INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Km Sonali Gangwar

Roll Number : 196121013

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Thesis Title: **Structure and dynamics of the spin-orbit coupled ultra-dilute quantum droplets**

Name of Thesis Supervisor(s) : Dr. Pankaj Kumar Mishra

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SHORT ABSTRACT

In recent years, quantum droplets (QDs) have emerged as a new form of matter in ultracold atomic systems, with research still in its early stages. QDs typically form due to the interplay between attractive mean-field (MF) interactions and repulsive beyond-mean-field (BMF) interactions caused by quantum fluctuations. In one-dimensional systems, however, QDs in binary mixtures are predicted to form through a different mechanism, where the balance between attractive BMF and repulsive MF interactions plays a crucial role in the droplet formation.

Using the extended Gross-Pitaevskii model, the thesis numerically and analytically investigates the ground-state structure and non-equilibrium dynamics of ultra dilute quantum droplets in one-dimensional spin-orbit (SO) coupled binary Bose-Einstein condensates. Initially, we explore the effect of BMF terms on the droplet's structure and dynamics when the MF contribution is negligible, finding that BMF stabilizes the droplet and plays a crucial role in generating various dynamical phase transitions. We then analyze the competitive effects of MF and BMF interactions, revealing that the MF term alters the droplet's shape, causing a transition from a soliton-like form to a sech-flattened droplet. Further, we examine how changes in atom number and MF interactions affect the droplet's ground-state structure and dynamics, showing that for low SO coupling, the droplet undergoes a transition from a Gaussian shape to a flat-top droplet as the atom number or MF interaction increases. Finally, we explore the effects of population imbalance between the up and down components of the condensate, with

and without a trap, demonstrating a transition from flat-top to Gaussian droplets as the population imbalance increases.