COMMENTS ABOUT NEUTRON FEEDBACK NPL DRIVEN ICF

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ABSTRACT

The use of a neutron-feedback-coupled Nuclear-Pumped Laser (NPL) driver for ICF would greatly enhance the overall system efficiency. In this case neutrons from the target implosion create nuclear reactions in the laser medium, providing the energy input to the laser. Thus the recycle energy to the laser does not go through an electrical conversion cycle, greatly increasing the system efficiency. Electrical energy is generated in a conventional fashion from energy deposited in the blanket as the energetic neutrons are thermalized.

Here we consider a variation on the conventional DT reactor driven by an NPL; namely, an advanced DT-seeded, D-3He-fueled target. Then, in addition to the efficiency gain due to the neutron coupling, the target allows an added gain through use of a direct energy conversion technique for the large fraction of energy carried by charged particles. While the neutrons produced are reduced compared to a D-T target, they are still adequate to pump the NPL. At the same time, neutron-induced activation and radioactive waste production are decreased.

INTRODUCTION

The possibility of using advanced fuels (AFs) for fusion is gaining increased attention with the realization of the importance of improved environmental and safety factors as well as the need for high efficiency power plants.[1-3] It appears that a D-T spark-ignited target (called AFLINT [4]) represents one of the best near-term approaches to burning AFs. Reactor designs employing AF's have generally assumed the use of a heavy-ion-beam driver due to its high energy capability plus its high efficiency [5]. On the other hand, a nuclear pumped laser (NPL) could also provide a high efficiency, and this route is also explored here.
PRIOR DEVELOPMENTS

The potential advantage of using AFs for fusion has been recognized for a number of years following its initial elaboration in 1975 in the book Fusion Energy Conversion[1]. At that time the use of AFs was viewed as a long range goal which would enable fusion power to achieve its ultimate potential as a very clean and efficient energy supply. However, the increasing emphasis on safety and environmental aspects [2,3] of future power sources places even more urgency on the AF approach for fusion.

Two types of AFs have been recognized: Deuterium based reactions, for example, D-D, Catalyzed-D, Semicatalyzed-D, D-3He; and proton based reactions such as, p-6Li, p-11B [1,4,6-7]. Indeed, the possibility of burning p-11B was first discussed in connection with its possible use in inertial confinement fusion (ICF) targets.[6] The plan then was to capitalize on the fact that cyclotron radiation losses are avoided in ICF (vs. magnetic confinement fusion). However, the energy balance required for a reasonable gain is difficult to achieve. Earlier investigations showed that the energetics for such a burn were marginal. More recently it was shown[8,9] that a modest gain is possible with p-11B targets if ultra high compressions (> 10^4) can ultimately be obtained.

Another fuel which verges on being aneutronic is D-3He. A major advantage of D-3He is that its cross section is much more favorable than p-11B.[10] In this case, though, neutrons from D-D reactions occur in the mixture and result in about 5-10% of the fusion energy going into the neutrons.

Studies of these fuel cycles were carried out between 1975-1985 by several groups[1,6,7,11]. While good progress has been made in understanding the physics of proton based fuels, it appears that, until new confinement techniques are discovered, burning p-11B remains beyond our reach. D-3He, on the other hand, offers many advantages and is generally viewed as quite attractive except for the lack of a "natural" 3He source. In 1987, however, the situation was radically changed with the revelation that 3He is implanted in the lunar soil due to bombardment by the solar wind[12]. Subsequent studies indicated that mining of the 3He on a relative near-term basis should be taken as a serious option[13-14]. It should be stressed, however, that three other sources of 3He still remain feasible; namely breeding 3He in a semicatalyzed deuterium reactor, in a special beam-target facility, or by breeding excess tritium and allowing it to decay to 3He[15]. Breeding, e.g. by proton bombardment of a Li plasma target, is generally viewed as complex and expensive due to the cost of electricity needed for the accelerator. However, how breeding compares with lunar mining from an economic point of view has yet to be studied.

D-3He FUSION REACTORS

Almost simultaneously with the rising interest in D-3He, several studies began to stress the environmental impact of fusion. These included the ESECOM study[2] and a contemporary review of the European Fusion Program[3]. A broad generali-