INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Dangka Shylla

Roll Number : 166121009

Programme of Study : Ph.D.

Thesis Title: Atomic Coherence Based Electromagnetic Wave Interferometry

Name of Thesis Supervisor(s) : Dr Kanhaiya Pandey

Thesis Submitted to the Department/ ~~Center~~ : Physics

Date of completion of Thesis Viva-Voce Exam : 15-03-2023

Key words for description of Thesis Work : Atomic coherence, Electromagnetically induced transparency (EIT) and Atom based MW Interferometry.

SHORT ABSTRACT

This thesis reports on the theoretical and experimental studies of closed loop multi-level systems, where electromagnetically induced transparency (EIT) is dependent on the phase difference between the electromagnetic fields forming the loop. We first theoretically investigate a scheme to develop an atomic-based microwave (MW) interferometry in Rb, based on a six-level loopy ladder system involving the Rydberg states in which two excitation pathways interfere constructively or destructively depending on the phase between the MW electric fields closing the loop. Then we compared the field strength sensitivity to previous demonstrations on MW electrometry employing Rydberg atomic states, this is two orders of magnitude more sensitive to field strength. Because previously investigated atomic systems are only sensitive to field strength but not to phase, this scheme offers a great opportunity to characterize the MW completely, including the propagation direction and wavefront. Currently, we do not have the experimental facility for Rydberg excitation so we cannot conduct the experiment of the above theoretically proposed work. However, we could demonstrate the phase-dependent EIT in the different configurations of a closed loop double-lambda system at 780 nm and 420 nm transitions in ^{87}Rb at room temperature.

For the MW field measurements, the sensitivity can be improved by employing the cold atoms because cold atoms reduce the Doppler mismatch between the 780 nm probe and 480 nm control fields and also minimizes the collisions and transit time dephasing effect. Taking this into consideration, we have also set up the cold atom experiments and so far, we have characterized the ^{85}Rb atoms in the MOT using the $5S_{1/2}(F = 3) \rightarrow 5P_{3/2}(F = 4)$ broad cyclic IR transition at 780 nm where we trap around 1.5×10^8 number of atoms at a typical temperature of 500 μK.

In laser cooling and trapping experiments, the temperature of the cold atoms is sensitive to the lock point of the laser fields. The laser locking can have an offset from the line center of the transition which depends upon the linewidth of the transition. In order to determine the laser lock o set on a particular atomic transition, we also present an experimental study on the effect of detuning on a velocity-induced population oscillation (VIPO) dip which is used to precisely determine the lock point with an uncertainty of around 100 kHz.