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磁場揺動計測を目指した原子磁力計の設計検討

Design of Atomic Magnetometer for Application in Fusion Plasmas

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1. Introduction

The detailed magnetic field measurement is very significant in fusion research and various methods such as the Faraday rotation and motional stark spectroscopy techniques have been developed.

An atomic magnetometer, especially amplitude modulated atomic magnetometer (AM-AOM) [1], allows spatially resolved magnetic field measurements even inside the fusion plasma, and Helium atoms suggested as probing targets in this work are produced from the D-T fusion reaction. Accordingly neither heating beam nor impurity species are necessary.

Aiming at investigating the proposed AM-AOM, we developed the prototype and conducted rudimentary experiments: measuring small magnetic fields (about a few microtesla). In a poster session, the possibility of AM-AOM application in fusion plasmas is discussed.

2. Design of the prototype AM-AOM

Our prototype of AM-AOM is shown in Fig.1. For simplifying the setup, single beam configuration was adapted, with which amplitude of magnetic field on the beam pass can be measured. The beam of which wavelength is 1083nm (He D1 line), are injected into a He discharge cell. This beam is amplitude modulated at frequency f_{pump} and circularly polarized for the spin polarization of the He atoms. When f_{pump} equals the Larmor frequency $f_L(=\gamma B)$, the resonant property is detected in the transmittance rate, and magnitude of the magnetic field at the cell is evaluated. Here, γ is the gyromagnetic ratio; 28[GHz/T] for He. The transmitted light intensity is detected by a photo diode amplifier circuit. Furthermore, the signal is amplified with Rock-in amp whose reference is synchronized the AM frequency. The direction of generated magnetic field is perpendicular to the beam direction, since this configuration maximizes resonant signal [2].

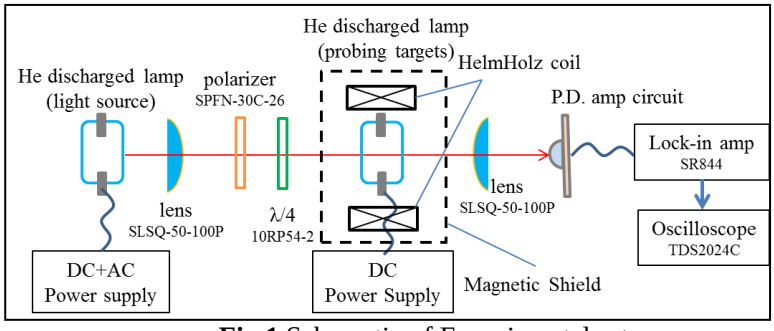

Fig.1 Schematic of Experimental setup

3. Property of the developed light source

As a light source for our prototype AM-AOM, a hollow-cathode type He discharge lamp has been developed in the lab. In order to produce amplitude modulated light emission, its power supply has also been designed and built. This power supply can produce tunable frequency AC voltage with DC voltage offset which is high enough to discharge the lamp. Fig.2 shows AM emission intensity of this light source measured in the optical system shown in Fig.1. Though the intensity decreases in high frequency region possibly due to the parasitic capacitance of the lamp, frequency tunable AM He D1 emission was successfully obtained.

4. Status of the experiment

With the developed AM-AOM, we have performed an exploratory experiment of test magnetic field (5 [μT]) measurement. Fig.3 shows the transmittance rate versus AM frequency. The transmittance rate seems to have its peak around 130 [kHz] corresponding to 4.6[μT], which is possibly sign of magnetic field detection. Intensive effort for defining the peak is in underway.

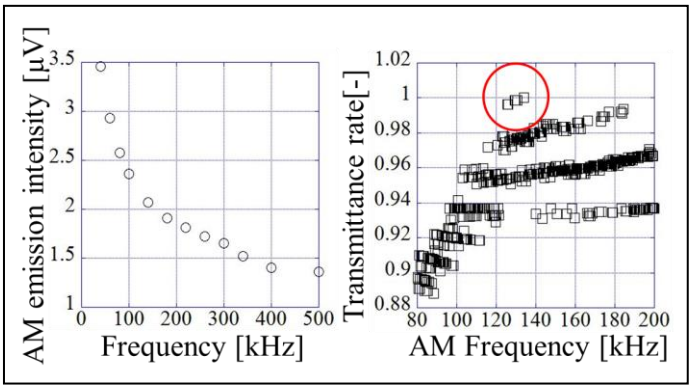

Fig.2 AC emission intensity VS frequency (left).
Fig.3 Transmittance rate VS frequency (right). Around 130 [kHz], transmittance rate seems to have its peak, and this corresponds to 4.6[uT] which roughly equals to the amplitude of test magnetic field (5 [μT]).

Reference

[1]W.E.Bell and H.L.Bloom, Phy.Rev.Lett.6, 280.
[2]Volkmar Schultze et al., Optics Express20,13,14201