A pulsed gradiometer in Earth's field with direct optical readout

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We describe an atomic gradiometer based on the magnetically sensitive hyperfine coherence in two vapor cells of warm ^{87}Rb atoms [2]. The device provides a direct readout of the gradient field, unlike traditional gradiometers which subtract the outputs of two spatially separated magnetometers. A pulsed microwave field resonant with the hyperfine ground state splitting prepares an atomic coherence and generates sidebands offset from a weak (carrier) beam incident on two vapor cells [1]. The sidebands interfere and an optical beat note is produced, with the frequency of the beat directly proportional to the magnetic field gradient between the two cells. We also describe a theoretical framework and numerical model we developed to understand the sideband generation process and to inform experiments. For a practical gradiometer, it is important to be able to measure the gradient regardless of the direction of the ambient magnetic field, either perpendicular or parallel to the laser beam propagation axis. Operation of the gradiometer in multiple field orientations is discussed as well as single beam operation, where one beam acts as both a pump and carrier. Single beam operation is simpler and more compact and is beneficial for applications such as Magnetoencephalography (MEG), where multiple sensor channels are tightly positioned around the human skull.

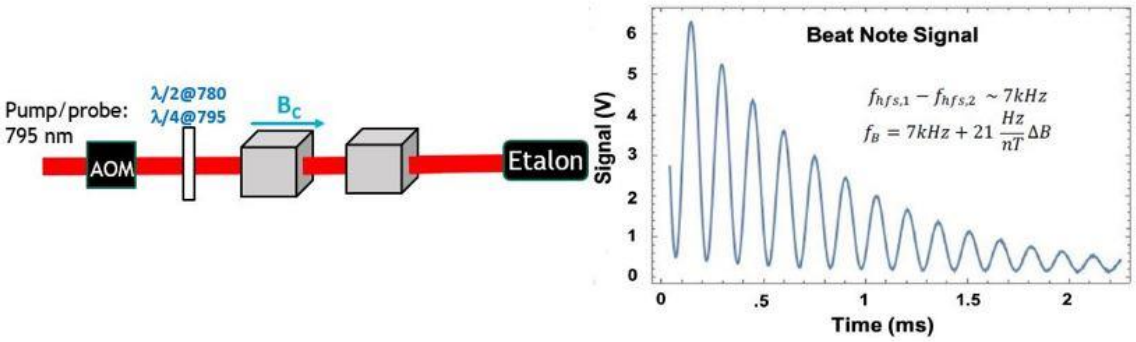

Fig. 1 (Left) Gradiometer setup with 795nm beam acting as both carrier and pump. An Etalon is used to separate the sidebands from the carrier. (Right) Beat note signal from the gradiometer

References

[1] Henry Tang, *Parametric Frequency Conversion of Resonance Radiation in Optically Pumped ^{87}Rb Vapor*. Phys. Rev. A **7**, 2010 (1973).

[2] Vishal Shah, *System and Method for Measuring a Magnetic Gradient Field*. Patent. US10088535 (2018)

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