Construction of atomic magnetometer base on Rb - 87

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Abstract

Ultrahigh precision magnetometers are used in many fields, for example in medical, military and space exploration. This study aimed to demonstrate one type of them, atomic magnetometer base on Rb 87. The reference cell, contain isotope 87 of rubidium is placed at the center of two layer three – axis compensation Helmholtz coil which used to cancel earth and noise magnetic field. 780 nm circular polarized laser shine into the cell as pump and probe beam. Pump beam is used for preparing atoms by optical pumping process which is transferring energy and angular momentum from laser into atoms to change its quantum state to L = 0, F=2 and mf = 2 state. probe beam is used for observing behavior inside the cell. When magnetometers sense magnetic fields the polarization of atom changes and affect to probe beam. Signals from probe beam are detected by photodiode. Without the test sample, photodiode read full power of probe beam but when there are test samples the read power drops due to changing polarization of the cell.

Introduction

Atomic magnetometers can have precision around 1 fT and does not need ultracold temperature to operate. The heart of atomic magnetometers are optical pumping and signal detection method. The prime objective of this project is to demonstrate an atomic magnetometer but due to limited time, this poster show the progress of the project.

Theory

-Optical pumping is a process of preparing state of atoms via state transition of valence electron and angular momentum transfer between laser and atoms.

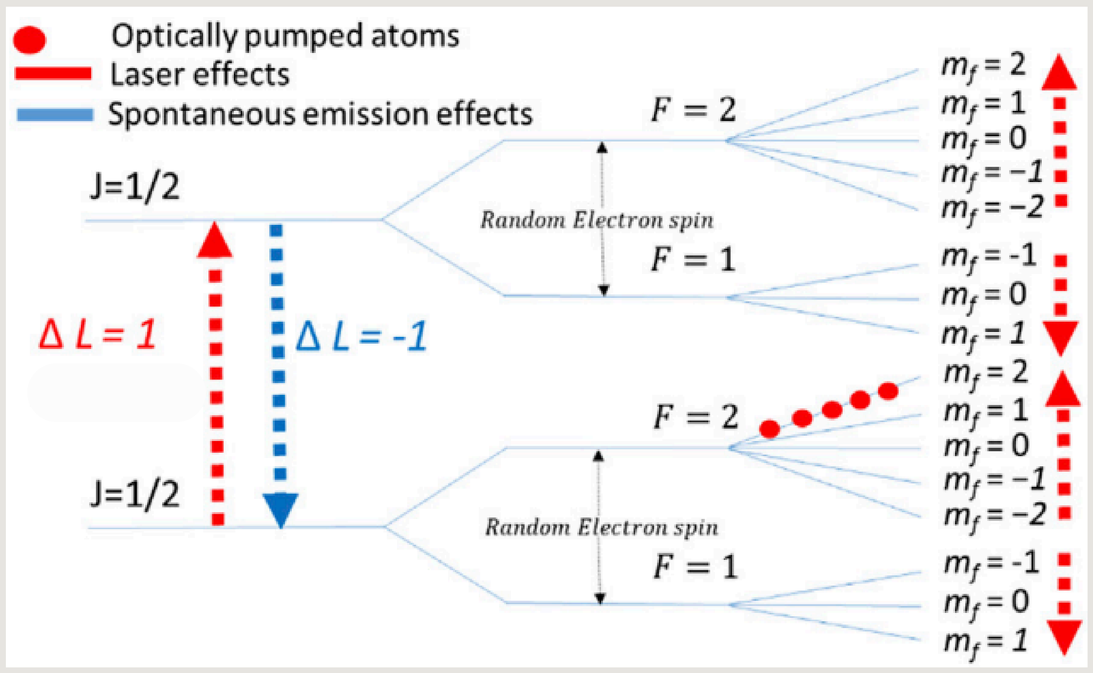

Fig 1) Optical pumping diagram, the positive circular polarize laser 780 nm wavelength is shining into rubidium 87 which corresponds to transition of state of D2 line. [1]

-Relaxation means process which cause of changing phase of atom. To operate magnetometer, these relaxation must be reduced by increase amount of atom through increasing temperature and decrease background magnetic field.

Experiment set up

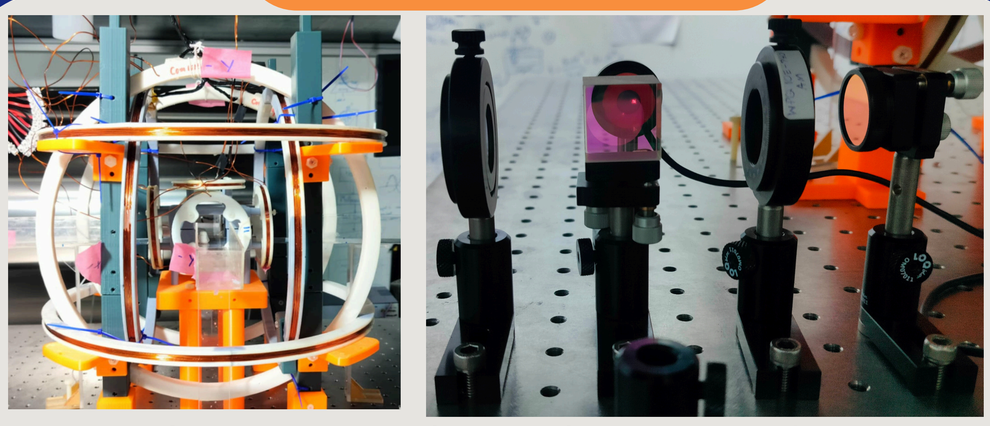

Fig 2) (Left) magnetic coil control system. (Right) Positive circular polarize optical alinement.

Result

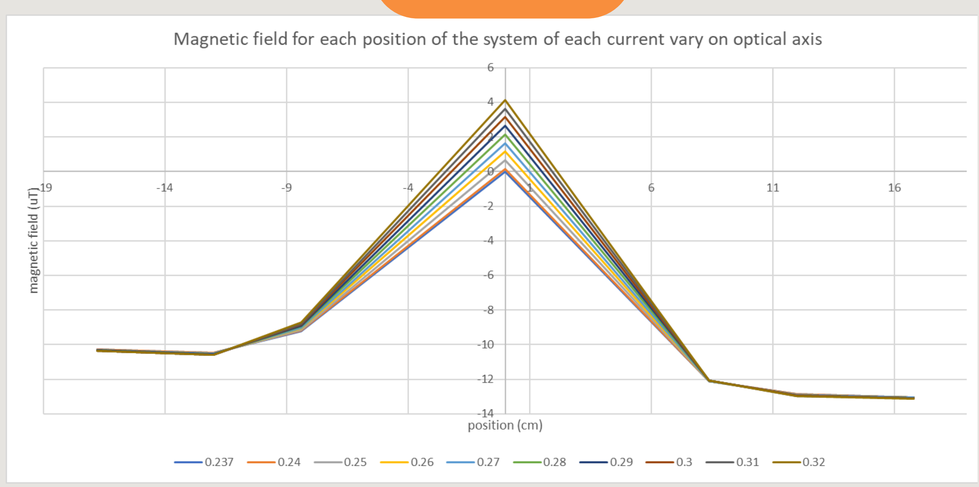

Fig 3) Magnetic field to each position in system when vary current given to quantization coil.

- relationship between quantization coil given current and magnetic field amplitude is $M = 49.896\, I - 11.83$

where M is magnetic field amplitude (uT) and I is given current (AM).

- relationship between given cuerrent and temperature of vapour cell is $T = 42.373\, I^2 - 20.97 I + 28.895$

where T is temperature (C) and I is given current (AM).

Conclusion

From the result, the relationships allow controlling the vapour cell temperature and system background magnetic field though control the given current. High temperature reduces the relaxation and also decreases precision as well while background magnetic field could change over times. These two factors have a dramatic impact on precision and sensitivity of the device. Controlling them is one of the importance progress on demonstrated atomic magnetometer.

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