Thermonuclear fusion

Inertial confinement in trouble

Washington

ANTARES, the world's most powerful fusion research laser, could face premature retirement later this year after only two years in operation, unless the US Congress takes pity on the $63.5 million instrument. The laser, at Los Alamos National Laboratory, is being used for experiments in inertial confinement fusion, but has proved to be the instrument of its own fate: it has clearly demonstrated that carbon dioxide lasers such as Antares have no potential for economic fusion. Hopes of a reprieve are now pinned on the possible use of Antares in the Strategic Defense Initiative (SDI) programme of research into anti-missile defences.

Antares is capable of producing a 40-kilojoule pulse of light lasting for one nanosecond. The problem is that radiation of wavelength 10.3 micrometres is, with the benefit of hindsight, too long for economic fusion power. When focused onto a glass bead containing fusion fuel, radiation of this wavelength stimulates the emission of hot electrons that pre-heat the fuel and so prevent the high degree of compression and simultaneous high temperature needed to achieve plasma ignition. Carbon dioxide lasers would be useful only if their cost dropped drastically, to about $10 per joule. This is an unlikely prospect; Antares costs $1,500 per joule, and the cheapest imaginable mass-produced carbon dioxide laser would still cost $300 per joule.

The administration's inertial confinement fusion budget request for fiscal year 1986 assumes that Antares will be taken out of service before the end of 1985. The total request at $70 million is about the figure for the current year. Donald Kerr, director at Los Alamos, has testified before Congress that about 100 people may lose their jobs in inertial confinement fusion if the proposed cuts go ahead.

David Cartwright, principal programme manager for inertial confinement fusion at Los Alamos, has recently informally requested an extra $5 million to allow the current series of experiments on Antares to be completed, because recent results suggest that the temperature of the troublesome hot electrons can be reduced by increasing pulse duration from about 1 nanosecond to 5 nanoseconds. This sum would nevertheless keep Antares in operation for only a few months, and would not allow modifications for new experiments. Hence the hopes that the SDI organization might take an interest.

Cartwright says Antares is the only national facility that could be used to test the predicted effects of high intensity laser radiation on nuclear warhead re-entry vehicles. The pulse length and power could without much difficulty be increased to a few microseconds and 0.25 megajoules, a region of importance for laser weapon concepts. Mirrors would have to be repositioned so that, instead of converging in three dimensions on a single point, the laser beams would illuminate a larger spot from one side. A request for $15 million has been made to the SDI organization for this purpose. Antares might also be used to drive X-ray lasers, also of SDI interest.

Congress is sympathetic to the idea of keeping Antares running, and both houses have authorized sums of around $145 million for inertial confinement fusion — twice the administration's request. The appropriations hearings, which will decide how much will actually be spent, have, however, only just started.

Some support for Antares has come from the National Academy of Sciences, which is carrying out for Congress a study of inertial confinement fusion. The committee responsible has made known its opinion that it would be unwise to dismantle a facility while its usefulness is still being evaluated. Congress might therefore take this cue to override the Office of Management and Budget, as it has been known to do before. Congressional aides warn, however, that there may be jurisdictional obstacles to supporting Antares directly through the SDI organization, if only because that would entail a transfer of funds between two subcommittees. On Capitol Hill, subcommittees' territories are guarded jealously, and the political difficulties are seen as far more daunting than the technical modifications that Antares itself would need.

The other major fusion research laser facility in the United States, known as Nova, is close to completion at Lawrence Livermore laboratory. The light produced by the neodymium-glass lasers in Nova has a wavelength of around 1 micrometre, but is then frequency-multiplied by a factor of 3 to give light with 0.35 micrometre wavelength. Even this is not expected to

Uranium enrichment

France also plumps for lasers

THE French nuclear fuel company, COGEMA, announced earlier this month plans to enrich uranium by laser, rather than by the diffusion or centrifugation of uranium hexafluoride gas, and said that this would cut costs by a factor of two. But one French observer says the statement is a "bluff" prompted by competition with the United States for the supply of enriched uranium to Japan and by a wish to pre-empt the announcement by the US Department of Energy of its decision to adopt the laser process.

Research on laser enrichment has been under way at the laboratory of the Commissariat à l'Energie Atomique at Saclay, near Paris, for some years. But the feeling in France appears to have been that the technique was not yet required, so that the project has been poorly supported. According to M. Claude Bearnaud, director of the isotope separation research unit at Saclay, it will be 15 years before full-scale laser separation plants are in operation.

Bearnaud spends some FF 100 million (about £9 million) a year on laser separation experiments with the French SILVA process, which is similar to the AVLIS process, developed by Lawrence Livermore Laboratory in the United States, using uranium metal vapour. But following the COGEMA announcement, he expects his budget to rise next year by some 20–30 per cent, taking SILVA to the "pre-pilot phase". The separation of kilogram quantities of uranium will come only later, Bearnaud says. The Lawrence Livermore Laboratory, after a year's frantic competition with the Oak Ridge advanced gas centrifuge, has now claimed the successful enrichment of some five kilogrammes of uranium.

Even so, says Bearnaud, there is no commercial need for a laser plant as yet. So why the US haste? One British laser physicist believes the spur may be the need to accumulate separated plutonium for the increasing numbers of US multi-warhead (MIRV-ed) missiles. In these missiles space is at a premium, and plutonium, with a lower critical mass than uranium, makes smaller triggers. The United States has plenty of plutonium in spent fuel from its 90-odd pressurized water reactors, but that is contaminated with isotopes which dampen the fast chain reaction which is essential in warhead applications.

AVLIS, or SILVA, could help. The principles could be applied to any isotope system, but Bearnaud says he is not at liberty to say if his group has worked on plutonium.

For commercial uranium separation, on the other hand, French sources are more forthcoming. Estimates are that the optimum size of a laser plant will be some ½–1 million units "separative work" (SWU) a year, enough to supply three to six 1,000-MW pressurized water reactors with fuel. By comparison, the giant Eurodif diffusion plant at Tricastin in France is capable of nearly 11 million SWU a year, but is under-utilized. Laser separation will be cheaper in the long run, according to Bearnaud. Indeed, COGEMA is said to have offered in Japan to halve future enriched uranium prices.

Robert Walgate

be economically viable for fusion; the best hope among lasers is probably the krypton fluoride excimer laser, which has a wavelength of 0.25 micrometres and which has been developed since work on Antares and Nova began. Los Alamos has a small experimental krypton fluoride laser known as Aurora. Many now believe, however, that light ion beams will beat lasers to achieving plasma ignition. What might be the first machine to reach plasma ignition, known as Particle Beam Fusion Accelerator-2, will begin tests early next year at Sandia National Laboratory in New Mexico. **Tim Beardsley**

Proliferation

The atomic vapour laser isotope separation process (AVLIS), chosen by the US Department of Energy for separating the fissile uranium-235 isotope from natural uranium (see above), relies on selective three-photon ionization in an electric field, which sweeps out the ionized uranium-235.

Success depends on the relatively large (1 GHz) isotope shifts of spectral lines of the actinide elements on the low thermal velocities of such heavy atoms (implying reduced Doppler broadening) and the use of laser beams impinging perpendicularly on a collimated jet of uranium vapour (reducing Doppler effect still further).

In principle, the excitation could be effected in two steps, by a photon carefully tuned to an internal excitation and a photon of almost any wavelength to take the excited electron out to the continuum, leaving the atom ionized. But the ionization energy of uranium-235 is so high that the two photons would have to be at the blue end of the spectrum, where tunable lasers are expensive and where photons tend to degrade laser mirrors. So AVLIS uses instead two low-energy mid-spectrum photons, produced by a dye laser, to effect the finely-tuned selective excitation. A third ultraviolet photon is then used to take the excited electron far out into the continuum, where auto-ionization resonance increases the ionization cross-section tenfold.

The use of two successive excitation photons also has the advantage that each can be fired from different sides of the uranium jet, so that the first-order Doppler effects cancel. The Lawrence Livermore dye lasers are pumped by a high-efficiency high repetition-rate copper-vapour laser which has the advantage over continuous lasers of an extremely high average power.

According to one British laser physicist, such devices "could be run in a university laboratory" to separate kilogram quantities of fissile uranium-235. If a dye-laser system were established in Libya, for example, "it would be invisible", which is "why we're worried about them".

Robert Walgate

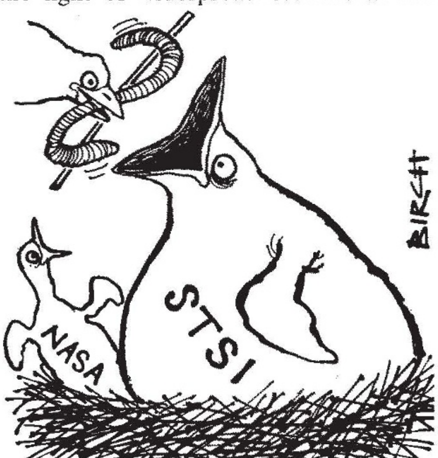
Hubble telescope

Space institute's wings clipped

Washington

A study of the Space Telescope Science Institute (STSI) by a National Research Council task group has concluded that the ever-expanding institute should not be allowed to grow much beyond its present size. The study, which was commissioned by the National Aeronautics and Space Administration (NASA), says that new scientific functions required for the Hubble Space Telescope should instead be contracted to outside organizations, with STSI restricted to an advisory role wherever possible.

The task group undertook its study in the light of widespread concern in the



astronomy community about the institute's rapid growth since it was established in 1981. NASA originally planned an institute with a staff of 100 and an annual budget of less than \$5 million; STSI's budget for this year, however, is \$12.8 million and is expected to reach \$21 million by the end of the decade (at 1984 prices). The staff already numbers over 200 and is expected to top 250 before long. Some fear that the institute might squeeze out other NASA astronomy projects.

The task group, chaired by William Gordon of Rice University, agrees that NASA's original idea of having a special institute to manage science for the space telescope was a good one, and says the institute, which is based at Johns Hopkins University, has done a good job of surmounting the many unplanned technical obstacles that have beset the space telescope. But the task group euphemistically suggests that STSI's stated objectives should be modified by adding a requirement that STSI work "within available resources". What those available resources should be is not specified, although the task group notes that STSI was intended to be comparable in size with other ground-based astronomy facilities; that being the case, STSI is already close to the upper limit.

Gordon's task group also has some implied criticism for the Association of Universities for Research in Astronomy (AURA), the organization that is nominally in control of STSI. Gordon says that AURA should play a more active role in mediating in the frequent jurisdictional conflicts that have arisen between NASA and STSI.

Other recommendations include the suggestion that STSI develop remotely accessible data archives and software that can be run on computers at researchers' home institutions, to avoid pressure on computer time at STSI. The task group also says NASA and STSI should plan a joint public information service for when the telescope is operational. In the longer term, however, Gordon says it is up to NASA to make clear its plan for the future of the institute. **Tim Beardsley**

The report, Institutional Arrangements for the Space Telescope: A Mid-Term Review *is by the Committee on Space, Astronomy and Astrophysics, National Research Council, Washington, DC.*

East German physicist

Absence noted

At a physics conference in Visby, Sweden, this month, Dr John F. Sharpey-Schafer from the University of Liverpool announced that his paper was dedicated to Dr Stefan Frauendorf of the Zentral Institut für Kernforschung at Rossendorf, East Germany. Dr Frauendorf had been invited to read a paper at the conference, but was arrested last November, and is now said to be facing charges of espionage, based on alleged contacts with West German intelligence services.

Dr Frauendorf had for several years been a regular visitor to the Niels Bohr Institute in Copenhagen, where he was working with several other scientists on a joint project on nuclear structure.

At the time of his arrest, he was in the process of reading and correcting a paper, written jointly with the Niels Bohr team, on high spin states. This paper seems to have disappeared at the time of his arrest and, as there was no copy, much work has had to be redone. A letter from the Niels Bohr Institute, enquiring about the paper and deploring the breaking off of collaboration with Dr Frauendorf, brought only the answer that the physicist was under investigation for espionage carried out over a number of years.

The Niels Bohr Institute has been working with Rossendorf for some 20 years, an association which has been especially fruitful over the past five years or so, roughly the period of Dr Frauendorf's visits. Cooperation arrangements have not been entirely broken off by the incident, however; three further visitors have arrived from Rossendorf since the scientist's arrest. **Vera Rich**