CHAPTER -7

CONCLUSIONS AND FUTURE PROSPECTS

The compiled thesis offers theoretical investigation of complex astrophysical fluid stabilities in diversified astrophysical environs, such as viscoelastic complex neutral fluids, DMCs, neutron star crusts, etc. The dynamical behaviour of self-gravitating complex fluids is greatly influenced by the presence of several realistic agents. It includes polytropicity, buoyancy, thermal fluctuation, volumetric expansion, magnetic field, dust-charge fluctuation, system geometry, etc. We analyse the model stabilities constructed from the fluidic viewpoint focused in the generalized hydrodynamic (GH) framework. The methodology applied involves different standard techniques, such as linear perturbation approach, reductive perturbation method, mean-fluidic magnetohydrodyanmic (MHD) technique along with the Fourier analysis. These techniques enables us to explore the dynamical mechanisms behind the excitation of diversified collective waves, oscillations, and instabilities in different astrophysical environs. The main conclusive points drawn from the various Chapters of the compiled thesis are summarized as follows:

1. We study the long-range self-gravitational instability dynamics in a large scale viscoelastic fluid medium. It considers the effects of fluid polytropicity, non-thermality, buoyancy, and so on. A local linear normal mode analysis shows that the instability remains unaffected due to the considered thermo-mechanical diffusion processes in the presence of gravitational effects. In addition, the fluid viscoelasticity stabilizes the complex fluid; whereas, the combined effects of the volume expansion and polytropicity lead the complex fluid of our interest towards enhanced instability. The semi-analytic findings could be helpful in understanding the gravito-thermally triggered coupled collective instabilities and saturation phenomena in super-dense compact astrophysical objects and their sub-dense surrounding ambient atmospheres.

2. We formulate a non-linear analysis of the same viscoelastic medium together with the effects of polytropicity, non-thermality, fluid buoyancy, and so forth. It reveals the microphysical insights of the exact patterns of the instability. It shows that the perturbed density evolves as an admixture of compressive and rarefactive solitary chain patterns. Moreover, the closed loop in the form of geometrical trajectories confirm the

conservative nature of the weakly non-linear perturbation dynamics in the fluid system. In addition, the polytopicity, viscoelastic relaxation time, and volumetric expansion destabilizes the system. It is interesting to note that the relaxation time alters its role in the non-linear case against the linear counterpart. The investigated eigen-mode signatures may be relevant in the mechanism of energization, transportation, and redistribution of the fluid constitutive particle producing non-homologous dense sites in diversified interstellar fluid media subsequently converted into bounded neonatal astrophysical structures, such as stellesimals, planetsimals, and so forth.

3. In spherical DMCs, the effects of polytropicity, fluid buoyancy, volumetric expansion, are re-examined, but in the presence of magnetic field in the g-MHD framework. It is found that the mean-fluidic temperature, polytropicity, viscoelastic relaxation time, effective generalized viscosity, and radial cloud size act as active stabilizing factors against the self-gravity action. In contrast, the constitutive mass and magnetic field act as destabilizing agents against the canonical Jeans collapse. It is theoretically seen for the first time that the magnetic field acts as the cloud destabilizer, which is in accord with the previous astronomic observations, experimentally centred on the Zeeman effect. Clearly, it is a novel result caused due to the concurrent action of the diversified non-ideal mean-fluidic factors in the curved (spherical) geometry, causing the field lines to curve (as if, induced purely by ambipolar diffusion phenomena).

4. We study the excitation of the DAW and DCW in the extreme dust-fugacity and viscoelasticity conditions of gravito-magnetically bounded spherical DMCs. It includes mainly the effects of non-local self-gravity, non-thermal pressure, and dust-charge fluctuation in a non-planar geometry. It is found that the fluctuations are free from viscoelasticity effects in the WCL against the SCL. It is to be noted that the DAW (DCW) mode is excited in the LFR (HFR) of the cloud. The LFR mode (DAW) and HFR mode (DCW) are dispersive in the short-wavelength (acoustic) regime and non-dispersive in the long-wavelength (gravitational) regime propagating with their respective distinct critical existential scales. In SCL, the viscoelastic force is directed inward (outward) in the $\kappa-$case (MB-case). In addition, the non-thermal pressure greatly influence the DMCs. It leads the DMC towards more stability. The RCW 38 region of the dark DMCs may provide favourable environs for the DCW excitation.

5. We investigate the stability behaviours of the inner crust properties of non-rotating neutron stars from the hydrodynamic viewpoint. A GNA instability mode is found to be excited therein. In GNA mode, the electrostatic influence arises here from all the Coulombic (charged) species (electrons + nuclei) and the self-gravitational effect from the Newtonian (gravitating) species (neutrons + nuclei). In the inner crust of neutron star, the heavy neutron rich nucleus, electron, geometric curvature act as its destabilizers. It is only neutron that acts as a GNA stabilizing agent. The high-K regions are more unstable spectral windows indicating that the GNA mode plays dominant role in the inner crust zone towards the local stability. Its fair reliability is indicated in light of the Rossi X-Ray Timing Explorer (RXTE) data from the December-2004 hyperflare originating from SGR 1806+20. This global oscillation mode frequency has been found to be 625 Hz, which is close to our estimated Jeans frequency value of 648 Hz.

It is admitted that the proposed works in the compiled thesis have some facts and faults. The simplifications could be dropped out in the model formalisms. It provides new refinement scope in the futuristic directions. In this context, our main concerns are:

a) An extensive DCW-dispersion analysis with extraordinary dust-fugacity effects in complex astrocloud conditions.
b) Effect of the Coriolis rotation and strong magnetic field in the GNA instability.
c) Study of higher order modes in the GNA instability dynamics.
d) Development of non-linear relativistic model to study GNA instability dynamics.
e) Non-radial mode analysis of the GNA instability could be an interesting and useful work for a more realistic instability characterization.