Investigation of Inertial Sensing Using Electromagnetically Induced Transparency

Measuring the motion of quantum particles has been playing a significant role in performing high precision inertial sensing and studying fundamental physics. While most of the motional sensing schemes with cold atoms are based on single-particles. In this thesis, I introduce a new measuring method of using a collective state of atoms for motional quantum sensing. As a pioneer of a new measuring technique, I demonstrate two experiments to investigate its feasibility. One is the light-dragging effect in an electromagnetically induced transparent (EIT) cold 85Rb atomic ensemble. I enhance the dragging coefficient $F_d$ is $1.67 \times 10^5$, three orders of magnitude better than the previous experiments. With a large enhancement of the dragging effect, I realise an atom-based velocimeter that has a sensitivity of 1 mm/s, two orders of magnitude higher than the velocity width of the atomic medium used. Such a demonstration could pave the way for motional sensing using the collective state of atoms in a room temperature vapour cell or solid-state material. Another experiment is the motional sensing in a driven periodic potential. I measure the motion of the atomic ensemble undergoing Bloch oscillation using the light dragging method. In order to have efficient Bloch oscillation of atoms, I achieve the first Raman sideband cooling of 85Rb to pre-cool atomic ensemble close to the recoil temperature (357 nK). The phase shift measurements show the linear-like relation to the accelerating time with the data precision 0.00036 rad (0.005 ns, 0.11 mm/s), instead of the stepwise oscillation period $t_B$. To observe the stepwise motion, it is required to reduce the lattice field intensity and implement the velocity selection technique to select atoms with a narrow velocity width.