state & society

US and Japan discuss joint fusion projects

International cooperation has been highlighted recently in several efforts undertaken to develop nuclear fusion as a source of energy. The US and Japan are seriously discussing cooperation in the promotion of R&D of new energy sources and other fields, with primary emphasis on nuclear fusion and coal liquefaction. The US has also participated in initial discussions on the recent proposal of the USSR that a next-generation fusion device (experimental tokamak reactor) be developed and built on an international basis.

US–Japan. The prospect of further US–Japan cooperation in science and technology is a result of several meetings that have occurred over the past year between scientific experts and high-level US government officials and their counterparts in Japan. The latest of these occurred in September when John Deutch (director of the Department of Energy's Office of Energy Research), George Pimentel (deputy director of the National Science Foundation) and several other representatives from DOE, the Department of State and the White House Office of Science and Technology Policy met with their Japanese counterparts in Tokyo. A follow-up meeting will take place in Washington toward the end of this year.

KINTNER

At the September meeting the Japanese cited nuclear fusion as "a particularly useful area for joint R&D," and both delegations agreed to give this field priority in Japanese–American cooperative efforts. They also agreed to seek cooperation in coal liquefaction, as well as in solar energy-photosynthesis, geothermal energy and high-energy physics.

Edwin Kintner, director of DOE's Office of Magnetic Fusion Energy and a participant in the Tokyo meeting, told PHYSICS TODAY that Japanese–American cooperation in fusion would include:

- exchange of personnel, visits, workshops and similar programs;
- formation of a joint institute of advanced plasma physics;
- participation by the Japanese in the operation and upgrading of the newly dedicated Doublet III device at General Atomic, La Jolla, Calif., and
- mutual planning and collaboration on alternative concepts for confinement—that is, concepts other than the mainline tokamak and mirror approaches.

There was no discussion at the Tokyo meeting of possible collaboration in inertial-confinement fusion; John Clarke, Kintner's deputy, told us that "it was not put high on the list of priorities" for collaboration probably because much of the program (at least in the US) is conducted at weapons laboratories.

Clarke told us that the purpose of the advanced plasma-physics institute would be "to provide a place where the very best minds that would care to address themselves to the fusion question could come and work on the most advanced problems." He indicated that its location would depend on available buildings, computer connections and where people

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DOE uses science-court concept; Minnesota does not

Two tests of the science-court concept have taken place in the last year and a half. The Department of Energy used an adversary or science-court-like procedure in spring 1977 to evaluate various alternative fusion concepts. The science court was also proposed (but eventually not undertaken) in attempts to resolve certain aspects of a Minnesota powerline-siting controversy.

As envisioned by the Task Force of the Presidential Advisory Group on Anticipated Advances in Science and Technology, headed by Arthur Kantrowitz (Avco Everett Research Laboratory), the science court was to be an adversary hearing in which expert proponents of opposing scientific positions on an issue would present their cases before a panel of impartial scientists/judges with expertise in areas adjacent to the dispute. Then the judges would reach judgments on disputed statements of fact.

The Minnesota powerline-siting controversy arose from the intention, first announced in 1973, of two electric utilities—Cooperative Power Association and United Power Association—to build a 172-mile-long, high-voltage (±400 kilovolts), dc transmission line across western Minnesota. After Federal agencies refused permission for the line to follow interstate highways (it would be "unsightly") and state agencies ruled out wildlife areas, the utilities proposed paths diagonally across many farmers' fields.

This siting decision raised a number of concerns voiced by the farmers, and they were still being debated when Rudy Perpich became governor in December 1976. Ronnie Brooks, a special assistant to the governor, told us that legislative hearings in early 1977 suggested to the governor's staff that basically three issues seemed to be in contention—compensation (how much were the farmers being paid for taking land out of production?), procedures (had the utilities properly followed the law in siting the line?) and health and safety. The staff concluded that the courts and the legislature, respectively, were the appropriate institutions to decide the first two issues. To resolve the third, the governor in March 1977 pub-

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licly proposed the use of the science-court mechanism. Then Ford Foundation and NSF officials indicated their willingness to fund the court.

The utilities and the farmers disagreed in their final positions, however, on the scope of the court. The utilities, like the governor, wanted it limited to health and safety issues. The farmers, on the other hand, proposed that the court be broadened to include additional topics such as need for the line, alternate routes, "eminent domain" and the impact of the line on an agricultural environment, and that the governor, rather than scientific experts, serve as the judge. This spring Governor Perpich rejected both suggestions, and the science court never materialized.

Barry "Mike" Casper, chairman of the physics department at Carleton College in Northfield, Minn., became interested in the science-court aspect of the powerline controversy. Subsequently, he was so moved by the farmers' position that he ran in the Democratic Farmer-Labor Party primary for lieutenant governor on a campaign based on the powerline controversy and related issues. He and his running mate received 20% of the vote, with Perpich and his running mate receiving the rest.

In contrast to Brooks's contention that health and safety were "by far, the major issues voiced," Casper and his political-science colleague Paul D. Wellstone state (in the August *Hastings Center Report*), based on interviews with farmers involved with the protest, that these issues have not been the dominant reasons behind the powerline issue. Rather, they observe, "considerable attention has been paid to this issue in the protest, in part, because the institutions available to the protestors, such as environmental impact statements, have channeled them in this direction; and in part, because uncertain threats to health and safety make good organizing issues for a protest movement." The farmers thus viewed the proposed science court as "a forum that would consider only quite peripheral technical issues," rather than their basic concern—"the sacrifice of their land without their consent for an allegedly greater social need whose validity they question." Casper and Wellstone argue for a much broader adversary forum to deal with technology disputes.

Kantrowitz, in reply, argues that this broadened forum is possible "provided that only the scientific factual basis of these issues be the responsibility of a Science Court. It should not get involved with considerations of values or of competing life styles." Kantrowitz earlier has argued that for the science court to be effective, it "must continually exercise the utmost caution to avoid making public-policy recommendations" (PHYSICS TODAY, August 1976, page 70).

The proposal of a science court to resolve some aspects of the Minnesota powerline controversy is cited in this Craig MacIntosh cartoon, which appeared in the 2 Dec. 1977 *The Minneapolis Star*.

The DOE "science-court" evaluation was aimed at improving the data base for a future selection of promising alternative fusion concepts. DOE would then accelerate R&D programs on these concepts, hoping to obtain an adequate data base so that comparisons can be made with tokamaks and mirrors. The choice of the science-court procedure was motivated by a concern for efficiency; DOE officials believe that a standard peer-review procedure would have required an "unacceptable" amount of time.

The participants in the evaluation included an Evaluation Panel (composed of plasma physicists, fusion-reactor systems experts and a representative of the utility industry) who carried out the actual evaluations; Advocates—scientists and engineers who were responsible for defending the reactor configuration and its physics and engineering assumptions, and who were usually participants in its development, and Critics, whose responsibility was "to ferret out crucial physics and technology questions and to aid the Evaluation Panel in the review of experimental results and theoretical models." Each concept underwent three separate evaluations—confidence in the physics assumptions, confidence in the development of technologies required for a reactor, and reactor desirability—and was rated on each by a numerical scoring system. James F. Decker, director of DOE's division of applied plasma physics and chairman of the steering committee that organized the evaluations, observed that the scoring system had the advantage of forcing the evaluators to make difficult judgments, but cautioned that it is the "critical examination of individual issues for each concept," rather than overall numerical scores, that should be taken as the major result of the evaluation.

Although Decker was generally pleased with the adversary procedure, he said that "some of the Critics did not fully understand their role or did not take their jobs as seriously as others." He also observed that "the participants—Advocates and Critics—behaved much more like scientists than lawyers. In some instances, when the Advocates provided convincing scientific evidence, the Critics became supportive of the Advocates' position." The participants tried "to define reality (or truth) and to avoid the pitfall of excessive advocacy required by an attorney when discharging his responsibility to a client."

Kantrowitz told us that "the key thing about the DOE situation is that DOE was indeed in possession of enough power to say 'this is the way [science-court] we are going to do it.' The governor of Minnesota did not have enough power to compel people to do things this way."

The eleven concepts evaluated by DOE were the Elmo Bumpy Torus, reversed field pinch, TORMAC, field-reversing ion rings, linear theta pinch, laser-heated solenoid, e-beam heated solenoid, multiple mirrors, fast linear reactor, LINUS and SURMAC. In mid-October DOE was to hold a further evaluation of the most promising alternative concepts and will shortly select one or two for experimental testing at the proof-of-principle level.

Another proposal. The science-court

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DOE uses science court

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process was also proposed in early 1977 by John C. Bailor, editor-in-chief of the *Journal of the National Cancer Institute*, who believed that guidelines were needed for the routine x-ray screening of women for breast cancer. Bailor reports "that the very possibility of a science-court procedure" was sufficient to impel the relevant societies to agree on guidelines.

—CBW

Joint fusion projects

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are willing to go; Hiroshima, Nagoya, Princeton and UCLA have been suggested so far.

At the mid-September dedication of the Doublet III device, Kintner noted that "One of the most interesting possibilities in [the Japanese–American] discussions is a full collaboration between our two nations in the improvements to Doublet III . . . and in the advanced experimental operations which would then be possible." He explained that additional power supplies could almost double the magnetic-field strength of Doublet III and that "it could accept three times the auxiliary plasma heating power presently committed." If such improvements were done and the machine operates as theoretically predicted, Kintner observed, it could become "the first machine in the world to produce simultaneously the conditions of plasma temperature needed for a practical fusion reactor."

Kintner told us that the Bumpy Torus and the torsatron (a stellarator variant) are among the alternative concepts that could benefit from US–Japan cooperation. Collaboration on the future extension of the Bumpy Torus concept is an obvious possibility, Clarke noted, because the only two devices of this type in the world are at Oak Ridge National Laboratory and the University of Nagoya. He pointed out that more substantive cooperation with the Japanese may be possible if the Elmo Bumpy Torus at Oak Ridge successfully passes an October DOE review of alternative concepts and becomes one of those that the department will test experimentally at the proof-of-principle level.

As for the torsatron concept, the University of Kyoto is presently building Heliotron E (l = 2), and the University of Wisconsin and MIT are proposing to build devices of this type: the WISTOR (l = 3) and the TOREX-4 (l = 4), respectively (l = the number of windings). Larry Lidsky (MIT) told us that, based on unofficial conversations that he and his colleague Peter A. Politzer recently had with Japanese scientists, he foresees US–Japan collaboration on the torsatron concept possibly occurring in three stages:

- short-term exchange of personnel, probably requiring little, if any, government sanction;
- longer-term exchange (with government approval) of personnel such as diagnosticians when the Heliotron (1980), TOREX-4 (1981) and WISTOR devices would come on line, and
- planning (fairly soon) for the next step—Lidsky believes this will probably be a single fairly large superconducting machine, possibly of ignition scale, that might be built on an international basis.

Clarke told us that the revival of the stellarator concept in a variant form is due at least in part to the successes of the tokamaks: "We've developed heating and vacuum techniques that did not exist back in the days when the stellarators were [originally] being pushed. We've learned a lot about physics, stability, particle transport, energy confinement and so forth. And a lot of that applies directly to stellarators because they are toroidal systems." He also noted that "People suspect that one of the problems of stellarators back in the old days was that their magnetic-field geometry was not correct, because of errors in the winding. It was purely a technological thing that was associated with stellarators." Clarke observed the stellarators built in recent years—CLEO (Culham Laboratory, England), Wendelstein VII (Garching, Germany) and L2 (Lebedev Institute, USSR)—work much better than previously because of the new technology.

Lidsky told us that the torsatron concept allows the coils to be wound in such a way as to reduce the forces on them by a factor of 20 to 30 over the old stellarator concept. He also noted that stellarator and torsatron experiments in Russia, England, Germany and Japan over the last few years have indicated that stellarators can hold plasma at least as well as tokamaks of equivalent size.

The Russian proposal was received by the International Fusion Research Council of the International Atomic Energy Agency in Vienna. It stated that "The Soviet Union considers it important and timely to develop and build a next generation fusion (experimental Tokamak reactor) on a multinational basis and under the auspices of the International Atomic Energy Agency. The USSR considers that it would be appropriate to set up immediately a group of experts at the IAEA to study the problem and initiate a project. On its part, the USSR is ready to participate in the initiation and implementation of the project and to provide a site for the project on the Soviet territory."

In response to this proposal, the IFRC formed a group to suggest objectives, terms of reference and the means of implementing such a project. This group was headed by R. S. Pease (chairman of the IFRC and director of the Culham Laboratory) and consisted of Kintner, Evgeniy Velikhov (head of the USSR fusion program and associate director of the Kurchatov Institute, Moscow), Donato Palumbo (head of the fusion division of the West European Community) and Segeriu Mori (head of the Japan Atomic Energy Research Institute's fusion program).

This group in turn recommended (and the director general of the IAEA has approved, according to Kintner) the formation of a study group of 12 to 16 people (3 to 4 each from the US, USSR, Japanese and European fusion communities) to meet intermittently over the next year and then issue a report on the scope and function of this proposed device. Heading the respective delegations will be Weston Stacey (Georgia Tech), Boris B. Kadomtsev (director of fusion program, Kurchatov Institute), Mori and G. Grieger (Max-Planck-Institut für Plasmaphysik, Garching).

Kintner told us that there has been only "coffee-klatsch" discussion of the site of the proposed fusion device. In addition to the USSR offer, Sweden and Canada have expressed interest, and Cadarache, France and Ispra, Italy have been suggested as possible locations.

Kintner observed that "All that's being done at this time is just trying to conceptualize what it might look like, what its benefits might be" and basically "Is it worth doing?" He noted that before such an international project could become a reality, a number of political and financial questions would have to be resolved and thus "people are entering this with the idea that it's a long walk, but you have to take the first step."

—CBW

in brief

Copies of the first two supporting papers prepared for the National Research Council's Committee on Nuclear and Alternative Energy Systems (co-chaired by Harvey Brooks and Edward Ginzton) are now available from the Office of Publications, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. The first paper is entitled, "Problems of Uranium Resources and Supply to the Year 2010," and the second, "Energy Modeling for an Uncertain Future." They are being sold for $6.00 and $9.75, respectively.

Johannes J. Gruemm, an Austrian, will succeed Rudolf Rometsch as deputy director general for the department of safeguards of the International Atomic Energy Agency. Since 1971 Gruemm has been the scientific director of the Oesterreichische Studiengesellschaft für Atomenergie. □