"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 $V:MgF_2$ 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 silaceous (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

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