destabilized depending on whether the magnetic pressure on the interface opposes the instability driving shock pressure or acts in the same direction. An interesting result is that if both the fluids are magnetized, interface as well as velocity of bubble and spike will show oscillating stabilization and R-M instability is mitigated. All analytical results are also supported by numerical results. Numerically it is seen that magnetic field above certain minimum value reduces the instability for compression the target in ICF.

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Laser induced ablatively driven interfacial nonlinear fluid instabilities in multilayer targets

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High power laser driven shock waves in condensed matter have important application for studying equation of state (EOS) and high pressure physics. This is an important phenomenon in fuel compression for Inertial Confinement Fusion (ICF) experiments where multilayer targets of differing shock impedance are interacted by laser induced shocks. The interface between the two fluid becomes unstable when driven by the impulsive force (Richtmyer-Meshkov) due to such a shock wave or a continuously acting force e.g., gravity (Rayleigh-Taylo). In the nonlinear stage, the fluid interface is found to develop structures having finger-like shapes. The structures resemble a bubble (spike) accordingly as a lighter (heavier) fluid pushes in a heavier (lighter) fluid. These effects need to be mitigated for efficient compression in ICF experiment. We have studied the effect of density variation on R-T and R-M instability on the temporal development of nonlinear two fluid interfacial structures like bubble and spike. It is shown that the velocity of bubble or spike decreases leading to stabilization if the density of the fluids leads to lowering of the Atwood number. The Atwood number $A = \frac{\rho_a - \rho_b}{\rho_a + \rho_b}$ changes to $A^* = \frac{\rho_a^* - \rho_b^*}{\rho_a^* + \rho_b^*}$ where $\rho_m^* = \rho_m \left(1 - \frac{1}{\gamma_m}\right)$, $m = [a, b]$, assuming $\rho_a > \rho_b$.

It has been seen that the stabilization or destabilization (depending on the algebraic sign of the gradient) will be proportional to the pressure p_0 at the interface [1].

The set of equation describing the dynamics of the bubbles and spikes in presence of fluid density variation are not analytically intergrable in closed form. All the results are derived by numerical methods and are represented and interpreted. Analytical calculations are performed (not presented here) to modify the dynamical boundary condition between the two fluids and we have finally arrived at the following expression for the asymptotic bubble velocity $v_b^2 = \frac{2(r*-1)}{3r*} gk + (\frac{\alpha}{3}\sqrt{\frac{C_{a0}C_{b0}}{(\gamma_a - 1)(\gamma_b - 1)}}\frac{\sqrt{r*}}{\gamma_a} KL)$; where $r* = \frac{\rho_a^*}{\rho_b^*}$,

$k =$ wave number,

$g =$ gravity factor.

Here L denotes the density gradient inhomogeneity scale length and L>0 or <0 accordingly as density is increasing or decreasing while $\sqrt{C_{a0}C_{b0}}$ is proportional to p_0' and $\alpha = 0(1)$ $[C_{a0} = \gamma_a p_0 / \rho_a]$. Clearly instability is reduced if the bracketed term is negative. The opposite occurs when it is positive.

We have obtained the conditions for stabilization of the fluid instabilities for various conditions of density variations of heavier fluid and or lighter fluid. It is interesting to note that compression of lighter fluid and decompression of heavier fluid leads to stabilize the two fluid interfaces which is desirable for ICF target design.

Numerical calculations are performed for composite target material (Au-foam) as well as (SF6 -Air).Results obtained would be useful for target design in ICF and studying EOS of material.

References

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Effect of viscosity and surface tension on the growth of Rayleigh-Taylor Instability and Richtmyer-Meshkov instability under nonlinear domain

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The Rayleigh-Taylor(R-T) instability and Richtmyer-Meshkov(R-M) instability are well known problems in the formation of some astrophysical structures such as the supernova remnants in the Eagle and Crab nebula. A core collapse supernova is driven by an externally powerful shock, and strong shocks are the breeding ground of hydrodynamic instability such as Rayleigh-Taylor Instability or Richtmyer-Meshkov instability. These instabilities are also important issues in the design of targets for inertial confinement fusion (ICF). In an ICF target, a high density fluid is frequently accelerated by the pressure of a low density fluid and after ablation the density quickly decays. So, small ripples at such an interface will grow. Under potential flow model, the perturbed interface between heavier fluid and lighter fluid form bubble and spike like structures.

The bubbles are in the form of columns of lighter fluid interleaved by falling spike of heavy fluid. In this paper, we like to presented the effect of viscosity and surface tension on Rayleigh-Taylor instability and Richtmyer-Meshkov instability under the non-linear Layzer's[1] approach and described the displacement curvature, growth and velocity of the tip of the bubble as well as spike. It is seen that, in absence of surface tension the lowering of the asymptotic velocity of the tip of the bubble which is formed when the lighter fluid penetrates into the denser fluid and thus encounters the viscous drag due to the denser fluid, which depends only on the denser fluid's viscosity coefficient. On the other hand the asymptotic velocity of the tip of the spike formed as the denser fluid penetrates into the lighter fluid is reduced by an amount which depends only on the viscosity coefficient of the lighter fluid and the spike is resisted by the viscous drag due to the lighter fluid. However, in presence of surface tension the asymptotic velocity of the tip of the bubble (spike) and nonlinear perturbed surface are oscillating under certain conditions. For Rayleigh-Taylor Instability this oscillation depends only on the surface tension but for Richtmyer-Meshkov instability it depends on surface tension as well as viscosity.

References

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