was firm in his support of the wave theory of light and in his refutation of localized energy quanta. Finally, the Nobel Prizes to Einstein (1922) and Millikan (1923) do nothing to change this picture. Einstein got his prize not for his *theory* of the photoelectric effect, but, as the Nobel committee was careful to point out, for his *law* of the photoelectric effect. The distinction is significant. Millikan, who in his Nobel address described the photoelectric effect as an as yet not understood "interaction between ether waves and electrons," appreciated this distinction. So should the physicist of today.

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MARGARITONDO REPLIES: Helge Kragh's criticism misses the target, since my article was not a chronicle of events in the early years of quantum physics. The article presents fundamental contributions of the photoelectric effect to modern physics, in celebration of the first centennial of its discovery. Einstein's use of the idea of the photon to derive the linear frequency law was one of these fundamental contributions. Robert Millikan's work is still remembered not because it proved the linear frequency law, but because Einstein had derived the law using the idea of the photon. In comparison with Einstein's derivation, neither the triggering hypothesis nor Millikan's and the Nobel Prize committee's opinions are relevant to the centennial of Heinrich Hertz's discovery.

The importance of Einstein's derivation stems from its seminal role in establishing the concept of the photon and quantum physics in general. "Establishing" has nothing to do with the majority opinion at that time. Many facts in physics are established before the majority of physicists accept or even know them. For example, we now realize that the results of Georg Bednorz and Alex Müller had established the existence of high-temperature superconductors when these results were known by a very few people, and believed by even fewer. Similarly, we can see that the quantum revolution became irreversible in 1916, even if the contemporary majority opposed it.

As to the distinction between "equation" and "theory," the seminal role of Einstein's theory is not affected by the possibility of obtaining the law with time-dependent perturbation theory and without using the concept of the photon. It was Einstein's derivation that contributed to the development of basic quantum mechanics, and without basic quantum mechanics we would not have time-dependent perturbation theory.

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## Bachelor's Booster

The roundtable on physics research in industry in the February 1988 issue (page 54) was stimulating and insightful. Inevitably, the roles of engineers as well as those of physicists were discussed. In recent years these two groups have become closer, yet some longtime myths and misinformation persist. I was struck by Robert Frosch's perceptive comment that "industrial physicists [with PhDs], who are in with a large number of engineers with bachelor's degrees, are very likely to shine. But whether this happens because of the difference between physics and engineering or the difference between a lot of education and some education isn't clear to me." Later Robert Stratton says, "At least 50% of all electrical engineering degrees are being awarded to noncitizens." Stratton is, of course, referring to PhDs; far fewer than 10% of all bachelor's degrees in engineering are awarded to noncitizens.

It appears to be a common presumption in the physics community that only PhDs are real physicists or electrical engineers. While the doctoral degree is certainly an important component of our educational system, the bachelor's degree remains a very significant one for engineers, and perhaps it should be for physicists too. The well-documented shift in undergraduate enrollment from the physical sciences to engineering over the last decade or more may be in part a reflection of the difference in attitude toward the bachelor's degree between physicists and engineers. This trend has occurred even more strongly among the brightest students than for the general student population. I would also note that data over several years on per capita awards of degrees to citizens in Japan and the United States show a lead for Japan at the bachelor's level and a lead for the United States at the PhD level. Thus it is difficult to make the case that from the standpoint of economic competitiveness the PhD degree is more significant than the BS.

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