Our experimental apparatus is dedicated to high precision measurement of gravitational phenomena with atom interferometry. Freely falling rubidium atoms are used as probe masses to test the gravitational acceleration produced by nearby source masses. The combination of Raman atom interferometry and laser cooling has given us the physical insight to achieve high sensitivity. Using atoms with their well-known properties, instead of macroscopic probe masses, helps to reduce systematic errors and permits a higher level of accuracy.

For our experiment of high precision gravimetry with atom interferometry, we have used an atomic fountain to launch the ^{87}Rb cloud formed by the MOT at 4μK. As per the present situation in our laboratory, we need our ^{87}Rb cloud sample to achieve lesser temperatures than 4μK. It is important to do this because in the present setup, sensitivity is limited by the transversal temperature of the ^{87}Rb cloud. Our objective is to freeze the expansion of the cloud such that during the ballistic launch of the ^{87}Rb samples in the gravity gradiometer, cloud should experience minimum expansion.

To achieve this, we will implement scheme described by Vuletić's group [1]. To proceed with this scheme, we are planning to build a 1064nm laser setup [2] to generate an optical dipole trap. Using 795nm laser setup, we plan to employ dSRC (degenerate Raman Sideband Cooling) technique [3]. This experimental method involves the following steps:-

1) ^{87}Rb atoms are trapped in a 2D lattice formed by two orthogonal retroreflected trapping beams at 1064nm. The cooling light at 795nm propagates along the magnetic field and is σ^--polarized.

2) dSRC: Because of an applied magnetic field, Zeeman splitting results in the degeneracy between the two vibrational levels (denoted here as $| F, m_F; \nu >$) in the tightly confined direction which is matched to the magnetic sublevels (created by Zeeman effect). In detail, there are 3 following participation transitions in this process which eventually result in the cooling of the sample:-

- First step is to drive a degenerate raman transition from $| 2, -2; 1 >$ to $| 2, -1; 0 >$.
- After the degenerate raman transition, drive the optical pumping transition from $| 2, -1; 0 >$ to $| 2, -2; 0 >$.
- In case there is a decay of atoms in the state $|1, -1; 0 >$, then an optical pumping transition can be made from $| 1, -1; 0 >$ to $| 2, -1; 0 >$, such that $\Delta\nu$ in this process is equal to zero. Then, finally we can drive a normal dipole transition from $| 2, -1; 0 >$ to $| 2, -2; 0 >$.

With these three transitions, at the end of this complete process we have $\Delta\nu = -1$. So, with the loss of phonons (quanta of vibrations), we lose the total energy from the atomic sample. This results in the slowing down of the atoms and lowering their temperature without exchange of any photons as observed in other traditional laser cooling methods.

3) Now we can finally implement the release-and-retrap compression sequence used to increase the atomic density in the MOT chamber. Starting from a sparsely filled 2D lattice, we perform dSRC and then switch off one of the lasers to compress the atoms in the directions orthogonal to the laser beam that is switched off. After a short thermalization time, we switch back to the 2D lattice with an increased number of atoms per trap. Repeating the same procedure with other lasers orthogonal to the previous lasers finally results in a condensate.

References:-

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