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Wave modes and Gravitational instability in Degenerate Quantum Plasmas including Radiation Pressure and Viscoelastic Effects

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The wave modes and linear Jeans instability in the ultra-relativistic degenerate strongly coupled quantum plasma have been studied using the quantum hydrodynamic fluid description considering the influence of radiation pressure, Ohmic diffusivity and uniform rotation. The modified equation of state is considered in the fluid model, which includes the effects of radiation pressure of weakly coupled, degenerate, and ultra-relativistic electrons and non-degenerate strongly coupled ions. The general dispersion relation is analytically derived using the normal mode analysis and examined in the transverse and longitudinal modes of propagation in hydrodynamic and kinetic limits. The Jeans instability criterion depends upon the characteristic wave speed of the system modified due to radiation pressure, electron degeneracy pressure, and ion gas pressure. For an infinitely conducting fluid, the Alfven speed is observed to intervene in the instability condition and modify the critical Jeans wavenumber in transverse propagation. The graphical illustrations show that the growth rate of Jeans instability in the kinetic limit is significantly reduced due to the prominent role of radiation pressure, compressional viscoelastic effects, electron degeneracy pressure, fluid rotation, and quantum corrections. The dispersion properties of wave modes and linear instabilities are analyzed in various limiting cases of interest. The present theoretical results have been applied to understand the gravitational collapse of white dwarfs, and it is observed that perturbations of wavelength larger than the Jeans length $\lambda_J \simeq 1.7 \times 10^5$ km make white dwarfs gravitationally unstable.

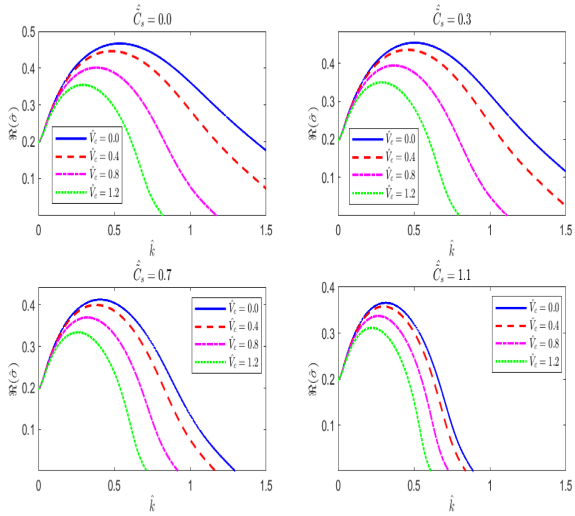

Fig.1. The normalized Jeans instability growth rate is illustrated in different subplots against the normalized wavenumber with the combined effects of modified sound speed and compressible viscoelastic speed.

References

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