

It was stated, among the conclusions of their own studies, by certain sociologists. This is the claim that many scientists so heatedly challenge. I accept Collins and Pinch's declaration that they are not among the sociologists who take this view, though much of what they say in *The Golem* about the general character of science would seem to place them squarely in that camp. Perhaps it is just a case of the rhetoric getting in the way of the message, in which case the moral is clear: We should all pay more attention to explaining clearly where we stand, and steer away from extravagant and sometimes inflammatory flourishes.

N. DAVID MERMIN
Cornell University
Ithaca, New York

ITER Debaters Reply to Pro and Con Fusion Comments from Readers

We welcome the letters from Janis Lawyer, Igor Fodor and Bruno Coppi (PHYSICS TODAY, December 1996, page 11) commenting on our debate about the pros and cons of proceeding to the actual construction of the International Thermonuclear Experimental Reactor (ITER) following completion of the six-year Engineering Design Activities (EDA) phase in mid-1998 (PHYSICS TODAY, June 1996, page 21). We hope that the science and engineering communities will continue to offer critical comments on the future directions of fusion research—that is, on learning how to use thermonuclear energy in a benevolent fashion to generate electric power.

Lawyer suggests a similar debate on the merits of fusion research itself. Underlying this suggestion is the point, recognized by the fusion research community, that even its best efforts may not lead to a full scenario for economically competitive fusion power. However, along with many others, the members of this community believe that fusion does have a great potential for environmentally safe power generation—a potential that mandates exploration and understanding.

We concur with Fodor's comment that the time scale for fusion power could well stretch to the year 2050. But our society will probably not be able to continue for another century as an economy based on fossil fuels. A crisis is coming and there are a limited number of possible responses, none of them free of risk and proven to be economically and environmen-

tally viable. All of them—including fission, fusion and solar (biomass, direct conversion and heating)—need more support now, and the cost for even the most vigorous research program would be only a minor fraction of 1% of the nation's current annual spending on energy consumption. A far greater cost will be incurred down the road if we postpone the hunt for a benign energy source. Magnetic and inertial fusion in particular will take a long time to develop or even realistically assess. Clearly the completion date is a strong function of funding levels. To lose the present infrastructure and multinational momentum would add many years to the timetable.

Fodor also brings up other long-standing issues for fusion prospects, as have been identified elsewhere.¹ Here, we respond briefly to three of his specific points.

First, it is premature to guess what the ultimate cost and reliability of a fusion reactor will prove to be. Studies with present-day "credible" assumptions find fusion reactors to be competitive with other nonfossil energy sources, but only further scientific exploration and technological experience will make it possible to develop realistic answers.

Second, a number of studies have indicated that liquid lithium can be employed safely, as in other liquid metal-cooled reactors. A more conservative approach for tritium breeding could utilize nonreactive solid pellets formed of oxides or zirconates of lithium.

Third, the production of long-lived radionuclides will be orders of magnitude below that in comparable fission reactors, particularly if low-activation structural materials such as vanadium are used. Still, as Fodor points out, there will be large quantities of low-level waste. It is thought that this waste can be recycled for reactor reuse. Nevertheless, the building of a successful fusion reactor will require a much more comprehensive knowledge of low-activation material technology than is now available, and we encourage continued research in this area.

Coppi points to the important ideas for a burning-plasma experiment pioneered in the Ignitor concept. Our June 1996 dialogue specifically cited Ignitor, which is now being prototyped in Italy, as one example of an affordable ignition or near-ignition experiment. Constructed soon, Ignitor could provide unusually worthy insights pertaining to the characteristics and performance of a fusion plasma, including ITER, and could guide

scenarios for plasma control, heating and diagnostics.

Our PHYSICS TODAY debate last June also cited the growing accuracy of computer modeling and simulation. Since then, this approach has started to yield a computer-theoretic understanding of the turbulence suppression discovered earlier in experiments using reversed magnetic shear. (See PHYSICS TODAY, January 1996, page 9.) Support for this increasingly powerful tool in plasma research has not kept pace with its potential, however, and we strongly endorse a much-increased level of funding for fusion-relevant computation.

Finally, we wish to point out that subsequent to the completion of the EDA in mid-1998, a determination is to be made by the present parties to the ITER agreement (the US, the European Union, Japan and Russia) regarding the construction of ITER. As of mid-December 1996, it appears likely that if the parties were to elect to construct, ITER would be sited in Europe or Japan, with the bulk of the cost to be borne by the host. We recognize that many factors will enter into the decision process and that the numerous and complex issues could be resolved in many different ways. In any case, these negotiations may be expected to define the character of a continuing ITER process that would consist of large-scale multinational collaboration in fusion research and technology. We believe that planning for an effective post-1998 fusion research program for the US must take place now and must contemplate the full range of possible outcomes of these discussions.

In summary, we believe that energetic research directed toward economically competitive fusion power is an essential component of today's long-range energy strategy, and we encourage a robust multinational program of fusion experimentation, theoretical analysis, computer-aided analysis and materials technology.

Reference

1. President's Committee of Advisers on Science and Technology, *Report of the Fusion Review Panel* (July 1995), and references therein.

MARSHALL ROSENBLUTH

University of California, San Diego
La Jolla, California

ANDREW SESSLER

Lawrence Berkeley National Laboratory
Berkeley, California

THOMAS STIX

Princeton University
Princeton, New Jersey ■