) separate from university-affiliated research institutes (UARIs). It lumps the former with government labs and the latter with universities. Both FFRDCs and UARIs are nonprofit entities that are sponsored by various government agencies and perform a broad range of research. But the mission-driven research at several FFRDCs, such as Los Alamos National Laboratory and Sandia National Laboratories, is much closer in nature to the work at UARIs, whereas the discovery science research at other FFRDCs, such as Oak Ridge National Laboratory and Argonne National Laboratory, parallels university-based research.

More egregious, however, was that the other two features in the careers issue focus mostly on academic careers. As Fitzgerald's article lays out, the vast majority of new recipients of physics bachelor's degrees and a majority of new recipients of physics PhDs do not find employment in academia. Why, then, ignore the many and important other ways that physicists contribute to society and the economy? This careers issue contributes to maintaining the myth that the only proper career path for physicists is one that is university based.

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