Assessment

of the

ACOUSTICALY DRIVEN MTF EXPERIMENTS

being conducted by

Dr. Michel Laberge of General Fusion, Inc.

I have reviewed the materials sent to me by Dr.Laberge and find his experiment to be very interesting.

There are several comments I would like to make in this regard:

1. Magnetized target fusion (MTF) is a relatively unexplored approach to fusion energy. While its earliest origins goes back many years, it does not share the decades long legacy of the magnetic confinement (CF) and inertial confinement (ICF) research on fusion, but it does take advantage of the many advancements in our understanding of the plasmas and compression systems associated with those approaches.

2. MCF and ICF plasmas are at the opposite extremes in required fusion parameters such as density, pressure, time scale and dimensions. MTF lies in an internediate regime, hopefully making posssible the use of less advanced, more readily available system components.

3. MTF seeks to marry the advantages of MCF and ICF, while avoiding the shortcomings of those two extreme approaches.

4. Only one set of MTF experiments at the level of Dr. Laberge's have been done before. In 1977 Sandia National Laboratory used an e-beam machine to drive some modified ICF targets. These were after-hours experiments done by interested staff on their own time. The two dozen or so shots (some being planned "null" experiments) indicated that the rather low neutron yield depended on the presence of an embedded magnetic field. No neutrons were generated in their main-line effort. While neutron output is not the only valid measure of success, it is an indicator of some kind of nuclear reactions, and can be observed at a distance without special effort to see what the plasma is doing. After-the-fact calculations indicated that the neutron output observed was about what should have been expected for the non-null targets. Also, these calculations indicated that the neutron output could have been significantly improved, if the insight provided by the calculations had been available when the experiments were in

progress. Unfortunately, the programatic direction of the Sandia effort did not allow pursuit of this direction of research.

5. Dr. Laberge's experiments are much larger than that of Sandia (using microballons), therefore requiring more energy and monetary investment in the system, but also allowing more detailed experimental examination. At this point in Dr Laberge's experiments, it is most critical to obtain reliable data to guide his progress toward thermonuclear burn conditions.

6. Because Dr. Laberge's experiments are currently fairly low level, the water remains close to incompressible, so that there is a natural velocity amplification as the shock from the peripheral configuration runs inward. The measured performance of the liner is quite encouraging. By spending some time on analyzing the behavior of different liner designs and backing these up with iterations of detailed hydrodynamic calculations, it should be possible to get improved liner performance. Similar design studies have been carried out at the Air Force Research Lab in Albuquerque. They have designed and fielded current-driven, deformable liners, which are ultimately intended for compressing a field-reversed configuration (FRC) type of plasma.

7. The plasma formation approach seems adequate for the current experiments, but in the future it may be prudent to examine other methods, perhaps including an en-situ approach using a discharge through a frozen deuterium fiber.

8. Dr Laberge's reactor concept based on his MTF approach seems reasonable, but will eventually need a more thorough analysis. He has made valid estimates, and the general concept is interesting, possibly even viable. However, the most important objective for now should be to thoroughly understand the current experiments and how their performance can be enhanced in the future. The data from these experiments and the quantitative understanding gained should allow a more secure projection of the potential for this MTF approach as a basis for a fusion reactor.

9. At first, the word "bubble" in early e-mails made me think that this was another sono-luminescence fusion scheme, but it differs significantly from those schemes which use ultrasonic sound waves to create bubbles in liquids. While the word bubble may reasonably apply to this approach, I think the confusion caused by its use makes "bubble" a detriment. One might for similar reasons use the word to describe ICF targets, but as far as I know, no one has ever thought of doing so.

10. I am excited by the significant progress Dr. Laberge has made using what are obviously limited resources. The main-line fusion approaches have vast resources, but need such vast researches because they are coming up against state-of-the-art limitations due to working at the extremes of the range of all possible fusion approaches.

Ronald C. Kirkpatrick, retired
Visiting Scientist
Los Alamos National Laboratory

Dr. Ronald Kirkpatrick has had a long and successful career working at Los Alamos on many aspects of the American Fusion research program.

Dear Dr. Laberge,

I am writing you about your proposal for magnetized target fusion using your unique and innovative idea of acoustic shockwaves to implode a liner, thereby solving the "standoff" problem of how one connects to the liner, for an eventual fusion reactor application. I think it is an idea worthy of further testing and development, and commend you on your initial experiments. Particularly interesting was your extruding and imploding of a thin lithium liner.

Key questions when using your eventual steam piston approach would be the precision of timing between all the different pistons, considering that as mechanical systems, they may have millisecond accuracy, and yet the desired symmetry of the shock arrival on a cylindrical surface is probably down at the 1 microsecond level.

Also, the demonstrating the efficiency of mechanical energy applied at the edge, to liner kinetic energy is important, in a low-Q batch burn system such as embodied by Magnetized Target Fusion.

Generally, the idea of merging two spheromaks, injected from opposite ends of your system, to make a field reversed configuration (FRC) target plasma, is a good one, but the density regime demonstrated by spheromaks to-date is about 2 orders of magnitude too low. An alternative would be two inject and merge two FRC's, which do have the desired performance, at least to within a factor of 2 or so, but that may require a guide magnetic field in your chamber.

Our experiments at Los Alamos and the Air Force Research Laboratory are addressing the basic plasma/liner physics and impurity issues, so I am not as concerned about those for your experiment, which undoubtedly limited your present performance.

I wish you the best of luck and progress in your experiments. Be careful on cost estimates for a "reactor demonstration". Just handling flowing liquid FLIBE wall materials will be a useful engineering challenge, independent of your driver system.

Sincerely,

Glen

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Dr. Glen Wurden is the leader of the Los Alamos team working on MTF.