Today's Shrinking Science: Another Dream Deferred

While I was finishing up my PhD from the University of Washington, I spent one morning in a second-grade classroom fielding questions on astronomy. The enthusiasm of those seven-year-olds for all things cosmic was delightful. They loved astronomy and they loved science. For every question I asked them a thousand possibilities spilled out of their heads at once like loose M&Ms. They *had* to know if the Sun would blow up, where the end of the universe was and why we hadn't seen life on other planets yet. They laughed when I shrugged my shoulders and said, "I dunno." They were, however, ready for the challenge when I told them answering those questions was their responsibility as the next generation of scientists. I left intoxicated with their excitement. It was a sad counterpoint to the rest of my day.

That afternoon I sat in on a seminar called "How to Find a Job in Science," given by a senior professor in biology. When I arrived the small classroom was filled to capacity with graduate students from all fields of science who, like me, were close to finishing their PhDs. All of us had been raised in the late 1960s and '70s, when this nation's enthusiasm for science seemed limitless. We caught the fire from watching the Apollo missions on TV, seeing a dinosaur for the first time at a museum or reading about the undersea explorations of the deep-sea submersible Alvin. Now the mood in the room was gray. We were facing a bitter truth. After a lifetime of dreaming science, studying science and training technically in science, the odds were slim that we would ever find a secure job in science.

Today America's young researchers are, like so many others, watching as their expectations and hopes are diminished. Though our personal loss is merely part of the arithmetic of a larger dream deferred, it is strange for us to think that all of our training and enthusiasm will go homeless. I have always thought that science, like art, is our society's way of looking outward beyond the details of everyday commerce. The effort made in science seems a measure of our culture's capacity for a wider vision of the world and its concern to forge links with a future it can barely imagine. When I was a child and dreamed of being a scientist I felt that my country was urging me to join in the adventure of building that future. Today I feel like my country has changed its mind. It is simultaneously sad and confusing.

I do not know what the solution is for scientists of my generation. In an era of tight budgets I do not know how or if many of us can survive. I would like to believe that as with so many problems, the issue revolves around resources and values. If budgets are tight then the need for huge projects like the Superconducting Super Collider and mapping the human genome may be questioned; the need to use the talent in science that America itself has nurtured, however, should not be. Most of us retain our enthusiasm for our fields of inquiry, but in the face of increasing pressures our ranks will diminish. Perhaps this has to happen; perhaps it is just another example of downsizing. If so, I can't help but wonder what will become of the next generation of American scientists. I can imagine myself in front of another group of second-graders, delighting in their excitement but reminding them: "I'm sorry you guys were born too late to join in. We are not in this business anymore."

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Atomic Parity Violation's Vaporous Beginnings

In his Reference Frame column "Some Small Big Science" (October, page 9) Daniel Kleppner is trying to say kind words about small science. But in jumping from some early (theoretical) proposals for parity violation in atoms to the present-day status of experiments he skips over the fascinating history of early experiments in this field. This is a pity, since the omitted history would

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have strengthened his case for the complementarity of little science to big science. The first correct experimental report of optical activity of bismuth vapor[1] preceded the results of the SLAC parity violation experiment.[2] These two experiments *together*, small and big, helped establish the now standard Glashow–Weinberg–Salam model, and not just the big experiment alone, as stated by Kleppner.

References

1. L. M. Barkov, M. S. Zolotorev, JETP Lett. **27**, 379 (1978).
2. C. Y. Prescott *et al.*, Phys. Lett. B **77**, 347 (1978).

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KLEPPNER REPLIES: L. M. Barkov and M. S. Zolotorev indeed observed the effect of the electroweak parity-violating interaction through optical rotation in bismuth. Unfortunately their work did not have the impact it could have had, because previous experiments at Oxford and Seattle appeared to be in disagreement with electroweak theory, and a fourth experiment carried out in Moscow also disagreed. By the time the atomic experiments became reliable, the electroweak theory had been confirmed at SLAC. Eugene D. Commins summarized references for these first-generation experiments in a 1981 review article.[1]

Reference

1. E. D. Commins, in *Atomic Physics 7*, D. Kleppner, F. M. Pipkin, eds., Plenum, New York, (1981), p. 121.

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Has Particle Physics Fulfilled Its Promise?

Having recently heard Martin Gutzwiller present a wonderful colloquium on the Earth–Moon–Sun system at the University of California, Santa Cruz, it was with a certain sense of sadness that I read his letter in PHYSICS TODAY (August 1994, page 9). He asks two questions. The second concerns the focus of many theorists on technical issues rather than real physics. Few would dispute that this is a serious problem, which we must strive to overcome in training our students. In this letter I would like to address the first question: What has particle physics produced in the last 45 years besides hype? The way in which Gutzwiller frames this question indicates a most profound misunderstanding of the developments in particle physics over the last 25 years or so, and particularly a lack of awareness of the precision with which the standard model has been tested in the last several years at Fermilab, SLAC, LEP and elsewhere.

Gutzwiller complains that particle physicists cannot yet calculate reliably the magnetic dipole moment of the neutron, and that this is just as things were 45 years ago. However, unlike at that time, we have a theory of strong interactions, quantum chromodynamics, with which we can calculate many things, and which is in good agreement with experiment. Just as in ordinary quantum mechanics, we cannot calculate everything. I would certainly not say to a condensed matter physicist that your discipline is a failure because you can't calculate the properties of metallic iron from the atomic number and mass of iron. The static properties of hadrons represent a similar sort of problem. There is no small parameter permitting a simple approximation. Even so, various sorts of crude calculations of the dipole moment are possible, and we can at least describe a systematic computation and estimate the computer resources needed to obtain a given level of accuracy. Forty-five years ago there was also almost no understanding of the weak interactions. Today we understand all of low-energy weak interactions in terms of essentially three parameters: the Fermi constant, the Z mass and α. Moreover, from these one obtains precise predictions of the Z width, the W mass and numerous other phenomena, which are being tested at LEP and SLAC at the 1% level or better.

Unfortunately it appears that the letter has a broader aim: an attack on particle physics and its funding. To say that the field has not revealed fundamental truths as intellectually significant as, say, Maxwell's equations is simply untrue. It is hard to understand how any physicist could suggest that it is not interesting to find, for example, the interactions that give rise to symmetry breaking in the weak interactions and the origin of fermion masses. Whether it is worth hundreds of millions of dollars a year is a fair topic for debate. Needless to say, many of us think the answer is a decided yes.

Gutzwiller might keep in mind that many of our fellow citizens feel no need to fund the education of their children, much less research into obscure aspects of condensed

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