

have strengthened his case for the complementarity of little science to big science. The first correct experimental report of optical activity of bismuth vapor¹ 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. Zolotarev, JETP Lett. **27**, 379 (1978).
2. C. Y. Prescott *et al.*, Phys. Lett. B **77**, 347 (1978).

►GABRIEL KARL

University of Guelph
Guelph, Ontario, Canada

KLEPPNER REPLIES: L. M. Barkov and M. S. Zolotarev 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.

►DANIEL KLEPPNER

Massachusetts Institute of Technology
Cambridge, Massachusetts

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

SUPERCONDUCTING MAGNET SYSTEMS



The Industry Standard For Quality And Reliability!

- ✓ Reliable "Workhorse" Magnet Systems For Demanding Applications
- ✓ MIL-STD Approved Quality Control
- ✓ A Magnet Pioneer With 27 Years Fabrication Experience
- ✓ World's Largest Supplier of Helium Level Instrumentation
- ✓ World's Largest Supplier of Vapor Cooled Current Leads
- ✓ On Time Delivery
- ✓ Technical Support
- ✓ Value Pricing

Call, Fax Or Write For Free! Product Catalog!

American Magnetics, Inc.
PO Box 2509, Oak Ridge, TN 37831

Phone: 615-482-1056
Fax: 615-482-5472

Circle number 12 on Reader Service Card

matter physics, fluid mechanics or other important disciplines. And while much of the public support of science that does exist comes from the belief—currently severely weakened—that science contributes to the public good, much of it comes from the natural human interest in subjects like the origin of our universe, the nature of fundamental laws and other topics that Gutzwiller feels we overemphasize.

►MICHAEL DINE
*University of California,
Santa Cruz*

GUTZWILLER REPLIES: Few physicists will deny that most of our beloved fields of inquiry have matured. While we get better at solving the technical problems in our daily work, the horizons that we want to reach seem to recede faster than we are able to move. Dialogue between the different special areas is essential if we want to maintain perspective in our enterprise and unity in our profession. Such a discussion has to come before (not after!) we try to enlist the sympathies and the support of the general public.

It was therefore very gratifying to receive Michael Dine's reply to my letter. Disagreements are not nearly as important as the willingness to exchange views, and not only to fight about them but to consider them seriously. We have to remind ourselves that in almost all practical situations there are mutually exclusive aspects of the same object. That is one of the basic lessons of quantum mechanics. I hope that Michael will overcome "a certain sense of sadness" and see more than "a most profound misunderstanding" in what I have to say. Maybe he has lower expectations than I do for his chosen field of high-energy physics, and he rightly points out that our command of condensed matter is shaky at best. We probably do a better job in calculating the ground-state properties of metallic iron than he thinks, but some of our shortcomings are dramatic. For example, neither statistical mechanics nor chemical physics understands the liquid state: We know how to work out the properties of ice and steam, but we have no clear idea why there is such a thing as ordinary liquid water! And even the marvelous Bardeen-Cooper-Schrieffer theory of superconductivity requires the input of its one essential parameter from empirical data. In these two cases we physicists have not been able to carry out the reduction from thermodynamics to atomic and molecular physics, Steven Weinberg's

"dream of a final theory" notwithstanding!

Dine does not want to call condensed matter physics a "failure" any more than I used that word in my letter. Nevertheless we should try to see more clearly what we have accomplished in the light of what is still ahead of us. That would be a great service to our students and might even make a difference in our own work. Theoreticians like to state over and over again that the electron's magnetic dipole moment represents the ultimate in agreement between experiment and theory. They do not mention, however, that Toichiro Kinoshita had to evaluate 891 Feynman diagrams on the computer to get the fourth-order correction (with huge error bounds) or that the empirical value of the fine-structure constant may rank as the greatest mystery in physics. Like all human beings, we love to brag about our success and forget the trouble. I am not satisfied with relegating the equally important magnetic dipole moment of the proton to "various sorts of crude calculations" and only "estimate[ing] the computer resources needed to obtain a given level of accuracy." In the long run, our sights should not be set exclusively by what our technical abilities can accomplish. If we cannot reach the goals that we find most interesting, we should say so, rather than sell some substitute as worthy of a crash program simply because it is technically feasible.

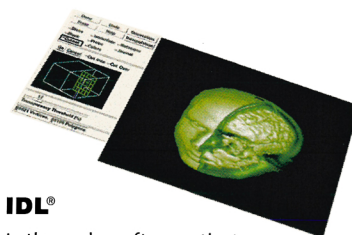
A good deal of the most immediate and important physics seems to be beyond our reach at this time. Are we going to talk openly with one another about this situation, which affects the very core of our profession? Or are we so worried about our future that we have to subdue any form of healthy skepticism in order to maintain a collective face of smiling optimism to the outside world? It won't work unless we first understand each other about where we stand and what we are looking for. More dialogue inside physics is critical for our survival!

►MARTIN C. GUTZWILLER
*IBM Thomas J. Watson Research Center
Yorktown Heights, New York*

Open Season on Lederman's 'Open Letter'

In "An Open Letter to Colleagues Who Publicly Opposed the SSC" (March 1994, page 9) Leon Leder-
continued on page 73

Spend More Time Doing Science and Less Time Programming



IDL®

is the only software that allows you to program four to ten times faster* than FORTRAN or C. It seamlessly integrates all of your scientific computing needs in a single package – breathtaking 2D, & 3D graphics, powerful number crunching, flexible data I/O and more. It even includes a complete GUI toolkit for creating point and click applications. And, because IDL runs on PCs, Macs, Unix and VMS workstations you won't have to rewrite your code every time you change machines.



Join the elite group of more than 20,000 scientists around the world who are saving time and money by using IDL.

Call us for a free demo.

303-786-9900 FAX 303-786-9909

Research Systems, Inc.
2995 Wilderness Place
Boulder CO 80301

IDL



*based on a survey of IDL users

Circle number 14 on Reader Service Card