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Evaluation of Sanders Associates Proposal of 6/12/63 and General Comments (Laser Heating of Thermonuclear Fuel)

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MEMORANDUM [redacted] August 12, 1963

TO: F. Fairbrother [redacted] 57/247

FROM: R. E. Kidder [redacted]

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SUBJECT: Evaluation of Sanders Associates Proposal of 6/12/63 and General Comments

DECLASSIFICATION STAMP ON REVERSE.

Sanders Associates have proposed that they be funded by the government to do research on the heating of thermonuclear fuels (LiDT, DT, D_2) to ignition temperatures by means of intense focussed laser radiation. In support of this proposal, they have done some preliminary calculations on the ignition of a small LiDT sphere in which it is hoped that confinement of the fuel will be effected by the radiation pressure exerted by the intense laser light. They believe that the surface of the sample will be heated to a kinetic temperature of 50 kev, and that the α-particle flux due to the DT reactions at the hot surface may be capable of triggering a fast fusion chain-reaction in the rest of the fuel.

MAY [redacted]

There are several technical comments to be made about their proposal.

1. The ignition of the fuel cannot take place as a fast fusion chain-reaction unless the electron temperature is so high that a rapid thermonuclear reaction would take place anyway. This is because the α-particles lose their energy to electrons predominantly, unless the electron temperature is greater than 30 kev. The authors of the proposal evidently neglected to consider the transfer of energy from α-particles to electrons in their treatment.

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2. In speaking of a very hot surface layer produced by the laser heating, the authors have evidently overlooked the diffusion of heat into the interior of the sample by electron thermal conduction. [redacted] heating takes place only near the surface (because the [redacted]

[redacted]

Classification (Declassification/Review Date) Changed to:

UNCLASSIFIED

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by authority of R2D2-COT-63-35 9/12/95 (date)

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by Stephen Hoffat 5/30/96 (date)

(Signature of person making the change)

verified by R. June Barrow 6/4/96 (date)

(Signature of person verifing this is the correct document or model) exceeds that of the laser light), electron thermal conduction is sufficient to cause the entire sphere to become isothermal in a time short compared with the duration of the incident light (10^{-8} seconds).

3. The ability of the light pressure to confine the fuel is questionable. The stability of confinement by radiation pressure in a spherically convergent light field was not looked into, and it is likely that the plasma is not stably confined. Also the rate of loss by diffusion from the confinement region was not examined, and may be large.

4. The statement that the laser required to accomplish the heating is within the present state of the art is not true. The proposal requires a laser which produces 10^4 megawatts <u>in a single mode</u> in order to be focused down to a spot whose diameter is equal to the wavelength of the light (10^{-4} cm). The present state of the art is lower in power by a factor of 10 (10^3 megawatts), and this power can only be focussed down to a spot $\sim 10^{-2}$ cm in diameter. Hence, their proposal calls for a power density at the focus 10^5 times as great as has yet been achieved. While it is true that the required high power in a single mode is possible in principle, it would require a very extensive research effort to evaluate whether these requirements can indeed be realized in practice.

To summarize, the underlying notion of the Sanders proposal that one can heat small samples of thermonuclear fuel to high temperature with high power strongly focussed laser light is correct. The proposed method of confining the fuel by the pressure of the laser light has not been demonstrated in theory, questions of stability of confinement and diffusion losses having been ignored. Contrary to the statement made in the proposal, major improvements beyond the present state of the laser art will be required to achieve radiation pressures high enough to confine the heated thermonuclear fuel, assuming that such confinement is indeed possible. The concept of a hot surface layer, and the concept of a fast thermonuclear reaction being triggered in the interior of the fuel are both incorrect.

General Comments and Recommendations

It is clear that Sanders Associates want to heat thermonuclear fuels with high power focussed laser light. This is a sensible idea that Livermore is already working on. They understand that the research program will be expensive, and so they want government funding. The specific proposal, and particularly the references to power production and the triggering of larger amounts of thermonuclear fuel, are mainly window dressing. It is also clear from their correspondence that it has never occurred to them that Livermore might logically already have an in-house program to study laser heating of thermonuclear fuels.

This proposal is the third proposal (that I know of) to the A.E.C. to obtain government funds to do research on the laser heating of thermonuclear fuels. The other two are Hughes, Malibu (Dr. W. Linlor) and the University of Michigan (Prof. Peter Franken). I am sure there will be many more as time goes on. (Lincoln Lab. and O.N.R. Boston are getting interested). A policy decision will have to be made by the A.E.C. whether or not it wants to fund research in this area to be done outside the A.E.C. laboratories. My recommendation would be not to fund these projects on the grounds that the A.E.C. Labs., notably Livermore and Los Alamos, have more knowledge about the pertinent thermonuclear physics than exists elsewhere and Livermore will soon have a capability with high power lasers that will not be matched elsewhere. The fact that Livermore is already actively

IS THIS REALLY SO?

pursuing this work should be brought to the attention of the A.E.C., since the A.E.C. does not seem to be fully aware of the situation.

The more difficult question relates to security, which of course is no problem if the work is done at a weapons laboratory. That is, if Sanders Associates or Hughes or General Motors should decide to go ahead and investigate the laser heating of thermonuclear fuels with their own money, then what? (Both Hughes and Prof. Franken of Michigan were informed by the A.E.C. that if they pursued such research, it would be classified SRD).

The problem arises because the distribution of fusionable materials, including tritium, is not restricted; because many laboratories are experimenting with high-power lasers; and because everyone knows that things can get very hot at the focus of a high-power laser. If they didn't know it, the Russian physicist Basov pointed it out to them in a paper given at the recent Quantum Electronics conference in Paris.

I believe the A.E.C. should formulate a policy which would not inhibit academic work on plasma heating with lasers, but which would render classified the heating of thermonuclear fuels by lasers with substantial power output. An approach I would recommend would be to require that the laser heating of materials containing tritium could only be done on an SRD basis. This would not hinder academic work. An additional or alternative restriction that could be applied would be to classify all experimental work on the laser heating of thermonuclear fuels in which the laser output would exceed, say, 10^3 joules of light per pulse. Again, this would not restrict academic work to any noticeable extent.

Better

Another area to be considered is the Sherwood project, which has been declassified. Proposals will no doubt be made that laser ignition of thermonuclear fuel can solve the unclassified problem of controlled thermonuclear reactions. The Sanders Associates proposal is a case in point. There is a strong motivation to associate the laser heating of thermonuclear fuels with the Sherwood program, regardless of the prospects of achieving a controlled release of net power, because the work can then be done on an unclassified basis. Our own Sherwood project, for example, recently contacted Westinghouse to obtain information about high power lasers which they are interested in using to heat dense plasmas. This is an indication that the various Sherwood projects may soon want to enter this field and will require security clarification.

It should be clearly drawn to the attention of the A.E.C. that its policy on these questions should be settled as soon as possible, so that it is prepared to deal with the numerous requests for funds and questions about classification that are certain to come from many universities, and laboratories that want to start thermonuclear fires with lasers. Of course, the policy of regarding all this work as unclassified would be the simplest solution, and perhaps the only practical one.

Distribution

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