FUSION IN A FLASK: EXPERT DOE PANEL THROWS COLD WATER ON UTAH 'DISCOVERY'

All last spring and summer the scientific world was agog with questions: What is cold fusion and is it for real? The event that caused the questions was the startling announcement on 23 March by two chemists, B. Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton in England, that they had achieved nuclear fusion in a simple tabletop experiment at room temperature. As evidence of their apparent success in achieving results that have thus far eluded scientists attempting to fuse atoms of hydrogen or deuterium at temperatures as high as those at the interior of the stars, they cited the production of "excess" amounts of heat in a small electrochemical cell and the observation of neutron production.

While the appearance of heat in an electrochemical experiment is not in itself unusual, the presence of neutrons would indicate that nuclear reactions are taking place. Many scientists were astonished and angered that the results achieved by Pons and Fleischmann were first revealed to the world in London's *Financial Times* and *The Wall Street Journal*, both prominent business dailies but obviously not refereed journals in which scientists traditionally report their research. The same day the accounts appeared in the two newspapers, the University of Utah called a press conference, at which Pons and Fleischmann described their findings. That night, when Dan Rather, on CBS–TV's Evening News, hailed the Utah work as "a remarkable breakthrough," cold fusion was on its way to becoming a well-known, if not well-understood, phenomenon.

In the weeks following, much of the physical science world was gripped by a cold fusion frenzy. Using telephones, computers and facsimile machines, scientists from Bell Labs to Beijing exchanged scraps of information gleaned from a copy of the paper Pons and Fleischmann had submitted on 11 March to the *Journal of Electroanalytic Chemistry* and from accounts in newspapers. Though reports of the experiment were sketchy, chemists and physicists scurried to repeat it—some simply out of curiosity, most because the scientific method requires each new advance to be examined and reproduced independently to assure its accuracy.

Research by rumors

It was hardly science as usual, however. Lacking information on the exact dimensions of the cell used, some researchers figured the size from newspaper photographs showing Pons holding the Dewar jar or Fleischmann pointing to it. Without knowing more about the electrolyte than that it contained D_2O, a group at Caltech guessed (wrongly at first) that another ingredient was perchloric acid. At MIT, recalled Mark Wrighton, who heads the chemistry department, a team of nearly 40 professors, postdocs and graduate students began each day by "reviewing the rumors." Researchers in Hungary, India, Italy, Brazil and the Soviet Union, as well as at Texas A&M, Stanford and the University of Minnesota claimed success in finding neutrons or other charged particles, usually in sporadic bursts. But other attempts at Lawrence Livermore, Los Alamos, Sandia, MIT, Yale, Caltech and hundreds of other places in the US and elsewhere failed to replicate the Pons-Fleischmann experiments .

Complicating the situation was an exotic type of cold fusion work going on since 1982 at Brigham Young University, also in Utah. This research, led by a physicist, Steven Jones, has observed neutron emissions near background levels, but no excess heat, in D_2O electrolysis experiments and later in D_2 gas experiments. Last December, when Jones learned about the work of Pons and Fleischmann, he proposed a collaboration, since his research coincided significantly with theirs, but nothing came of it. Then, in February, when the chemists learned that Jones was about to report his results at The American Physical Society meeting in Baltimore on 4 May, they asked him to delay the announcement until they prepared a paper of their own. In fact, they all agreed to mail their manuscripts simultaneously to *Nature* from the Salt Lake City Airport on 24 March.

Jones considered the agreement broken when he learned on 23 March that a paper, actually a shortened version of what was sent to the *Journal of Electroanalytical Chemistry*, had been submitted by the chemists to *Nature*. Irritated, Jones mailed his manuscript to the British journal the next day. The Pons–Fleischmann paper never appeared in *Nature*. When its editor, John Maddox, asked for additional details, the chemists replied they were too busy and withdrew the manuscript.

The principal difficulty in fusing light nuclei is the Coulomb repulsion between them. Thus, magnetic confinement machines, such as tokamaks, are designed to overcome the Coulomb barrier by generating extremely high temperatures. In another technique, inertial confinement devices seek to bring the nuclei together by an implosive shock, using lasers and heavy ion beams. Because controlled fusion reactions hold promise as a relatively clean and almost limitless source of power, physicists in the US, Soviet Union and Europe have spent the last 30 years and perhaps as much as $10 billion in fusion R&D, gaining knowledge and experience but nothing so far in the way of useful energy.

By contrast with the complicated and costly facilities for most fusion research, the Pons-Fleischmann experiment consisted of an apparatus that might be found in a freshman chemistry laboratory: a glass jar containing a thin palladium cathode surrounded by a grid of platinum wires, acting as an anode, all immersed in heavy water to which an

Ramsey: Unpersuaded but open minded.

electrolyte is added for conductivity. They claimed that deuterium nuclei fused somehow and produced heat at a rate four times greater than the 1 watt of electric power supplied by ordinary automobile batteries (PHYSICS TODAY, June, page 17). The conventional D + D fusion reaction explains only a small part of the energy emitted in their experiment, they asserted. The bulk of the energy, Pons and Fleischmann had argued in their original paper, "is due to a hitherto unknown nuclear process or processes."

Indeed, as negative results came in from other researchers, it began to appear that cold fusion was, as Winston Churchill once characterized the Soviet Union in a wartime radio talk, "a riddle wrapped in a mystery inside an enigma."

On 26 April, Pons and Fleischmann appeared in front of the House Science, Space and Technology Committee to explain their work before television cameras and a capacity crowd of Congressmen, reporters and lobbyists. When the committee chairman, Robert A. Roe, a New Jersey Democrat, asked what the government could do to speed up progress in cold fusion, Fleischmann replied that it should support technological development of the discovery, but that it would be expensive. Chase Peterson, president of the University of Utah, was more explicit. He thought it would be appropriate for Congress to put up \$25 million to \$40 million in fiscal 1990 to help create a \$100 million cold fusion institute at the university. A few weeks earlier, Representative Robert S. Walker of Pennsylvania, the senior Republican on the committee, had convinced members of the energy research and development subcommittee to shift \$5 million in the Department of Energy budget from magnetic fusion to cold fusion—though the full committee later refused to accept the change.

When asked how the Utah project had been funded, Pons informed the committee that he and Fleischmann had been working on cold fusion the past five years on \$100 000 of their own money. At the time of the hearing, Pons and Fleischmann had withdrawn their proposal from DOE's Division of Advanced Energy Projects. DOE was set to award them \$322 000 for an 18-month period, but the department acted slowly in sending the check; the Utah collaborators applied to the Office of Naval Research and got a \$1.2 million contract.

During one week in April, cold fusion dominated the covers of *Business Week, Newsweek, Time* and Britain's *The Economist*, exciting President Bush to wonder what all the fuss was about. Preferring to get his information from experts rather than third or fourth hand, according to sources in his Administration, Bush asked for a detailed briefing. Energy Secretary James D. Watkins called on Glenn Seaborg, a nuclear chemist at the University of California at Berkeley, once chairman of the Atomic Energy Commission (DOE's forerunner), to brief the President. At the White House meeting, however, Seaborg admitted he was baffled by the cold fusion findings and urged Watkins to appoint a committee of eminent chemists and physicists to attempt to clear up the inconsistencies of the various experiments.

Observing the labs

The suggestion convinced Watkins to appoint a 20-member panel under the co-chairmanship of John R. Huizenga, professor of chemistry and physics at the University of Rochester, and Norman F. Ramsey, professor of physics at Harvard, who won a Nobel Prize just before the study was completed (see page 17). Members of the panel attended a cold fusion conference in Santa Fe in May and visited six labs, including those at the University of Utah and at Brigham Young. On 2 November, Huizenga and Ramsey discussed the final report with DOE's Energy Research Advisory Board, which accepted it unanimously, suggesting only one editorial change, and sent it to Watkins.

In its report the panel states that the search for cold fusion by universities, national labs and industrial laboratories in the US has probably cost "tens of millions of dollars"—though in its deliberations an estimate of \$30 million was used for the US and \$40 million worldwide. The panel observes that cold fusion research so far has resulted in strangely mixed findings: "Some laboratories support the Utah claims of excessive heat production, usually for intermittent periods, but most report negative results. Those who claim excess heat do not find commensurate quantities of fusion products, such as neutrons or tritium, that should be by far the most sensitive signatures of fusion. Some laboratories have reported excess tritium. However, in these cases no secondary or other primary nuclear particles are found, ruling out the known D + D reaction as the source of tritium."

Huizenga: Unmoved by the anomalies.

The panel concludes in a key statement that "the experimental results on excess energy from calorimetric cells reported to date do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion. In addition, the panel concludes that experiments reported to date do not present convincing evidence to associate the reported anomalous heat with a nuclear process."

Elaborating on those conclusions, the 64-page report says: "Neutrons near background levels have been reported in some D_2O electrolysis and pressurized D_2 gas experiments, but at levels 10^{12} below the amounts required to explain the experiments claiming excess heat. Although these experiments have no apparent application to the production of useful energy, they would be of scientific interest, if confirmed. Recent experiments, some employing more sophisticated counter arrangements and improved backgrounds, found no fusion products and placed upper limits on the fusion probability for these experiments, at levels well below the initial positive results. Hence, the panel concludes that the present evidence for the discovery of a new nuclear process termed cold fusion is not persuasive."

The word "persuasive" was chosen deliberately, says Ramsey. "That's not to say it's untrue."

The report contains an extensive section on calorimetry and excess heat, with descriptions of the calorimeters used in various studies and data on results. There also are sections on fusion products and materials characterization, which document the panel's pessimistic findings.

So, while the panel "recommends against the establishment of special programs of research or research centers to develop cold fusion. . . there remain unresolved issues which may have interesting implications. The panel is, therefore, sympathetic toward modest support for carefully focused and cooperative experiments within the present funding system."

On the last day the panel met, when editorial changes were essentially complete, Ramsey argued for including a statement leaving open the question of unresolved results reported by a few investigators. At his urging, the panel agreed to include a preamble, written mainly by Ramsey. It says in part:

"Ordinarily, new scientific discoveries are claimed to be consistent and reproducible; as a result, if the experiments are not too complicated the discovery can usually be confirmed or disproved in a few months. The claims of cold fusion, however, are unusual in that even the strongest proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time. . . . Consequently, with the many contradictory existing claims, it is not possible at this time to state categorically that all the claims for cold fusion have been convincingly either proved or disproved."

Ramsey agreed under questioning by an ERAB member, H. Guyford Stever, who was President Ford's science adviser, that only a very small fraction of the experiments remained unexplained and that the uncertainties needed to be recognized. While the panel had accepted Ramsey's caveat, it insisted on a forceful concluding item: "Nuclear fusion at room temperature, of the type discussed in this report, would be contrary to all understanding gained of nuclear reactions in the last half century; it would require the invention of an entirely new nuclear process."

—IRWIN GOODWIN

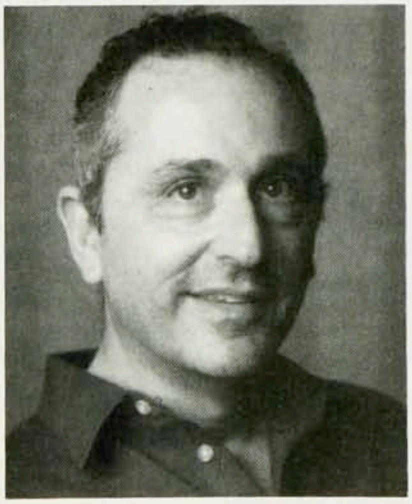
The report of the Cold Fusion Panel is available from the Energy Research Advisory Board, US Department of Energy, 1000 Independence Avenue, SW, Washington, D. C. 20585.

ACADEMY GROUP OBSERVES ASTRONOMY IN CLOUDY PERIOD OF BUDGET CUTS

It is no exaggeration to say that the new Astronomy and Astrophysics Survey is breaking tradition at the National Research Council. The way it is being conducted is such a departure from all previous studies that the committee's procedure was negotiated with Frank Press, president of the National Academy of Sciences, which operates the research council with the National Academy of Engineering and the Institute of Medicine.

For one thing, more than 300 astronomers and astrophysicists have signed on to 15 panels—more participants than any previous study for the academies and some three times the number that were involved in the last survey, completed in 1982, under the chairmanship of George Field of the Harvard–Smithsonian Center for Astrophysics. For another, the current survey committee will conduct an open forum at the American Astronomical Society meeting in Washington, D. C., on the evening of 11 January to further a candid exchange about the problems and prospects of the discipline. Normally, research council study groups avoid wide discussions with the community, which sometimes develop momentum for certain conclusions and recommendations. A committee is forbidden from revealing recommendations until its report has passed council review.

The departures from established protocol were devised by the survey's chairman, John Bahcall of the Institute for Advanced Study in Princeton, New Jersey. "We want to make sure that we don't miss anything," says Bahcall. "In the end, the strength of the report we issue will depend on consensus. One reason the Field Report spoke with such force is that it represented the whole community."



Bahcall: Seeking community consensus

This is the fourth time the research council has surveyed astronomy and astrophysics. All three previous surveys reported the field exploding with spectacular events, yet each was soon overtaken by new discoveries. The first survey, completed in 1964 under the chairmanship of Albert E. Whitford of the Lick Observatory, appeared in print a few months before the startling discovery of quasars. The second, led by Jesse L. Greenstein of Caltech, was issued in 1972, missing by weeks the discovery of Cygnus X-3's bizarre behavior as an x-ray binary spewing forth gamma rays with energies up to 10^{16} eV in millisecond pulses. The Field Report, published a decade later, came out nearly three years before detectors in Japan, the US, the Soviet Union and under Mont Blanc on the border of France and Italy spotted neutrinos from supernova 1987A, which excited wide interest in neutrino astronomy.

The three reports were a mixture of priorities and puffery. Each recommended an assortment of telescopes and satellites to enable astronomers to peer ever deeper into the universe for glimpses of its turmoil. Among the instruments proposed were optical telescopes ranging from about 1 m to 15 m, the Very Large Array radiotelescope, now in Socorro, New Mexico, the Multiple Mirror Telescope on Mt. Hopkins in Arizona, the Advanced X-Ray Astrophysics Facility, which NASA plans to launch in 1994, and the 2.4-m Hubble Space Telescope, set to go up next March.

But times have changed. The future of US astronomy is now clouded by the government's budget straits. NASA has delayed launching the space telescope several times and