Laser Beam Propagation through Target Debris and Mitigating Gas for IFE

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Executive Summary

Laser Inertial Confinement Fusion Energy engines will depend on the ability to generate large numbers of fusion neutrons (of energy ~ 14 MeV) via fusion. As currently envisioned, targets will be injected into a gas-filled chamber (radius ~ 2.5 m) at a rate of approximately 10 Hz. As the target reaches the center of the chamber, laser beams are then fired into either a hohlraum (indirect drive) or directly onto a target (direct drive) from final optics that are set approximately 50 m from chamber center. In the case of indirect drive, the laser energy is coupled into the hohlraum, converted to X-rays that drive the DT pellet, ultimately creating sufficiently high densities and temperatures such that thermonuclear burn occurs for a fraction of a nanosecond. The hohlraum-target assembly then disintegrates into ions which, along with of order 90 % of the resulting X-rays, must be stopped by the gas in the chamber. In the case of direct drive implosions, the lasers directly impinge onto the surface of the capsule, ablating plasma from the first layer, and sending the fuel toward the center of the spherical target. Again, the ions and X-rays created during the implosion and burn phase must be stopped by gas before they reach the chamber wall.

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In this white paper, a program is proposed to determine the required gas composition and density in the chamber, such that the density will be low enough such that the laser beams, for both indirect and direct drive options, will propagate to the hohlraum or the capsule itself (in the case of direct drive) with minimal degradation and energy loss (via inverse bremsstrahlung), while at the same time be high enough so that the amount of X-ray energy and ions reaching the first wall will result in negligible damage. In addition, for fusion schemes requiring high peak power lasers (like Fast Ignition designs,) B-integral will also be considered as another possible limitation on peak laser intensity that can travel through the chamber. Various gas fills and laser wavelengths will be considered, in order to find an optimal gas chamber environment for IFE, examples of which are shown below.

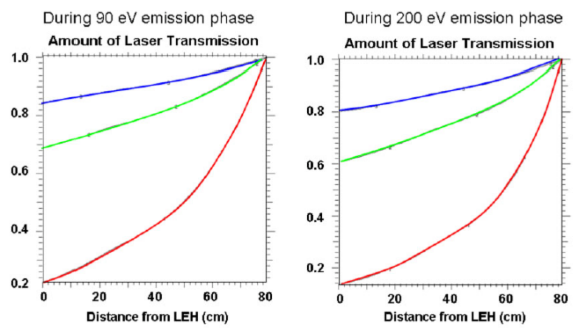

Fig. 3 (a) Amount of laser transmission, for 0.3 micron (blue), 0.5 micron (green), and 1.0 micron (red) light, through a path 80 cm from the LEH.

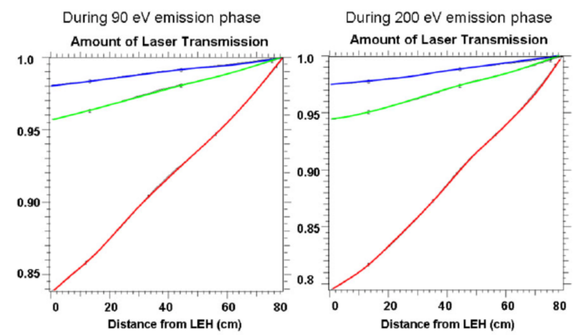

Fig. 5 Laser transmission for 2.3e-6 g/cc of xenon gas case.

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