



THE BIG, THE BAD AND THE BEAUTIFUL

Leo P. Kadanoff

This should be a good time for physics. Our President, several governors and many industrial leaders have eulogized science as significant both for its own sake and also in helping our nation maintain its long-term competitive position. But despite all this public goodwill, US physics continues to decay.

The first and most serious decay is on the industrial side. For example, Ed David estimates that over the last three years oil industry support of basic science and engineering has declined by about one-third. The breakup of AT&T has threatened the support base of the world's best industrial laboratory. Other labs have deteriorated, probably as part of the usual "life history" cycle of industrial laboratories. Because we have not seen any large offsetting growth of new private-sector centers in the physical sciences, the net result is decline.

Government-based science and technology have also done poorly. This result is most obvious in the NASA-based programs in planetary sciences, astronomy, atmospheric sciences and so on. As an apparent result of program misdirection, management incompetence and pursuit of publicity, during a period of several years we totally lost the capability of launching anything—shuttles or Atlases or balloons. So our once excellent planetary and space programs are in trouble. Still NASA continues to put publicity above science and technology. Corresponding losses have occurred in other areas of physics. Basic research in plasma physics has been too tightly coupled with fusion R&D, so that the recent cuts in the fusion program have hurt the basic work. "Environmental" science has disappeared precipitously from the national laboratories.

The universities have not done very

well either. Undergraduate training suffers because high-school teaching in mathematics and physics is so very poor. An adequate supply of really good American graduate students is unavailable, so that graduate education (and the supply of teaching assistants needed to teach undergraduates) must rely upon the availability of students from abroad.

Another university difficulty is the spottiness of governmental support. There has been oversupport for some chosen areas (mostly based on big science) like supercomputer-based numerical computation or high power laser experiments. However, over the last seven years, we have seen attrition in support for small-group efforts. For example, condensed matter experiment, which is strongly based in the small-group mode, has had considerable difficulty in keeping sufficient support to remain competitive with analogous efforts in Europe or in industry. Additional cutbacks in Federal funding of condensed matter experiment are in progress.

The decline in the support for small science is particularly painful because the small-science mode is particularly appropriate for graduate student training. Students can plan small experiments, build the equipment, take the data and assess the connection of the output with theory. The time constants and the scale of large science are much less appropriate for training new scientists.

Governmental action to improve this situation seems to be largely misdirected. Instead of investing in small science our leaders seem to be entranced by less valuable but more arresting big projects: Star Wars before mine sweepers; billions for Superconducting Super Colliders, but inadequate funds to even run the neutron sources that might give insights into the new superconductors; money poured into supercomputer centers, but no support for the more economical use of local or individual computers on individual campuses; math-

ematics institutes funded, but a steep decline in support for faculty doing mathematics research; and so forth.

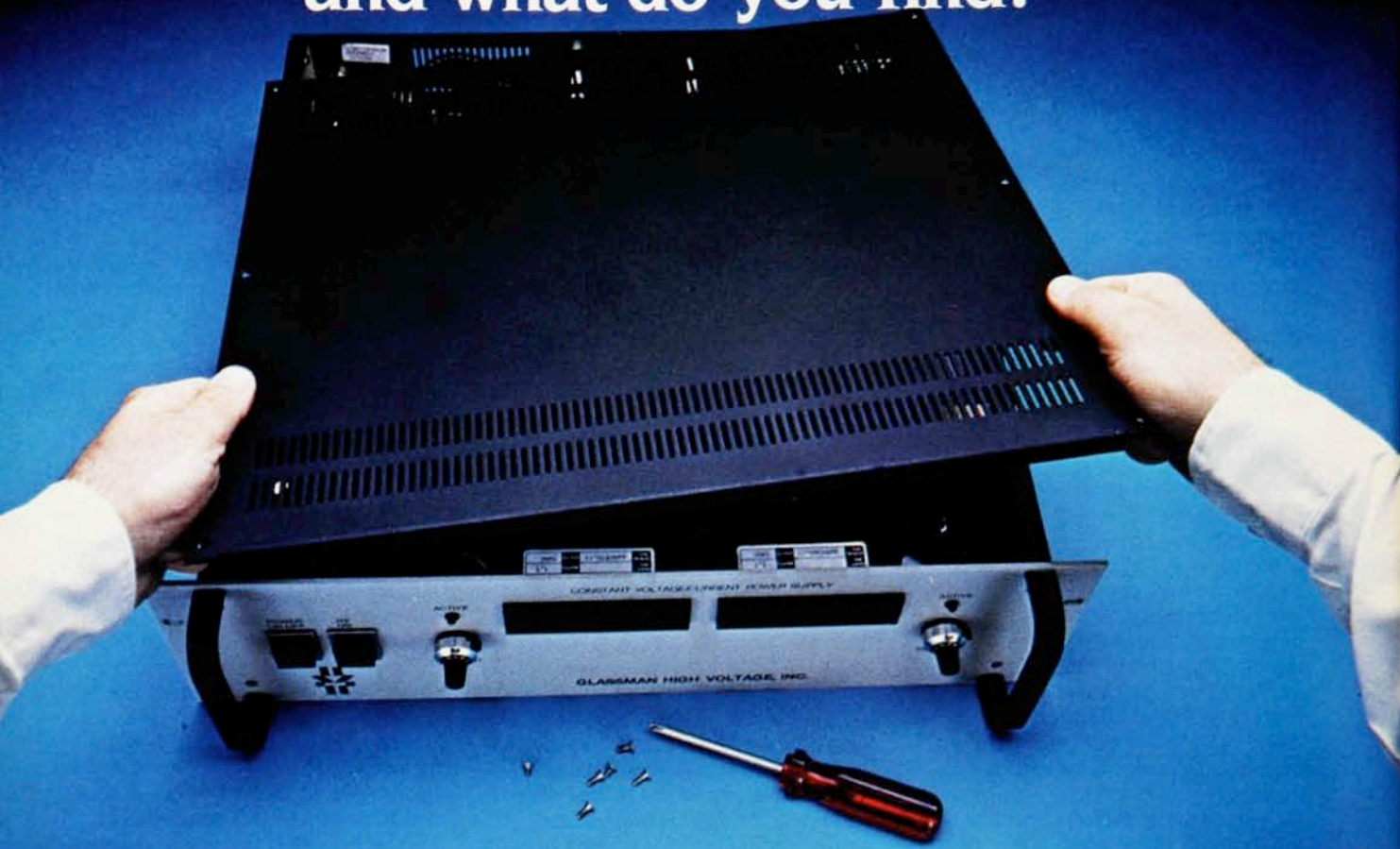
These tendencies can be seen in the NSF-sponsored Science and Technology Centers, which are intended to provide a meeting place for university and industrial scientists to work on common problems. The nation would indeed be helped by some carefully chosen additional possibilities for innovative research of the highest quality. Perhaps some of this would be helped by an interdisciplinary context in which new groupings of investigators would appear. But it looks as if these S&T centers are going to be a replacement for basic-science projects rather than a supplement to them.

These centers are also likely to focus upon the immediate needs of industry, rather than on basic science. In my view, this direction of development arises from a complete misunderstanding of what industry needs from the university world. By and large, big industrial concerns have sufficient resources to attack any technical problem they face. In some measure they need the universities to help in areas of sudden and unexpected need. For example, when oil firms suddenly realized that they could use tomography to "see into" rocks in a three-dimensional manner, they hired the knowledge of outside experts. But industry's most important need is for really new, "far out" ideas. Universities can serve as an important intellectual source. Big, project-directed science will be too focused and too goal oriented to provide the breadth and the innovation sorely needed by industry.

In this context, it is salutary to remember the disappointing results of the NSF Presidential Young Investigators Program. This program was intended to fund a group of promising young engineers and scientists and guide them into types of research that could be of long-term use to the US. The NSF was to give some money, and some of that money was to be matched

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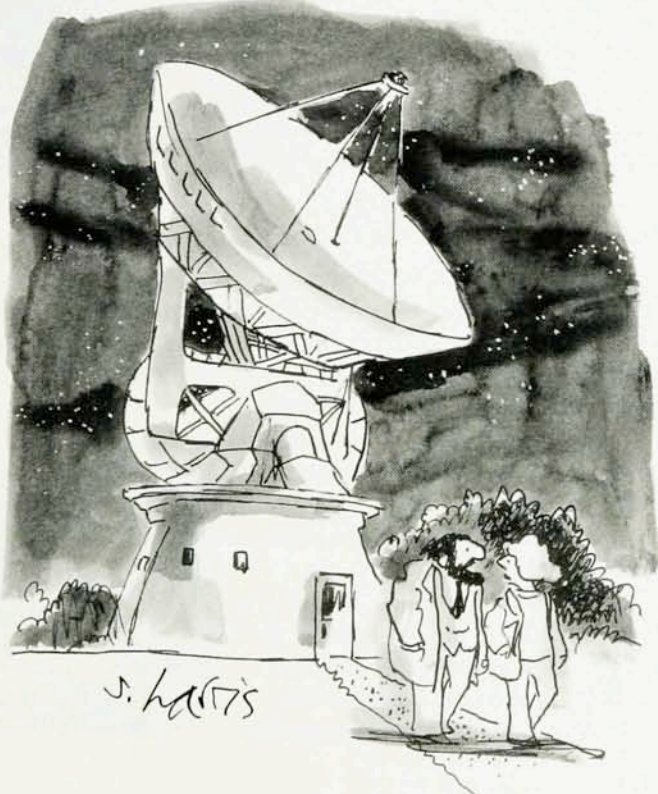
by industry, producing an incentive to joint exploration of new areas of interest. For many of the investigators, the match didn't work out. Often industry did not wish to invest in areas in which there would be only a long-term payoff—while promising young scientists did not wish to channel their research into areas with only short-term interest.

Much of the government sponsorship of research is forcing us to choose between the immediately fashionable and what will be interesting in the long term. The fashionable work is being structured into big projects and large teams, at considerable potential cost to the quality of US science and technology. Even in superconductivity, where almost all previous advances have come from very small groups, there is considerable governmental pressure for the construction of team-based "initiatives."

But I do not wish to suggest that the trouble lies entirely outside our physics community. In some measure, our own people are responsible. We scientists have chosen to follow fashion and have not continued research in less fashionable areas. We have thoughtlessly pushed our own subjects of research without concern for whether these areas have a value commensurate with their cost. And we have indeed pursued big science.

While giving lip service to statements that a balanced and solid physics program requires a major investment in small science, physicists have pushed for each of the big projects. It is easier to argue for another synchrotron light source or for a supercomputer or supercollider than for the broad programs that will provide the real intellectual base for understanding our natural world. The big projects provide jobs. They have sufficient "sex appeal" and economic impact to command attention. However, in the long run an overinvestment in such efforts detracts from good science.

The true value of science is in the development of beautiful and powerful ideas. Overinvestment in big science detracts from what is really worthwhile. I do not think that the nation's or the government's budget for research or for R&D is too small. It is, however, increasingly misdirected toward grandiose projects. We physicists have a responsibility to understand what is truly valuable in science and use this understanding to help the nation develop and express its priorities. In doing this, we should push for the kinds of work that are of enduring intellectual and technical value, rather than projects that are "in the right field" or are simply easy to sell. ■



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