Chapter 8

Results and discussions

In this thesis the following three types of instability problems are investigated in a composite electrically poorly conducting couple stress and/or ordinary fluids and fluid saturated nano–structured porous layer in the presence of an electric field and/or magnetic field and laser radiation using linear stability analysis and finite difference schemes;

1. Rayleigh–Taylor Instability (RTI)

2. Kelvin–Helmholtz Instability (KHI)

3. Ritchmyer–Meshkov Instability (RMI)

The investigations of problems carried out in this thesis given by Chapters 3 to 7 help in obtaining an efficient productions of Inertial Fusion Energy as explained in Chapter 1 of this thesis. In order to keep the environmental problems mathematically tractable several simplifying assumptions have been made to the extent that they do not obscure the actual phenomena which was purportedly modeled in a restrictive yet representative sense. The detailed discussions and conclusions are given below Chapter by Chapter.

Chapter 3

In this chapter we have investigated, the linear Electrorheological Rayleigh–Taylor Instability (ERTI) of an incompressible viscous poorly conducting couple stress fluid in a thin
film in the presence of an electric filed and laser radiation, bounded below by a rigid surface and above by densely packed porous layer consisting of heavy couple stress poorly conducting fluid of high density using the linear stability analysis combined with the normal mode solution. The dispersion relation is obtained as given in Eq.(3.4.4) and the ratio of maximum growth rate and classical growth rate is given in Eq.(3.5.7). This, $G_m$ is computed for different values of the couple stress parameter, $\beta$, electric number,$w_e$, porous parameter,$\sigma_p$ and absorption frequency $\Omega$ (expressed in difference in temperatures $\delta(1)$ at the interface) of the laser radiation and the results are tabulated in tables I, II and III. We note that the reduction of growth rate is 99% in the presence of laser radiation, couple stress and electric field, compared to 45% reduction predicted by Takabe[125] and 79% by Rudraiah[82] in the absence of these quantities.

The growth rate $n$ given by Eq. (3.4.4) is always real and is computed for different values of $\beta$, $w_e$, $B$ and $\delta(1)$ and the values are graphically depicted in Figures(??) to (3.4). These Figures represent the dispersion relation $n$ versus cutoff wave number $l$. Figure(3.1) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $\beta$ and with fixed values of $w_e = 1$, $\delta(1) = 10$, $B = 0.02$ and $\sigma = 0.001$. This figure shows decrease in $\beta$ that is increase in $\lambda$ a material property responsible for couple stress the negative growth rate $n$ decreases. Figure(3.2) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $w_e$ and with fixed values of $\beta = 1$, $\delta(1) = 10$, $B = 0.02$ and $\sigma = 0.001$. This graph shows that for an increase in $w_e$ the growth rate $n$ decreases. Figure(3.3) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $\delta(1)$ and with the fixed values of $\beta = 1$, $w_e = 1$, $B = 0.02$ and $\sigma = 0.001$. This figure shows that for an increase in $\delta(1)$ the growth rate $n$ decreases. Figure(??) represents the graph of the growth rate $n$ versus wave number $l$ for different values of Bond number $B$ with fixed values of $\beta = 1$, $w_e = 1$, $\delta(1) = 10$ and $\sigma = 0.001$. 

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This figure shows that decrease in $B$ (increase in surface tension) increases the negative growth rate.

Chapter 4

In this chapter we have investigated, the linear Electrohydrodynamic KHI of an incompressible viscous poorly conducting fluid in a thin film in the presence of an electric and magnetic fields, bounded below by a rigid surface and above by densely packed porous layer consisting of poorly conducting fluid of high density is investigated using the linear stability analysis combined with the normal mode solution. The dispersion relation is obtained as given in Eq.(4.4.4) and the ratio of maximum growth rate and classical growth rate is given in Eq.4.5.7. This $G_m$ is computed for different values of the Hartman number, $M$, electric number, $w_e$ and porous parameter and the results are tabulated in tables I and II. From these tables, we note that the reduction of growth rate is 99% in the presence of laser radiation; couple stress and electric field, compared to 45% reduction predicted by Takabe[125] and 79% by Rudraiah[82] in the absence of these quantities.

The growth rate $n$ given by Eq. (4.4.4) is always real. This $n$ is computed for different values of $M$, $w_e$, and $B$ and the values are depicted in the Figures(4.1) to (4.3). These Figures represent the dispersion relation $n$ versus cutoff wave number $l$. Figure(4.1) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $\beta$ and with fixed values of $w_e = 1$, $\delta(1) = 10$, $B = 0.02$ and $\sigma = 0.001$. This figure shows decrease in $\beta$ that is increase in $\lambda$ a material property responsible for couple stress the negative growth rate $n$ decreases. Figure(4.2) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $w_e$ and with fixed values of $\beta = 1$, $\delta(1) = 10$, $B = 0.02$ and $\sigma = 0.001$. This graph shows that for an increase in $w_e$ the growth rate $n$ decreases. Figure(4.3) represents the graph of the growth rate $n$ versus wave number $l$
for different values of $\delta(1)$ and with the fixed values of $\beta = 1$, $w_e = 1$, $B = 0.02$ and $\sigma = 0.001$. This figure shows that for an increase in $\delta(1)$ the growth rate $n$ decreases.

Chapter 5

In this chapter we have investigated, the linear Electrorheological Kelvin-Helmholtz Instability (EKHI) of an incompressible viscous poorly conducting couple stress fluid in a thin film in the presence of an electric filed and laser radiation, bounded below by a rigid surface and above by densely packed porous layer consisting of heavy couple stress poorly conducting fluid of high density is studied. The dispersion relation is obtained as given in Eq. (5.5.7) and the ratio of maximum growth rate and classical growth rate given by Eq. (5.5.7). This $G_m$ is computed for different values of the couple stress parameter $\beta$, electric number $w_e$, porous parameter $\sigma_p$ and absorption frequency $\Omega$ (expressed in difference in temperatures $\delta(1)$ at the interface) at the interface of the laser radiation and the results are tabulated in table I. We note that the reduction of growth rate is 98% in the presence of laser radiation; couple stress and electric field, compared to 45% reduction predicted by Takabe et al.[125] and 79% by Rudraiah and Kalal[84] in the absence of these quantities.

The growth rate $n$ given by Eq. (5.4.4) is always real. This is computed for different values of $\beta$, $w_e$, $B$, $\sigma_p$ and $\delta(1)$ and the values are depicted in the Figures (5.1) to (5.3), which represents the dispersion relation $n$ versus cutoff wave number $l$. Figure (5.1) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $\beta$ and with fixed values of $w_e = 1$, $\delta(1) = 1.5$, $B = 0.4$, $\alpha_1 = 0.001$ and $\sigma_p = 0.5$. This graph shows that an increase in $\beta$ the growth rate $n$ decreases. Figure (5.2) represents the graph of the growth rate $n$ versus wave number $l$ for different values of $w_e$ and with fixed values of $\beta = 1$, $\delta(1) = 1.5$, $B = 0.4$, $\alpha_1 = 0.001$ and $\sigma_p = 0.5$. This graph shows that for an
increase in $w_e$ the growth rate $n$ decreases. Figure 5.3 represents the graph of the growth rate $n$ versus wave number $l$ for different values of $B$ and with fixed values of $w_e = 1$, $\delta(1) = 1.5$, $\beta = 1$, $\alpha_1 = 0.001$ and $\sigma_p = 0.5$. This graph shows that for an increase in $B$ the growth rate $n$ decreases.

Chapter 6

We have investigated the effect of oblique electric field on KHI, based on the usual normal modes analysis. The linear KH instability of a poorly conducting fluid layer with a constant shear topped by a poorly conducting fluid saturated layer of negligible density under the effect of an oblique electric field. When the electric field is acted tangentially to the interface between the two media, we found that the constant shear, surface tension and the tangential electric field have a stabilizing effect, and that there are critical values of the wave number and the electric field which determine the marginal state separating the stability and instability conditions. In the absence of the electric field, we have recovered the corresponding pure hydrodynamical case and we have corrected the condition of stability for the critical wave number. When the electric field is acted normally to the interface between the two media, we have investigated the previous problem for two cases in the presence or absence of surface charges present at the interface between the two media. In both the cases we found that the normal electric field has always a destabilizing effect, and the instability is more effective in the second case than the first one. The corresponding stability conditions for the wave number (or wavelength) and the electric field are obtained for both the cases due to the suitable critical wave number and electric field values. We found also that the dielectric constant has no effect on the stability criterion.

Chapter 7

An extensive simulation of the two-dimensional incompressible Richtmyer-Meshkov in-
stability in a continuously stratified fluid is presented the shock-induced Richtmyer-Meshkov instability. The initial motion after the passage of the shock is assumed to be equivalent to the motion generated by an impulsive acceleration except for a small effect of compressibility. For a small single-scale perturbation on an interface, our numerical growth rates of the instability are the same as those predicted by Richtmyer theory. For a continuous stratification, and similarly for a highly perturbed layer, the Richtmyer formula over predicts the growth rate. The growth rate varies most strongly with variations of the layer thickness. Variation of the growth rate with amplitude and Atwood ratio are less pronounced. For the single-scale problem, with $L = 1.0$, our calculations covers the range of Atwood number $A$ from -0.8 to -0.05, and $\epsilon$ from 0.2 to 1.0. The numerical growth rates for these cases are about half of the Richtmyer results for the sharp profiles with an equivalent jump in density. The rate decreases in time in proportion to the nonlinear effects. The higher the perturbation amplitude and the Atwood number, the greater the reduction in the growth rate. The initial behavior follows the frozen field approximation over a time equivalent to the traversal of several layer thickness. For single-scale perturbations no self-similar long-time asymptotic behavior is observed for the growth of the layer. This is to be contrasted with the case of Rayleigh-Taylor instability in the single-scale regime. For all the cases, we observe the emergence of fluid plumes due to roll-up where the nonlinear effects become significant. This phenomenon causes the overall growth of the layer to decrease, and the initial deposited energy is used to increase the internal mixing of the stratified layer. The results obtained in this thesis are useful in reducing the asymmetry at the ablative surface of inertial fusion energy target (IFT) in fusing the hydrogen isotopes Deuterium and Tritium (DT) by high intensity laser radiation.