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CHAPTER 1

PELLET FUSION

STABILITY AND SYMMETRY REQUIREMENTS OF ELECTRON AND ION BEAM FUSION TARGETS*

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Abstract

Considerations of hydrodynamic stability impose severe restrictions on the design of electron and ion beam imploded fusion targets. Furthermore, in order to obtain a sufficiently spherical implosion, many target designs require electron or ion beams having a high degree of spherical symmetry.

We have studied the stability and symmetry requirements of several recently proposed target designs by numerical simulation using the computer program LASNEX.

The ion beam targets we have studied are more vulnerable to instability than the electron beam targets.

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I. Stability

The familiar phenomenon of Rayleigh-Taylor instability occurs when two fluids of density ρ_1 and ρ_2 ($\rho_1 \neq \rho_2$) are placed in contact and accelerated in a direction normal to the interface and directed toward the denser fluid. Specifically, let us assume an acceleration a along the z-axis. If a perturbation of the form $\eta_o \sin kx$ is applied to an interface at $z = z_o$ the amplitude η at time t is given by

$$\eta = \eta_o e^{\gamma t} \quad , \qquad (1)$$

where $$\gamma = \sqrt{\alpha k a} \qquad (2)$$

and $$\alpha = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$$

is the Atwood number. In this case we assume that the fluid of density ρ_2 occupies the region $z > z_o$ so that exponential growth occurs when $\rho_2 > \rho_1$ and $a > 0$.

Equation (1) is valid for $\eta \lesssim \lambda = 2\pi/k$. For $\eta \gtrsim \lambda$ the growth rate becomes more nearly linear in time.[1]

In this paper we consider only spherical fusion targets. In this case we expand the perturbation in spherical harmonics[2] of order ℓ and replace k in Equation (2) by $k \cong \ell/r$ where r is the radius of the interface.

There are at least three cases in typical electron and ion beam fusion targets where Rayleigh-Taylor instability is likely to play an important role. These are shown in Fig. 1.