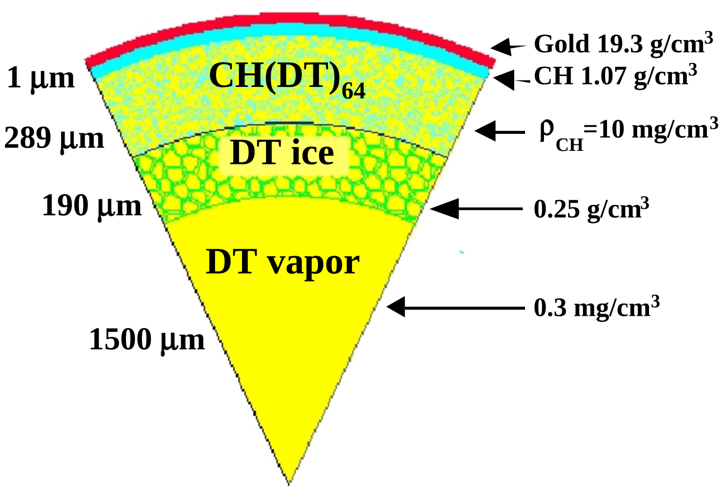
NRL LASER FUSION PROGRAM

September-October 1999 Bimonthly Highlights

A new KrF laser fusion target design has translated the concept of tuned adiabat into a practical design. It is based on a low fuel isentrope, radiation preheat of the ablator and a two-step zooming of the laser focal laser spot. It predicts gains of 125 using a 1.3 MJ KrF laser. 1D estimates of the Rayleigh-Taylor instability show that it reaches acceptable levels.

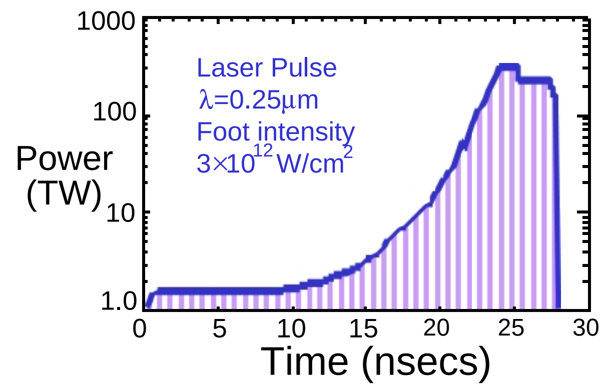
The pellet and the laser pulse shape are shown below. The pellet consists of a core of DT fuel surrounded by an ablator that is a CH foam (~10 mg/cm) filled with frozen DT. The ablator is surrounded by a thin plastic shell to confine the DT, and then by a few hundreds of Å of a high-Z overcoat such as gold.



The laser pulse rises slowly at first until half way into the implosion when the spot size is reduced (74% of its original size) and it is reduced again just after the pulse has reached its maximum intensity of ~10^{15} W/cm^2 (54% of its original size). Zooming reduces the laser energy requirement for this target from 2.1 MJ to 1.3 MJ (thus raising the gain from 72 to 125).

The calculations show that the foam-filled DT ablator is preheated by the soft gold radiation during the first 10 ns of the laser pulse, and then by the carbon radiation during the high-intensity portion of the laser pulse (starting after ~15 ns). The pure DT fuel stays on a very low isentrope, with α <1.5.

As for the RT stability of this pellet, the simplest ‘figures of merit’ are the distance-moved-over-thickness, DMOT, and then the in-flight-aspect-ratio, IFAR. DMOT is proportional to the number of classical e-folds of the RT instability, for a perturbation wavelength l/k that is comparable to the shell thickness.



The other parameter IFAR is also closely related to that number of e-folds. The maximum DMOT reaches about 40 and the peak IFAR reaches 60. The Atwood number at the ablator/fuel interface is less than 0.1 during most of the inward acceleration and the instability at that interface is probably not important for this target. From an analysis of the RT dispersion relation, we get 5.8 e-folds for the net RT growth, which means that a perturbation will grow to about 20 µm starting from one reaching 500 Å at the end of the laser pulse foot, just before the main acceleration starts. This number of e-folds has been checked by a full 2D calculation, turning on ISI at the end of the foot of the laser pulse.

In conclusion, we have put together a high gain target for KrF laser light which may provide sufficient control of the ablative RT instability. Gains above 100 have been found through the use of: a) direct-drive laser target coupling at 0.25µm laser wavelength; b) zooming so that the laser spot follows the target as it implodes; c) large contrast ratio for the laser pulse, which is equivalent to a low fuel isentrope or a long (>20 ns) foot pulse length; and d) controlled levels of radiative preheat in a low-opacity ablator.

For comments about content of the ***BIMONTHLY HIGHLIGHTS***, contact Steve Obenschain (202) 767 0689
To get on the mailing list contact Yefim Aglitskiy (202) 404 1158
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