**Annexure – IX**

**UNIVERSITY GRANTS COMMISSION**
**BAHADUR SHAH ZAFAR MARG NEW**
**DELHI – 110 002**

**PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT**

1. Title of the Project: **Hydromagnetic Instabilities in Strongly Coupled Complex Plasmas**

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR:

**Dr. R. P. Prajapati,**

**Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur-495009, Chhatisgarh**

3. NAME AND ADDRESS OF THE INSTITUTION:

**Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.)**

4. UGC APPROVAL LETTER NO. AND DATE: **(i) F. No. -43-514/2014(SR) Dated 28 Sep, 2015**
**(ii) F. No. -43-514/2014(SR) Dated 28 Oct, 2017**

5. DATE OF IMPLEMENTATION: **01/07/2015**

6. TENURE OF THE PROJECT: **01/07/2015 to 30/06/2018**

7. TOTAL GRANT ALLOCATED: **Rs.15,00,000/-**

8. TOTAL GRANT RECEIVED: **Rs.12,91,546/-**

9. FINAL EXPENDITURE: **Rs. 10,36,266/-**

10. TITLE OF THE PROJECT: **Hydromagnetic Instabilities in Strongly Coupled Complex Plasmas**

11. OBJECTIVES OF THE PROJECT:

In this research project we propose to investigate hydromagnetic instabilities in dusty plasma, strongly coupled plasma and quantum plasma. We proposed to investigate the effects of various parameter viz. Coriolis force, non-ideal effects (Hall current, electrical resistivity, electron inertia, ambipolar diffusion) on the instabilities of strongly coupled viscoelastic fluid and strongly coupled dusty plasmas. The various physical processes like radiative cooling mechanism, polarization of dust grain, magnetization due to collective spin, pressure anisotropy etc. affect the excited wave and instabilities associated with the medium. We wished to study the effects of these parameters on the structuring process of real physical systems. In the case of Kelvin-Helmholtz instability (KHI) we wished to discuss the effects of dust charge fluctuation, different flow velocities, dust streaming effect, strong coupling effects and Hall current. We wished to discuss and apply our results in the real situation of the astrophysical and laboratory plasmas.

12. WHETHER OBJECTIVES WERE ACHIEVED:

Yes, the major portion of the objectives are successfully worked out and the important results and findings of the problems have been published in international peer-review journals. Already we published a research paper in the American peer-review journal (Physics of Plasmas) based on the direct numerical simulation process and problems based on Molecular Dynamics (MD), Particle in cell (PIC), and some other analytical problems are in the progress.

13. ACHIEVEMENTS FROM THE PROJECT:

The results of the proposed works have been published in reputed international journal. Along with this one Project Fellow is also trained and he is registered for Ph.D. degree in the university.

14. SUMMARY OF THE FINDINGS: (IN 500 WORDS )

The hydromagnetic instabilities (Rayleigh-Taylor, Kelvin-Helmholtz, Jeans), internal waves and quantum magnetohydrodynamic waves are studied and influence of several important parameters have been investigated on the stability analysis of strongly coupled dusty plasmas. The role and importance of these instabilities and waves are discussed in both laboratory and astrophysical situations.

The Rayleigh-Taylor instability (RTI) in an incompressible strongly coupled viscoelastic fluid is investigated considering the effects of inhomogeneous magnetic field, density gradient, and uniform rotation. The stabilizing influence of magnetic field, rotation, and magnetic-viscoelastic Mach number while the destabilizing influence of viscoelastic Froude on the growth rate of RTI number is observed graphically. In another work the linear RTI in a uniformly rotating strongly coupled dusty plasma (SCDP) is investigated both analytically and numerically. The influence of the Coriolis force on the dust particles is considered mainly owing to the drag force of the magnetized ions. It is found that in the presence of intermediate magnetic field in SCDP, dust cloud rotation and strong correlation effects altogether stabilize the growth rate of linear RTI. This work will help to understand the rotating RT vortexes in experimental situation. Considering isothermal ion fluid compressibility we have investigated the RTI and internal waves in the both incompressible and compressible dense degenerate strongly coupled quantum plasma. The growth rates of unstable RT modes are solved numerically and plotted which shows suppression due to the quantum Froude number, strong coupling effects, and isothermal compressibility of the medium. The results are analyzed for understanding the suppression of the RTI in dense white dwarfs which consist of degenerate electrons and strongly coupled ions. The combined KHI and RTI of two superimposed incompressible dusty fluids have been investigated in presence of different dust flow velocities and two dimensional magnetic field. A single fluid reduced dusty magnetohydrodynamic model is obtained for the three component magnetized incompressible dusty plasma. We find that the condition of RTI depends upon both longitudinal and transverse magnetic field components and relative dust flow velocity. In the case of the KH configuration, the effect of magnetic field and relative dust flow velocity is observed and it is shown that dust flow velocity must be larger than a particular value of Alfven speed in order to excite KHI.

It is found that in the long wavelength perturbations, the Jeans instability criterion depends upon strong coupling effect, polarization interaction parameter, and thermal loss, but it is independent of dust-neutral collision frequency. Viscoelasticity and dust-neutral collision frequency have stabilizing effect while electron radiative condensation, polarization force, and Jeans dust-neutral frequency have destabilizing effect on the Jeans instability. The results of this work is applied to understand the gravitational collapse of strongly coupled dusty plasma. It is found that the unstable gravitating mode modified by Bohm potential and the stable Alfven mode modified by non-ideal effects are obtained separately. The criterion of firehose instability remains unaffected due to the presence of non-ideal effects. In the perpendicular propagation, finite electrical resistivity and quantum pressure anisotropy modify the dispersion relation, whereas no effect of Hall current was observed in the dispersion characteristics. The Hall current finite electrical resistivity, rotation, and quantum corrections stabilize the growth rate. It is observed that in the quantum plasma due to the oblique propagation, the Jeans instability condition is modified due to the presence of neutrino beam effects, whereas no effect was observed in parallel and perpendicular propagations. The neutrino beam density stabilizes, while the free energy of the neutrino beam destabilizes the growth rate of Jeans instability. The time scale of neutrino beam instability is much shorter than the Jeans time scale which results in faster neutrino mixing in the gravitational collapse of the system.

The small amplitude quantum magnetohydrodynamic (QMHD) waves and linear firehose and mirror instabilities in uniformly rotating dense quantum plasma have been investigated using generalized polytropic pressure laws. The firehose instability remains unaffected while the mirror instability is modified by polytropic exponents and quantum diffraction parameter. The presence of uniform rotation stabilizes while quantum corrections destabilize the growth rate of the system. It is also observed that the growth rate stabilizes much faster in parallel wave propagation in comparison to the transverse mode of propagation. The quantum corrections and polytropic exponents also modify the pseudo-MHD and reverse-MHD modes in dense quantum plasma. The phase speed (Friedrichs) diagrams of slow, fast, and intermediate wave modes are illustrated for isotropic MHD and double adiabatic MHD or CGL quantum plasmas, where the significant role of magnetic field and quantum diffraction parameters on the phase speed is observed.

15. CONTRIBUTION TO THE SOCIETY: ( GIVE DETAILS )

The new proposed theoretical models and results give extensive knowledge in the field of waves and instabilities in complex plasmas. These theories and results are applied to understand various phenomena of astrophysical and laboratory dusty plasmas.

16. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT:

Yes, the project fellow Mr. Bivash Dolai is enrolled for Ph.D. (registered on 1st January, 2017) and currently he is continuing research work as a Ph.D. student in Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya.

17. NO. OF PUBLICATIONS OUT OF THE PROJECT: **Eight (08)**

1. Effect of different dust flow velocities on combined Kelvin-Helmholtz and Rayleigh-Taylor Instabilities in Magnetized Incompressible Dusty Fluids, Bivash Dolai, R. P. Prajapati, and R. K. Chhajlani, ***Physics of Plasmas*** **23**, 113704 (2016).

2. Jeans instability in collisional strongly coupled dusty plasma with radiative condensation and polarization force, R. P. Prajapati, S. Bhakta, and R. K. Chhajlani, ***Physics of Plasmas*** **23**, 053703 (2016).

3. Rayleigh-Taylor instability in non-uniform magnetized rotating strongly coupled viscoelastic fluid, R. P. Prajapati, ***Physics of Plasmas*** **23**, 022106 (2016).

4. Small amplitude waves and linear firehose and mirror instabilities in rotating polytropic quantum plasma, Surajit Bhakta, R. P. Prajapati and Bivash Dolai, ***Physics of Plasmas*** **24**, 082113 (2017).

5. Rayleigh-Taylor instability and internal waves in strongly coupled quantum plasma, Bivash Dolai and R. P. Prajapati, ***Physics of Plasmas*** **24**, 112101 (2017).

6. Influence of neutrino beam on the Jeans instability in a magnetized quantum plasma, R. P. Prajapati, ***Physics of Plasmas*** **24**, 122902 (2017).

7. The rotating Rayleigh-Taylor instability in a strongly coupled dusty plasma, Bivash Dolai and R. P. Prajapati, ***Physics of Plasmas*** **25**, 083708 (2018).

8. Effects of Hall current and electrical resistivity on the stability of gravitating anisotropic quantum plasma, S. Bhakta and R. P. Prajapati, ***Physics of Plasmas*** **25**, 022101 (2018).

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24/05/19
(REGISTRAR/PRINCIPAL)
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