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AN ANTIPROTON DRIVER FOR ICF PROPULSION*

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SUMMARY

Inertial confinement fusion (ICF) utilizing an anitprotoncatalyzed target is discussed as a possible source of propulsion for rapid interplanetary manned space missions. The relevant compression, ignition and thrust mechanisms are presented. Progress on an experiment presently in progress at the Phillips Laboratory, Kirtland AFB, NM to demonstrate proof-of-principle is reviewed.

I. INTRODUCTION

Inertial confinement fusion (ICF) could provide thrust and high Isp from plasma created in micro-explosions in uranium-hydrogen pellets. We are studying the practicality of igniting the pellet with antiproton-induced fission. The driver system would include a trap in which antiprotons are stored and an accelerator to deliver antiprotons to the pellet. The antiproton part of the driver would be compact, making it especially attractive for space propulsion applications. A typical manned mission to Mars using this system (called ICAN, for Ion Compressed Antiproton Nuclear system) is graphically illustrated in Figure 1. A modern variant of the pusher plate technology of ORION due to J. Solem (1) for converting motion of hot plasma to thrust is shown in Figure 2.

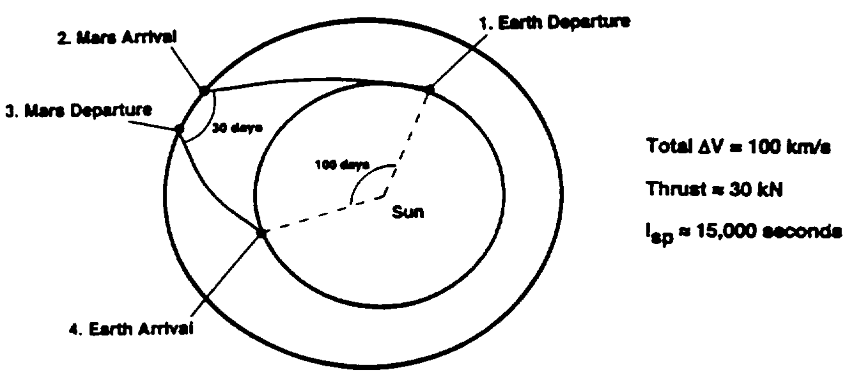

Fig. 1-ICAN Mars Mission for 1 Dec 2011 Launch

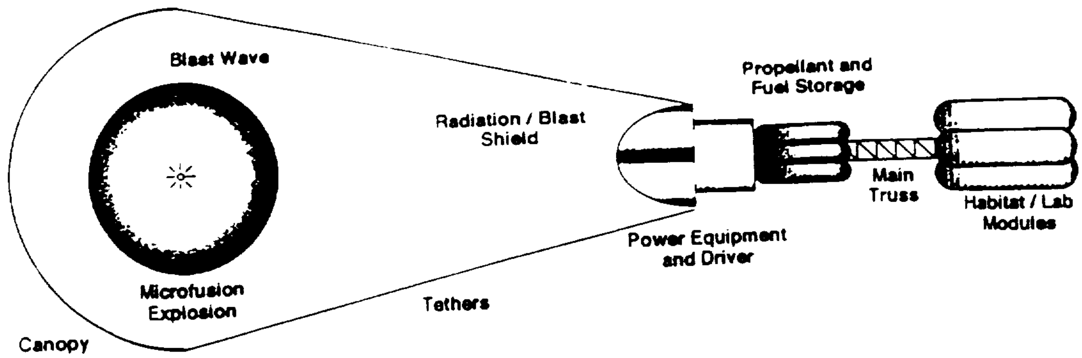

Fig. 2-ICAN spacecraft schematic layout after Solem/Medusa concept (1)

II. ANTIPROTON-CATALYZED MICROFISSION/FUSION

Recently our group has observed large fission and neutron yields from antiproton annihilation at rest in a natural uranium target (2). Calculations indicate that short bursts of stopped antiprotons could induce temperatures of several KeV in a small pellet heated by fission fragments. These conditions may be appropriate for ignition of a hydrogen fusion burn within the microsphere. The driver scheme presently under consideration would utilize antiprotons as a catalyst to the microfission/fusion process. Compression could be provided by a driver such as light ion beams. Targets with yields up to 50 Gjoules have been considered (3).

Figure 3 illustrates the calculated neutron yield per antiproton on a small (27 gram) uranium target versus target density x radius under conditions corresponding to subcritical gain (see Section III). Neutrons produced directly by antiprotons and charged pions confined by intense magnetic fields produced in the compression contribute equally to the gain.

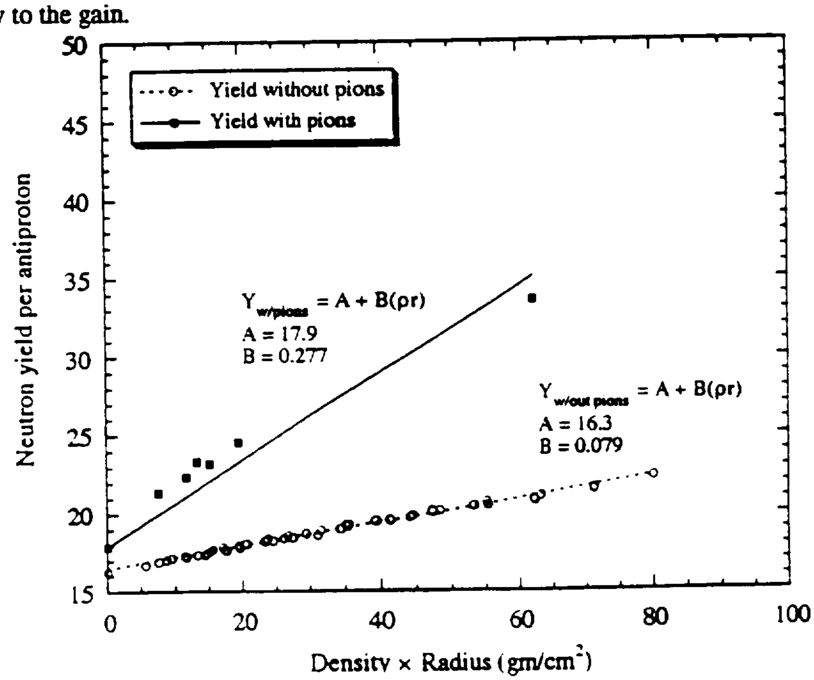

Fig. 3-Subcritical neutron yields for U-238

III. SHIVA STAR EXPERIMENT

We have embarked upon an experimental program using the Shiva Star facility at the Phillips Laboratory, Kirtland AFB. The goal is to demonstrate subcritical neutron multiplication due to antiproton fission in targets compressed to 10-40 Mbar pressure. These proof-of-principle experiments could lead to a program of full target experiments at a later time with direct applications to propulsion needs. Figure 4 shows a schematic layout of the experiment. Antiprotons, stored in a Penning trap, are released at 20 KeV energy, accelerated to 1.2 MeV by a radiofrequency quadrupole (RFQ) accelerator, and then bent and focused onto the compressed target inside an imploding solid liner driven by the SHIVA Star 5.2 MJ capacitor bank.

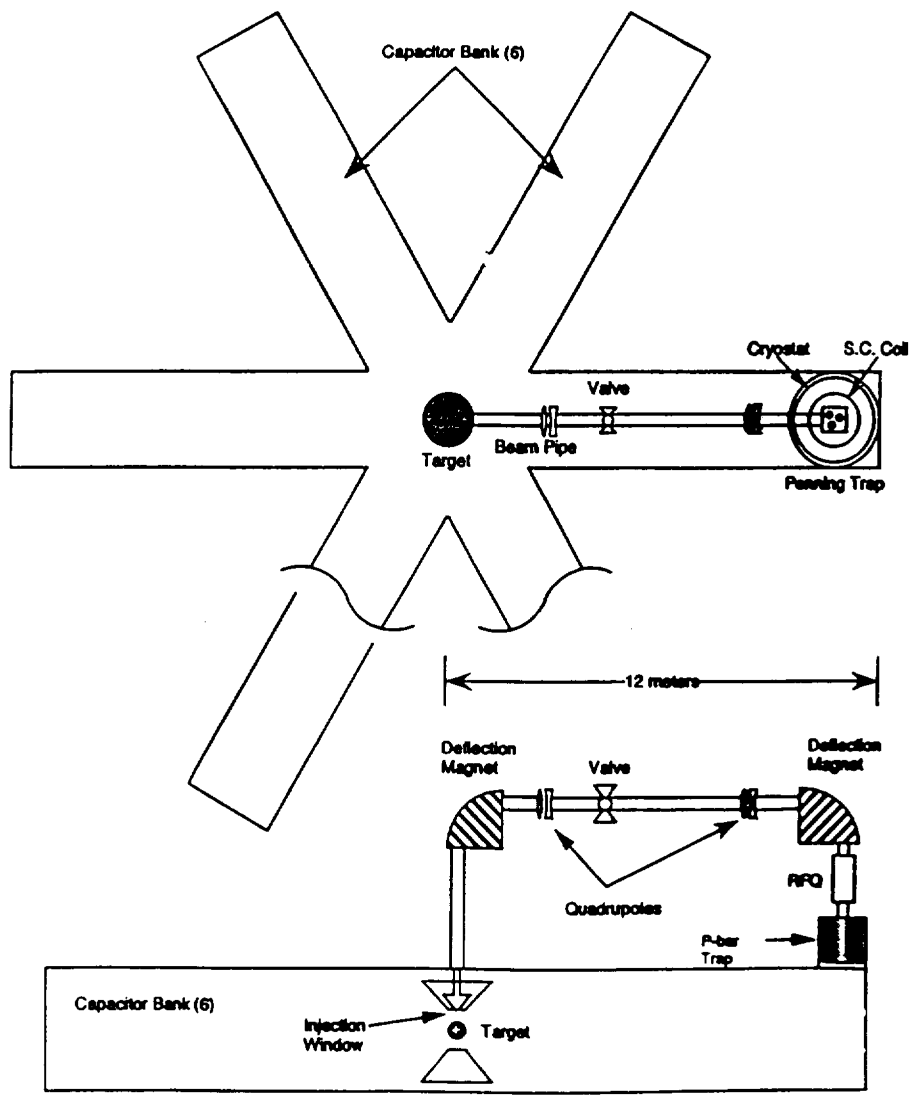

Fig. 4-SHIVA Star antiproton injection system

Figure 5 shows a close-up of the target region, indicating the liner moving in rapidly and compressing a hydrogen working fluid, which in turn compresses the target. A short burst of antiprotons ignites the target as it reaches peak compression.

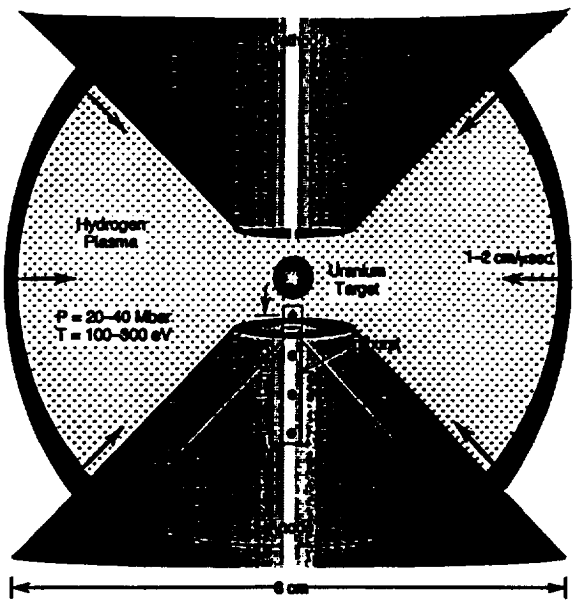

Fig. 5-Solid liner during compression cycle

IV. ANTIPROTON TRAPPING EXPERIMENTS

We are collaborating with the P-15 group at Los Alamos National Laboratory on antiproton trapping experiments at the Low Energy Antiproton Ring (LEAR) at CERN, Geneva, Switzerland. Recently we successfully trapped 700,000 antiprotons from single beam shots from the accelerator. With improved vacuum, using multipulse injection and electron cooling in the catcher trap we hope to trap and confine ten times this number before the end of 1993.

The design of a portable Penning tap and associated transfer optics for moving antiprotons from the catcher trap to the portable trap is complete, and construction of these systems is starting. It is planned to move antiprotons to the Phillips Laboratory in 1995 for the first of a series of subcritical microfission tests.

V. FOOTNOTES AND REFERENCES

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1. J. Solem, "MEDUSA: Nuclear Explosive Propulsion for Interplanetary Travel", LA-UR-91-1584, Los Alamos National Laboratory, to be published in the Journal of the British Interplanetary Society; "Nuclear Explosive Propulsion for Interplanetary Travel: Extension of the MEDUSA Concept for Higher Specific Impulse", LA-UR-92-765.

2. B. Chen et al., Phys.Rev.C45, 2332 (1992).

3. R. A. Lewis et al., "Antiproton Boosted Microfission", Nuc.Sci.Eng.109, 411 (1991); Fusion Tech. 20, 1046 (1991).