31st EPS Conference on Plasma Phys. London, 28 June - 2 July 2004 ECA Vol.**28G**, P-2.002 (2004)

New experimental implications for ICF

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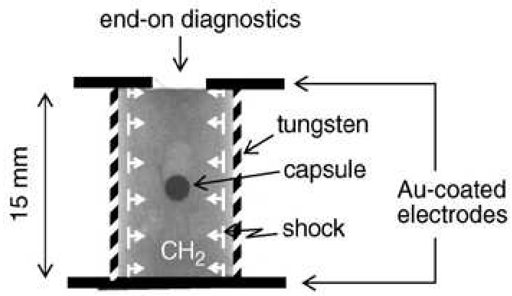
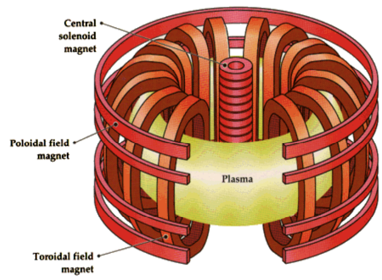
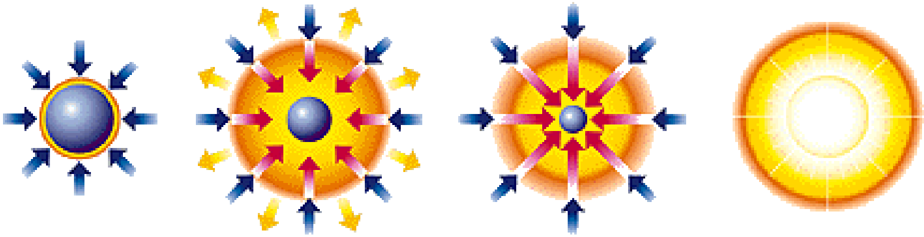
A novel melting and vaporization method and apparatus is described that may have implications for ICF. The method and design applies to the swelling (Z-pinch), the explosion (shock) and the implosion (radiation) steps of the ICF process. The apparatus is situated within an oven and is not subjected to any other external influence as part of the experimental setup. The experiment involves the heating of a solid sample within an evacuated and substantially spherical envelope in an oven. A magnetic field confinement is totally internally generated without external excitement.

Recently at CZ Technologies we have developed a novel and relatively low cost method and apparatus for the melting and vaporization of solids. This unique technique generates a sustainable magnetic confinement from the solid itself with in the hohlraum, and it might be applicable to some of the problems encountered in current fusion strategies such as ICF and by comparison, MCF. For this reason we will show you in Figure 1 a schematic representation of these two main confinement strategies and briefly summarize the differences between the two which explain the background of the problem. We continue by explaining our process and conclude by reporting visual evidence of the magnetic confinement totally internally generated by 24K gold solid within a substantially spherical envelope heated in an oven with out external excitement. Figure1

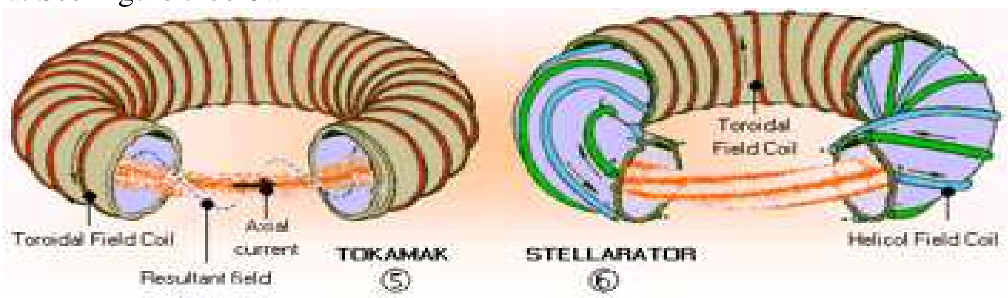




On the left of Figure 1 is a schematic of dynamic ICF (J.E.Bailey et al; PRL, Vol.89, No.9; 26 Aug.2002) and on the right is a schematic of MCF. The background problem is defined as the ICF/MCF Loss = The Lawson Criterion. ICF has no externally applied magnetic field and MCF does, The former is short - 15mm in size and the later is about 5 Km in diameter. ICF is short in duration ~10 nanoseconds and MCF is longer~10 minutes, but both are not long enough in duration to engage all the ions and electrons of the plasma so that a stable equilibrium is achieved. So, sustainable confinement is the issue. The ICF/MCF Loss has two main problems in achieving sustainable fusions: Confinement and sustainability. Figure 2 shows the ICF process. It requires highly symmetric capsule implosion which are hot dense implosions generated by Z-Pinch Dynamic hohlraum (ZPDH), which depend on the efficient generation and delivery of x-rays. So, adequate symmetry and temporal pulse shape control are needed to get the ZPDH to work. The external shockwave is generated by the vaporizing tungsten wires that line the foam all around. Further, ZPDH depends on indirect drive ICF, where the target is hit by lasers or particle beam or electrical power pulse, which generates the x-rays which ultimately generate the implosion. The x-ray flux induced implosion is intense but it only lasts 10 nanoseconds. So, the process has essentially 3 steps: 1. The shockwave heats up the foam liner to generate x-ray; 2. X-ray compresses and heats the target before shockwave reaches center target; 3. X-ray pulse is the final compression that causes implosion as shown in Figure 2 below: Laser energy (blue); Blow-off (yellow); Inward transported thermal energy (red)

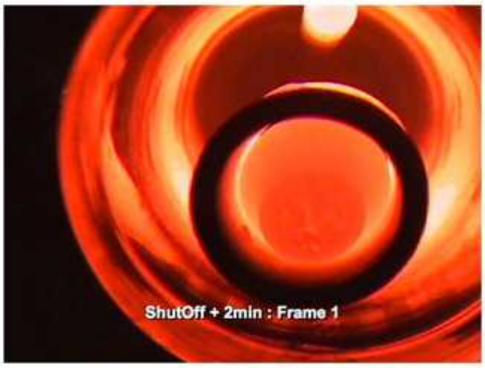


While ICF seeks to fuse nuclei so fast that they don't have time to move apart, MCF seeks to extend the time that ions spend close to each other in order to facilitate fusion. In MCF, the magnetic fields are used for containing the plasma for a relatively long time at a low density. The plasma density is thousands of times less dense than that of air at room temperature. The plasma is held by arranging the magnetic fields in just the right way so that a trap is created within the fields induced by the toroidal field magnets and the central solenoid magnet. While the plasma is held, it is heated through a combination of microwaves, particle beams and the heating generated from currents flowing through the plasma. See Figure 3 below

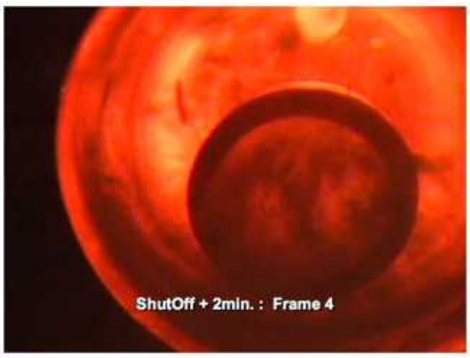


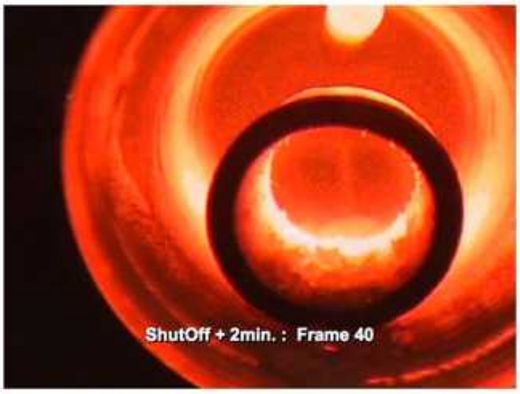
The toroidal form does not produce confinement in equilibrium, since the confinement time for fusion is no more than 10 minutes, and by comparison, for ICF, sustainability is at best 1 microsecond and symmetrical target compression requirements are very high. Therefore, the problem at hand that both strategies share is defined as: Ion Density + Confinement Time = Lawson Criterion, that is, for any particular material there is a particular value of nT (where n is the ion density in the plasma and T is the confinement time) that will result in more energy being released than is required to heat up the material to start the reaction. One of the largest problems lies in that it is not possible to reproduce the gravitational forces necessary to initiate and sustain a fusion reaction.

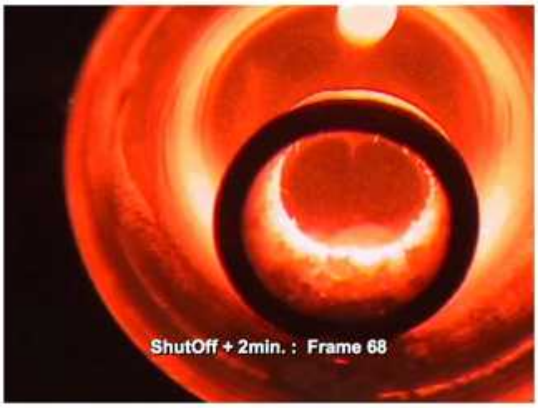
We, at CZT, think we have found a simple, practical and low cost solution which may have implications to the ICF/MCF sustainable confinement problem: CZT's magnetic confinement generated within hohlraum without external excitement produces more energy than what it takes to heat the plasma. This method and apparatus is suitable for any solid. As can be seen in Figure 4 below, a schematic representation of the process. The hohlraum is substantially spherical and can be made of fused quart, metal or other materials. The solid is placed in the envelope and evacuated. The envelope is place in an oven and heated. But, how do we get the magnetic field trap? Under normal circumstances, when the energy is added to the material, electrons are excited and leave the surface obeying Einstein's photoelectric effect. However, usually these electrons (-) will leave the close proximity of the material and the material left behind becomes positively charged. The motion of the electrons emitted from the solid surface are trying to come into equilibrium in a fixed volume that contains them. This total motion of the electrons creates a magnetic field parallel to the axis of motion, and due to the Lorentz force on each emitted electron moving around in the fixed volume, it generates additional energy to that of the heat flow, which then leads to the total disintegration of the material. It is appropriate to picture a 'drain in a bathtub'. As water flows down the drain it is slow at first, and then it speeds up. Aided by the geometry design and sustained by natural coulomb attraction between electrons floating and the positively charged material at the bottom of the envelope, all thermal energy is converted to electron energy, and total equilibrium is reached – all charged particles are engaged. How do we know this magnetic confinement is there? We take a hint from ICF. To induce the implosion, the oven is shut off. From that point on, the electrons start dropping back into the bottom of the envelope obeying the 'drain in the bathtub' effect. The quasi-bound orbits weaken as their radius, momentum and velocity changes with the magnetic field changing. At the speedup the implosion happens followed by an explosion. This is seen in Figures 4a-d. Two minutes after shutoff implosion explosion, the following minute exposes the magnetic dipole generated by the solid gold within the envelope. The dipole is there because the magnetic field was there to begin with. Each frame is 1.666seconds. The dipole dissipates at shutoff + 3 minutes.



Figures 4a (top), 4b (bottom)







Figures 4c (top), 4d (bottom)

In conclusion, it is obvious from the results, that the CZT Melting and Vaporization method and apparatus may actually solve some of the confinement issues that MCF and ICF are currently experiencing. This experimental setup and design are applicable to any solid and the assembly is scalable. It is patented and protected under PCT and wholly owned by CZT Inc.

The only way to get a stable Equilibrium is that the magnetic field that confines the charged particles is the result of the Total Field generated by All the particles in the system themselves. Therefore, the system is in Total Equilibrium and can last forever because it is a Coherent System.