"plug" the ends of a solenoid containing plasma, have led to the decision to include the mirror devices in the Mirror Fusion Test Facility (MFTF) at present under construction. Work is already under way on plans for a new, larger machine, tentatively referred to as the Tandem Mirror Next Step (TMNS), which could become a serious rival to the tokamak design.

The programme based on inertial confinement techniques is also looking well. Recent experimental data indicate that solid state lasers made from vanadium-doped magnesium fluoride crystals have characteristics, high energy efficiency chief among them, which may overcome the difficulties experienced with the use of more conventional solid state lasers to ignite a deuterium-tritium pellet.

The tandem mirror is a device first proposed in 1976, when experimenters were experiencing considerable difficulty in preventing plasma from escaping its containing magnets along field lines which are open rather than closed (as they are in a tokamak). Its ancient ancestor is the machine called DCX, developed at the Oak Ridge National Laboratory in the 1950s.

Proposed simultaneously by Ken Fowler and Grant Morgan at the Livermore Laboratory, and Soviet scientists at Novosibirsk, the mirror acts by using two magnets to contain a plasma in an electrostatic potential well, the plasma being positively charged because electrons are able to escape faster than protons.

Small-scale experiments were carried out by research workers at the University of Tsukuba in Japan last year, demonstrating that, in principle, a tandem mirror designed to contain a plasma in this way does create the predicted potential well.

Subsequently, Livermore scientists have concluded a series of experiments on the tandem magnet experiment (TMX) in which they have been able to demonstrate that a solenoid with such plugs at each end can contain a heated plasma at a mean energy of 0.2 keV per atom, as compared with 13 keV within the end mirrors.

The attraction of a commercial fusion reactor based on this design would not only be the easier design tasks presented by a straight solenoid rather than a toroidal tokamak, but also that, once the end plugs have been produced to the tandem mirror design, the length of the solenoid between them can be adjusted at will to provide the power characteristics required.

The US Congress has already been sufficiently impressed to approve substantially increased funding for the MFTF now being built.

Its success or otherwise will determine whether the department should proceed to the next logical step, the TMNS, Livermore scientists feel that magnetic mirror designs could catch up with tokamak technology, the most likely design for a Fusion Energy Device (FED), and which the department hopes to build over five to ten years.

Meanwhile, those working on the

inertial confinement techniques are hoping that the promise of vanadium-doped magnesium fluoride lasers may overcome doubts about the ultimate potential of solid state lasers as fusion drivers.

Most of the research so far has been done on glass lasers, initially with red light and more recently, following the development of techniques for doubling the wavelength, with green and blue light which has a greater ability to focus energy on a small deuterium-tritium pellet.

Preliminary evidence suggests that, in contrast with the conventional krypton fluoride laser, which only has an efficiency of between 5 and 7 per cent, a V:MgF₂ solid state laser would have an efficiency of between 5 and 10 per cent. With other advantages, this would help to reduce the cost of electricity from an estimated \$300 million to \$100 million per megajoule.

Livermore scientists are now carrying out further experiments to determine whether crystals with such characteristics can in fact be grown for use in lasers. If so, solid state lasers will remain a serious contender in the fusion stakes.

David Dickson

Radioactive waste

Brussels helps

The parallel research programmes of the European Economic Community (EEC) and Canada on the storage of radioactive waste are to be linked. A five-year agreement was signed in Brussels on 3 November between the European Atomic Energy Community (Euratom) and Atomic Energy of Canada Ltd. It follows on from the original Euratom/Canada agreement of 1959.

The new agreement relates particularly to the evaluation of the environmental impact of the storage of wastes in hard rocks, and to collecting data on the development of safe waste storage systems. There has already been considerable cooperation between scientists in these fields, so the agreement puts this on a more formal basis and opens the way for even closer cooperation.

Initially the agreement will lead to exchanges of technical information, organization of joint scientific meetings, and exchange visits of scientists between Canadian and European laboratories.

The agreement is the first in this field between the community and an outside country. It is likely to be a pointer to a trend towards more international cooperation, and the United States is already showing interest in closer cooperation with the EEC.

The community's own research programme was unveiled with a great fanfare in Luxembourg in May this year. The community's contribution, US\$130 million, is planned to extend over four years. Of the total, \$100 million will be contributed on a fifty-fifty basis to national research programmes, while \$30 million will be spent at the joint research

centre at Ispra.

Research on the disposal of high-level wastes is well advanced in France, West Germany and the United Kingdom. In each case, the objective is to embody high-level radioactive wastes in some solid form — France and the United Kingdom are chiefly interested in vitreous solids, while West German studies have also taken account of bitumen-like materials.

In several member states, investigations are also under way to identify disposal sites for solidified radioactive waste. France and the United Kingdom are exploring granite formations, West Germany salt formations while Belgium and Italy are concentrating on siliceous (clay) formations.

Jasper Becker

Waste disposal

UK goes French

British Nuclear Fuels Ltd (BNFL) whispered last week its intention to use the French AVM process for vitrifying highly active nuclear waste emerging from the Windscale reprocessing plant, thus bypassing the British "Harvest" vitrification research programme which has been under way at Harwell. There was no official announcement by BNFL: rather, the news emerged during a routine meeting of the Windscale local liaison committee, a group convened to keep the local community aware of developments at the plant. The leak was intentional, and confirmed rumours that BNFL had chosen AVM some time before.

A full commercial agreement between BNFL and Cogema, the French company which developed AVM, has not yet been reached, and if Cogema's price is too high the deal may still fall through. As presently envisaged, it would entail constructing an AVM (*atelier de vitrification a Marcoule*) plant at Windscale in the late 1980s, under licence from Cogema.

BNFL will not say at this stage why it has chosen AVM, though the reasons are not far to seek. Both the French and the British began work on vitrification in the late 1950s but work halted in Britain in 1966 when the principle had been demonstrated. (It was felt at the time that it would be possible to store liquid high active waste indefinitely in tanks.) Political pressure led to the setting up of the Harvest programme (Harwell vitrification engineering study) in 1973, but by then Cogema had established a seven-year technological lead.

While the Harvest team at Harwell is even now using only simulated nuclear waste, a plant called PIVER was built at Marcoule eleven years ago to handle the real stuff in commercial quantities. PIVER ran from 1969 to 1973, and produced 12 tonnes of vitrified waste containing 5 million curies of activity — roughly speaking the arisings of a 1 GW nuclear power plant working over the same period.

PIVER was a batch process, like

Product of Harvest

Harwell's Harvest; its successor AVM, incorporated in a plant at Marcoule which began operation two years ago, is continuous, allowing — it is claimed — a roughly twofold saving in capital equipment costs for the same waste throughput. The AVM plant is remotely controlled, and is constructed from units none larger than 500 kg for ease of handling and replacement. The French process is thus many years ahead of its British — or any — rival.

Nevertheless there is still a question mark over BNFL's haste to conclude an agreement with Cogema. The decision to abandon Harvest is as much a political as a commercial one. At present, about 1,000 m³ of high active waste is stored in liquid form in tanks at Windscale, and BNFL still considers that it could remain in these tanks, or new ones, for some decades. Further tanks could be built for the oncoming nuclear power programme, but it is felt that public opposition to the programme — which will be expressed in the promised PWR enquiry — may be less if vitrification work is seen to be progressing apace. The argument, however, turns a

The differences

High active waste emerges as a liquid from the reprocessing of spent fuel: it is a solution in concentrated nitric acid of the nitrates of actinides and fission products. The object of vitrification is to immobilize the radioactive elements. In the Harvest process, which is only at the pilot stage, a simulated waste is mixed with the components of a borosilicate glass, poured into a tube, evaporated and glassified in one step in a furnace. The tube becomes the primary container for the glass. The process is a batch process. In the AVM technique, a high active liquid stream is evaporated and calcined (converted to oxides) in a rotary calciner. Each hour, the calciner accepts 40 litres of liquid waste and converts it to brown granules, which leave the furnace continuously. The granules are mixed with borosilicates and melted in a stainless steel container. Every eight hours, the container pours out 140 kg of glassified waste into storage drums. The drums are moved out, lids are welded on, and the drums moved to storage caves — all automatically.

blind eye to local opposition to drilling tests, to find sites for future long-term disposal of the glass.

At Harwell, Dr Ron Flowers, who heads the chemical technology division that developed Harvest, says that he expects to close work on the project by next March, once experiments are completed and final publications prepared. Loss of the Harvest contract — which was paid for by BNFL, the Central Electricity Generating Board, and the Department of the Environment — will not be a serious blow to the division, he says.

Robert Walgate

Soviet dissidents Another taken

Viktor Brailovskii, the Moscow Jewish mathematician who regularly hosts the Sunday seminars for refusenik scientists, was arrested last week, reportedly under Article 109/1 of the Criminal Code which deals with slander of the Soviet Union and the socialist system and the circulation of "publications known to be false".

News of the arrest, coming shortly after the opening of the Madrid review conference on implementation of the Helsinki Final Act, has caused consternation among his colleagues and friends abroad, who see it not only as a threat to Brailovskii himself, but also an adverse omen for Soviet intentions regarding "Basket 3" of the Final Act, which deals with human rights.

Brailovskii, who is a specialist in cybernetics and computer programming, first applied to emigrate to Israel in 1972. His application was refused, and he was then dismissed from his academic post. Since then, he has had no chance of obtaining any job in science.

It was to help such "refusenik" scientists keep up their academic interests that the Sunday seminars were founded in 1973 by Aleksandr Voronel'. When Voronel' and then his successor as seminar leader Mark Azbel' finally managed to emigrate, Brailovskii and his wife Irina (also a mathematician) became hosts to the seminar.

A recent Western visitor reports that in spite of a total lack of access to scientific facilities, including journals, the standard of discussion remains high, and there is considerable participation by young Jewish scientists who are attempting to carry out some kind of postgraduate study on their own.

A frequent visitor to the seminar, the traveller said, is Evgenii Chudnovskii of Khar'kov — a city where the refusal rate has always been particularly high — who is now trying to organize what he calls a "Jewish university" for young refuseniks.

According to Mrs Brailovskaya, the seminars will continue in spite of her husband's arrest. The citation of Article 109/1 presumably refers to the *samizdat* journal *Jews in the USSR*, of which

Brailovskii was for a time editor. However, this journal ceased publication in summer 1979, and the long delay before an accusation on this charge seems unreasonable.

German science

New man arrives

Germany has a new Minister for Science and Technology: 43-year-old Andreas von Bülow, who since 1976 has been Parliamentary Undersecretary of State for Defence. The Bundesministerium für Forschung und Technologie BMFT is Dr von Bülow's first ministerial appointment — as it was for his predecessor, Dr Volker Hauff. Dr Hauff now moves on to the Ministry of Transport, which is considered to be a more senior political appointment.

Dr von Bülow has had no time yet to form his policies for the BMFT, but he is expected to lean more to the right of his party, the SPD, than Dr Hauff, who attempted to use the ministry as an

instrument of economic policy (through its involvement in technology). But Dr Hauff — after seven years in some capacity at the BMFT — was said to be becoming impatient at the inertia of the research community, and particularly the big science institutions like the Karlsruhe nuclear research centre and others which had grouped themselves into a powerful lobby, the Arbeitsgemeinschaft der Grossforschungseinrichtungen (AGF). It remains to be seen what Dr von Bülow will do with that. His ministry plays a coordinating role in German science, akin to that of the Delegation Générale à Recherche Scientifique et Technique in France; but it controls a much larger budget — around DM 6 billion (£1.25 billion). This is the bulk of the federal finance applied to R&D Germany, another DM 3 billion or so being under the direct control of other ministries. (A further DM 6 billion is spent by the state governments, mostly to support universities, and DM 16 billion by industry.) The BMFT, along with the state governments, supports the institutions of the AGF, the Max Planck Gesellschaft (which runs the Max Planck institutes), the Deutsches