SESSION OV3

Monday, 19 October 1998, at 4.30 p.m.

Chairman: T. Yamanaka (Japan)

OVERVIEWS 3

Paper IAEA-CN-69/OV3/1 (presented by B.A. Hammel)

DISCUSSION

T. DESAI: For laser energy coupling inside the hohlraum, you consider backscattered stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS) as loss mechanisms. Why do you neglect specular reflection inside the hohlraum which, although it remains inside the hohlraum, is rather dangerous?

B.A. HAMMEL: The issue with specular reflection that you would be concerned about is whether the light focused onto the target, after it had bounced off the inner cylindrical surface and led to a perturbation that was essentially a seed for Rayleigh-Taylor growth. We have not seen any evidence of this occurring. If it was thought to be a problem, one way of getting around it would be to have the hohlraum made up of facets instead of a cylinder. There is no evidence that it has been a problem. It is certainly not a case of laser loss, but rather a Rayleigh-Taylor imprint phenomenon.

Paper IAEA-CN-69/OV3/2 (presented by K. Mima)

DISCUSSION

D.D. RYUTOV: What was the ion current in the jet-like object?

K. MIMA: In the experiment, the total number of MeV ions is estimated from the neutron yield to be $10^{12} \sim 10^{13}$. Roughly speaking, ion pulse duration is 1 ps and the jet is 30 μm in diameter. These parameters indicate that the maximum peak ion current is $10^{10} \sim 10^{11}$ A/cm^2.

K. LACKNER: If there is a finite angle between the incoming laser and the electron beam produced, this will limit the interaction length between the two and thus, ultimately, the intensity of the electron beam. Is the process whereby the finite angle is produced understood? Will this not limit the usefulness of this effect for the fast ignitor concept?

K. MIMA: The dominant mechanism of MeV electron generation is the electron acceleration by large amplitude longitudinal waves which are excited by the usual mode conversion and/or the second harmonic mode conversion near the cut-off surface. The electron beam direction is determined by the plasma density gradient and the laser propagation direction. Accordingly, the interaction distance is very short and the finite angle between the laser and the electron beam does not therefore limit the electron beam intensity. As for the direction of the forward electron beam, this has not yet been resolved. Recent experiments and simulations indicate that the electron beams are pinched strongly by a self-generated magnetic field. There is therefore a need for more study of electron beam dynamics from the standpoint of fast ignition usefulness.

Paper IAEA-CN-69/OV3/3 (presented by J.M. Soures)

DISCUSSION

H. NISHIMURA: In the direct-drive scheme, an order of % non-uniformity must be attained in a wide range of mode numbers. On OMEGA, how do you evaluate experimentally the irradiation uniformity on spherical targets?

J.M. SOURES: We characterize the irradiation non-uniformity by several means. First, we measure the equivalent target plane energy distribution of individual OMEGA beams and then calculate the irradiation profile when these beams are superposed on the surface of spherical targets. Second, we carry out irradiation uniformity measurements on target by using X-ray emission from Au-coated spherical targets. Third, we carry out time-resolved imprinting measurements of the type discussed in this paper. Finally, we characterize the beam-to-beam power variance by measuring the time-history of many of the OMEGA beams using streak cameras.

Paper IAEA-CN-69/OV3/4 (presented by R.J. Leeper)

DISCUSSION

G. FUSSMANN: Supposing you are successful and can bring your 5 mm diameter pellets to ignition, would that not be a small H-bomb?

R.J. LEEPER: The highest yield capsule described here has a yield of 600 MJ. The highest yield that anyone has ever discussed for these types of systems is 1000 MJ. Energy output in this range is certainly very small relative to a “small” H-bomb. Even small conventional chemical explosives produce much higher energies than these capsules.

S. ELIEZER: What are the threshold parameters (such as current (I), $\frac{dI}{dt}$, number of wires per unit length, radius of wire, etc.) for a symmetric Z-pinch?

R.J. LEEPER: In answering this question, let me first describe the parameters on Z that underlie symmetric Z-pinches. Single wire arrays of 290 7.5 μm diameter tungsten wires that are at an initial diameter of 40 mm located inside a solid return current can (no holes), driven by a 3.5 MV, 19-20 MA, 100 ns risetime pulse, give a symmetric Z-pinch. We also use nested wire arrays of 240 wires at 40 mm diameter onto 120 wires at 20 mm of 7.5 μm tungsten wires driven by the same 3.5 MV, 19-20 MA, 100 ns risetime pulse. In this work, the single most important parameter for a symmetric implosion is the intergap wire spacing in the array, which must be < 0.5 mm. Symmetric implosions depend on prepulse and wire material, but we do not yet know how to completely evaluate this effect. On the Sandia Saturn Facility, it was found that a prepulse that went from 0-100 kA in 150 ns enabled a 40 Al (aluminium) wire array to merge into a plasma shell that, when driven by a 7 MA pulse in 50 ns, yielded a symmetric implosion. If the prepulse was doubled in current, a wire array of only 20 Al wires was found adequate for a symmetric implosion. If the prepulse current was halved to 50 kA, 80 wires were necessary for symmetric implosion. Finally, another consideration for symmetric implosions is Rayleigh-Taylor (RT) instabilities in the r-z plane. To minimize the effects of RT, the implosion time needs to be reduced to a minimum value while still maintaining coupling to the accelerator. This can be done by either reducing the mass of the wire array and/or reducing the radius of the array. These results are to be found in T.W.L. Sanford et al., PRL 5063 (1996).

K. LACKNER: Considering reactor aspects of the concepts presented, some components would be sacrificed at each shot and others would have to survive long-term. Where would you place the boundary between them, and how do you plan to protect the “permanent” components from the explosion, seeing that they will be much closer to the pellet than in other inertial fusion schemes.

R.J. LEEPER: The main goal of our work is to demonstrate high yield capsule implosions in the laboratory before worrying too much about engineering a reactor scheme. That would be a significant scientific achievement, establishing inertial confinement as a viable potential energy source. Then, on the basis of a sound knowledge of high yield capsule physics, we could start thinking seriously about engineering a reactor with a Z-pinch type scheme, or perhaps another approach like heavy ions. The boundary between "sacrificed" and "permanent" components for a Z-pinch reactor scheme has not yet been determined. It may not be necessary for the "permanent" components in a Z-pinch scheme to be closer to the pellet than in other inertial schemes; that would depend on the design. For example, we have considered an "inverse diode" scheme in which the Z-pinch components would be driven by a remote ion beam located many metres from the Z-pinch components. With this type of approach we would use conventional ICF reactor schemes with Li waterfalls and so on.