NINETEENTH FUSION ENERGY CONFERENCE

SESSION IF

Thursday, 17 October 2002, at 14:00

Chair: S. NAKAI (Japan)

SESSION IF: Inertial Fusion

Paper IAEA-CN94/IF-1 (presented by R.L. McCrory)

Discussion

J.D. Sethian: For your gain 81 target, what is the adiabat? What pulse shape did you use?

R.L. McCrory: The adiabat of the gain 81 target is approximately 2. It has a standard foot followed by transition to drive pulse, without a picket (or prepulse).

R.J. Goldston: Can you compare your measurements of asymmetry with multidimensional calculations? Is there more to learn in this area from NIF?

R.L. McCrory: The cryogenic results were compared to 2-D simulations. The warm target implosions to study mix are qualitatively consistent with simulations and a more detailed understanding is being developed. There will be more to learn on NIF. The larger scales, including three times greater acceleration and deceleration distances, may affect the conclusions from OMEGA and make them easier to diagnose. More importantly, ablative stabilization during the deceleration phase due to the hot spot can only be studied on NIF as OMEGA doesn’t have enough energy.

M.H. Key: Your experimental results show some significant differences between achieved and ideal performance of the implosions. The question is, what significance do these differences have in relation to the goal of ignition at NIF?

R.L. McCrory: Plastic shell implosions show ~30% of predicted 1-D yield. We attribute this to low order power imbalance, primarily due to the reproducibility of the current phase plates. These are being remanufactured to improve performance. The cryogenic targets on OMEGA are probably less sensitive to this power imbalance currently. Taken together, given that plastic targets are less stable than cryogenic ones, I think that the OMEGA results are encouraging for ignition.

Paper IAEA-CN94/IF-2 (presented by B.A. Hammel)

Discussion

M.H. Key: With regard to the interesting possibility of using 2ω, you showed that the backscatter loss may be only mildly increased. Have you considered the problem of the hot electron temperature scaling as $I\lambda^2$, which historically caused a serious problem and motivated the use of 3ω?

B.A. Hammel: Assuming an isotropic distribution of hot electrons produced near the hohlraum wall, the NIF baseline target can tolerate about 5% of the laser energy in hot electrons at the worst energy of about 50 keV. With 15% scattering near 15% critical density, the hot electron fraction could be high enough to cause some preheat. However, the electrons from SRS are forward scattered in the direction of the laser beam and those electrons reaching the capsule must first scatter off the hohlraum wall, which they do with 40–50% efficiency. So, expectations are that preheat will not be a problem, but it is one of the issues for further study.

R.B. Stephens: Are the new robust target designs well enough in hand to permit relaxing NIF target specifications?

B.A. Hammel: The estimates of increased robustness to surface roughness are still preliminary at this point. In addition, surface roughness is only one of the fabrication defects that can contribute to RT growth. Density and composition inhomogeneity also contribute and the final specifications must include all of these.

Paper IAEA-CN94/IF-3 (presented by K. Mima)

Discussion

G. Logan: Did you adjust the symmetry or power balance in the compression lasers to get compressed fuel close to the tip of the cone?

K. Mima: No, we did not adjust the power for better compression. This is our future task. However, the mixing of Au and fuel should be taken into account.

D.D. Ryutov: What was the prepulse level in your heating laser? Couldn't it generate some blow-off plasma?

K. Mima: If we have a prepulse of 10^{-5} or more of the main pulse, we have to be careful about the ablation of the solid surface since the surface plasma changes the absorption rate significantly. In our PW laser, the optical parametric chirped pulse amplification (OPCPA) front end reduces the prepulse significantly.

D. Meyerhofer: The two dimensional cone target hydrodynamic simulations do not appear to be optimized to put the high density region near the cone tip. Why not?

K. Mima: The two dimensional cone target implosion simulations were preliminary, so we did not try to optimize the high density core plasma position and the shape. The implosion hydrodynamics of the cone target is complicated because of the non-spherical nature, so it takes time to find the optimum implosion condition. Of course, I agree that the optimization is a very important issue.

Paper IAEA-CN94/IF-4Ra,b (presented by M.G. Haines)

Discussion

G. Logan: Does your new model explain why the peak X ray power at stagnation increases with larger numbers of smaller wires?

M.G. Haines: There are residual Rayleigh–Taylor instabilities due to some acceleration in the snowplough. The seed perturbation will scale as $n^{-1/2}$ where n is the number of wires. With reference to this model of coronal plasma interacting by heat flow to the liquid–vapour wire cores, the area will scale as $n^{1/2}$. So there is better thermal coupling and lower R–T seed as n is increased. The drop in X ray power found by Sandia at $n \geq 500$ could be due to a tighter final pinch and less area for black body radiation.

K. Mima: Does PENELOPE include the Weibel instability and filamentation instability?

M.G. Haines: Yes, in principle it does. The field generation model is the same as the codes by J.R. Davies and L. Gremillet, and cylindrical symmetry is assumed. So we can observe filamentation, i.e. the formation of ring-like structures.

K. Mima: Do you have a plan to combine the PIC relativistic electron generation simulation with PENELOPE? If yes, would you please describe the connection scheme.

M.G. Haines: Yes, we plan to do so, but this is still more “wishful thinking” than “work in progress”, so we have not considered technical details yet. I would also like to stress that the surface instabilities observed in PIC simulations may give an “imprint” for the filaments, that is, to trigger a mode with given wave vector. Thus, the simplest approach to combine PIC and PENELOPE simulations is to initialize the latter with an electron distribution having an imprint-wave vector.

Paper IAEA-CN94/IF-5 (presented by A. Macchi)

Discussion

M.G. Haines: Have you considered that the current filaments could be the result of electrothermal instabilities associated primarily with the return cold (resistive) current?

A. Macchi: Yes, we are aware of “your” electrothermal instability. In principle it is possible to observe it in the simulation with the hybrid PENELOPE code (not with the PIC code, which only takes the collisionless dynamics into account). So far, in the range of parameters that were simulated, we observe no filamentation. If we observe filamentation in future runs, we will take electrothermal instabilities into account.

D. Meyerhofer: What happens to filamentation and enhanced slowing down in a fully ionized, warm DT plasma?

A. Macchi: If the DT conductivity is very high, then the electric field inhibition observed in solid-target experiments (which depends upon the material conductivity) may not hold. However, collisionless instabilities (Weibel, surface parametric instabilities, etc.) are still at play and may be even stronger in DT and/or in typical fast ignition conditions, i.e. when the current is very large. These are open problems that possibly require an improvement in existing transport codes.

Paper IAEA-CN94/IF-6 (presented by G. Velarde)

Discussion

D. Meyerhofer: Did you propose a cylindrical implosion of boron, heated by a PW-generated proton beam?

G. Velarde: At this stage, the calculations were made by a compression (isentropic) of a (H+B) cylindrical target which will be heated by a “classical” (laser induced) fast ignitor scheme. A potential “cartoon” showing your possibility is not envisioned at this time.

D. Meyerhofer: How do you extract the energy from the p–B fusion?

G. Velarde: The classical extraction of a charged particle cycle is through the action of the current against an electromagnetic field inducing electrical currents in such a system. Then direct electric conversion should be the most appropriate and efficient choice.

F. De Marco: What is the density to which you must compress the pellet in the case of p–B_{11} fusion? In the same case, what is the fraction of radiation from the surface with respect to fusion yield?

G. Velarde: At this time the calculations are being performed assuming isentropic compression of the cylindrical target to densities higher than the classical values, in the range of 1000 g/cm^3. Higher densities are also studied. Remember that densities in the range of 600 g/cm^3 are considered in typical hot spark ignition. The losses by radiation (black body) have not been considered, and they will be (in the first step) not significant in the scheme of a burn wave propagation from the central part to the external area. This is not a volume ignition.