DETERMINING RUBIDIUM NUMBER DENSITY BY MEASURING FARADAY ROTATION NEAR RESONANCE

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Introduction

Importance of Rubidium Number Density:
Critical in high-precision systems such as magnetometers and atomic clocks [1,2]

No Purpose-Built Equipment:
Lack of specialised apparatus to measure Rb density, current methods suffer from limited range & accuracy [3]

Industrial Need
Widen range | High accuracy | Simple configuration

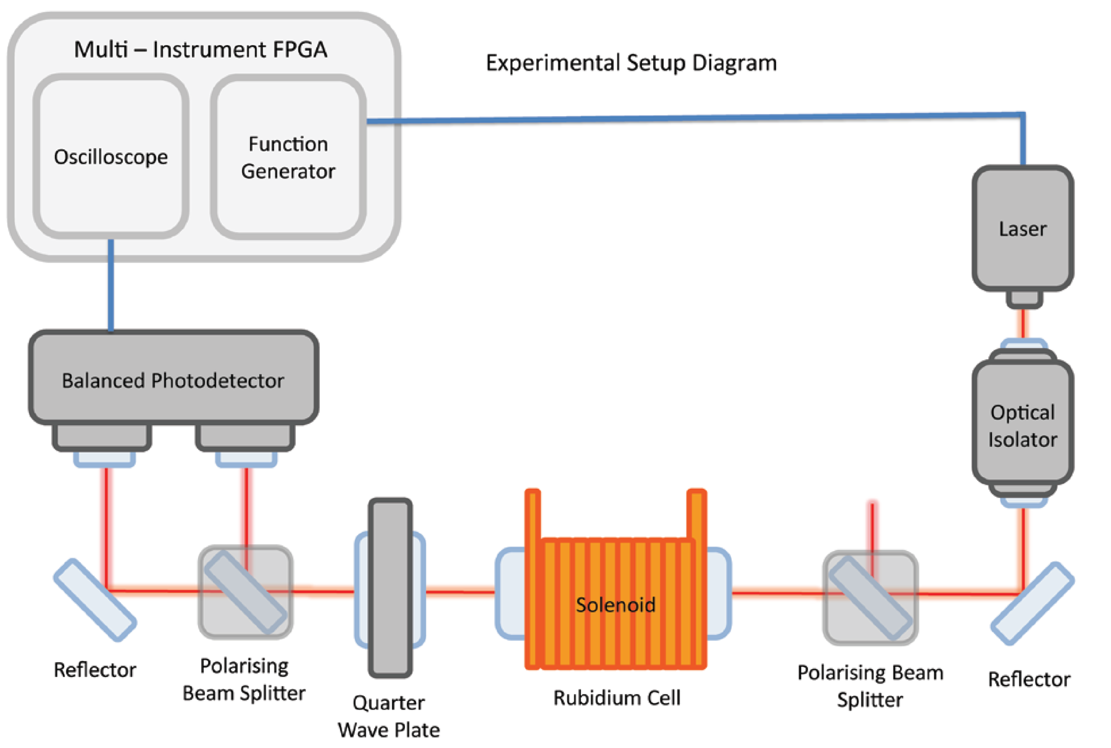
Research Objective

Develop a system that determines Rubidium Number Density by measuring Faraday Rotation near Resonance (D2 transition), with a maximum deviation of 1 order of magnitude from Killian's empirical formulae

Solution: Measuring Faraday Rotation near Resonance

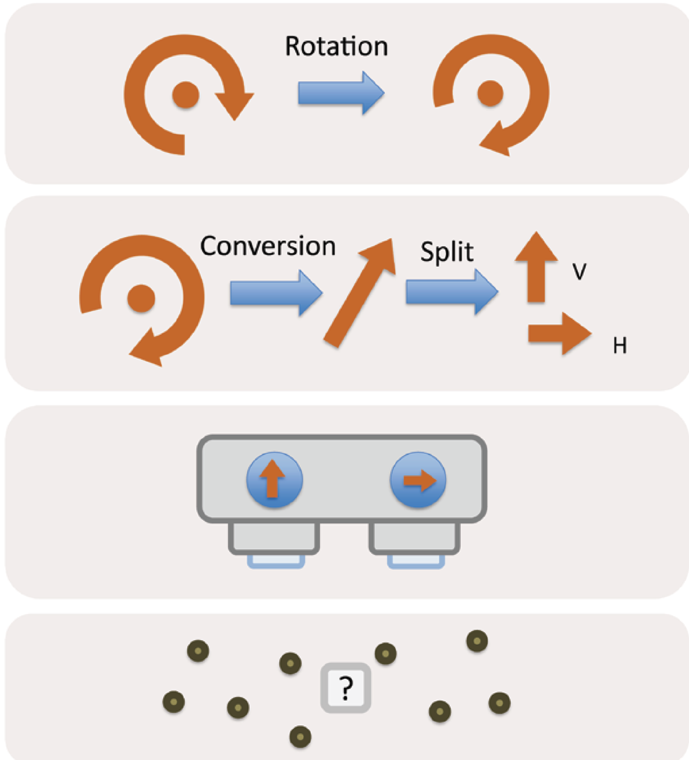
Advantages

- Does not need extensive equipment and extreme experimental conditions to observe angle change
- Greater range of measurement of rubidium density, especially in "optically thick cases" [3]
- Ratio Analysis negates non-intended polarisation effects by glass walls and other contaminants



Methodology

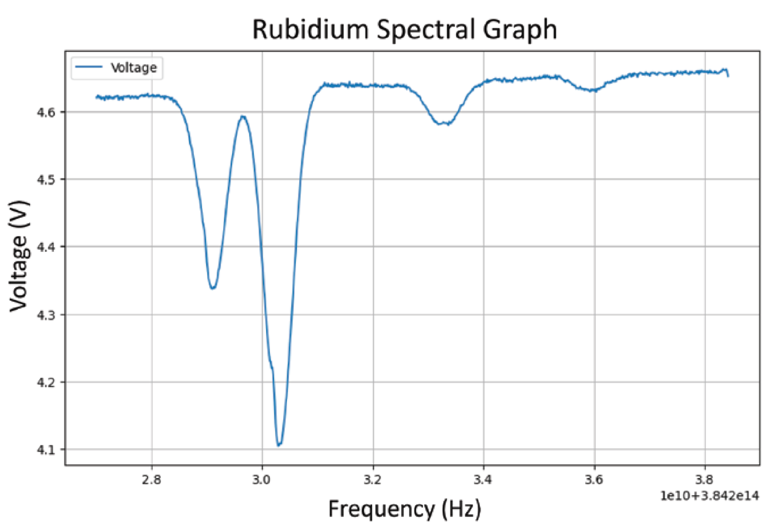
1. Faraday Rotation rotates the plane of polarisation of laser beam travelling through Rubidium Atoms with magnetic field [4]
2. QWP & PBS convert circularly polarised light to linearly polarised light & their horizontal & vertical components [5]
3. Dual-channel photodetector measures proportions of Horizontally and Vertically polarised light → computed to angular rotation
4. Rubidium Number Density calculated via mathematical relation to angular rotation



Results and Discussion

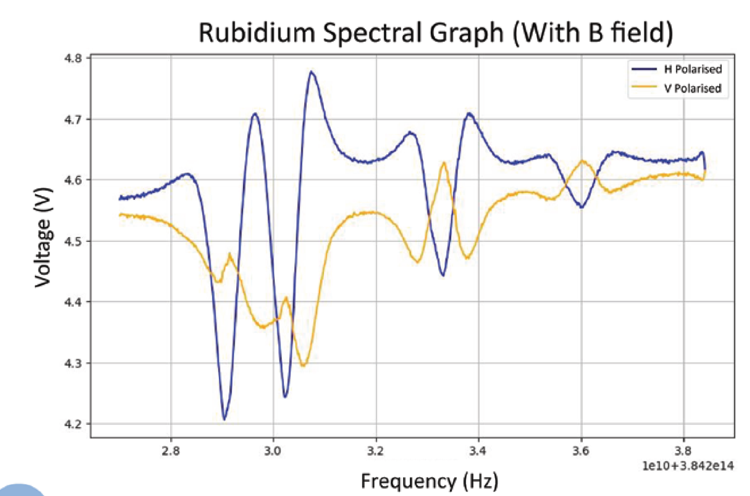
Rubidium Spectral Graphs

Basic Spectral Graph (no field)



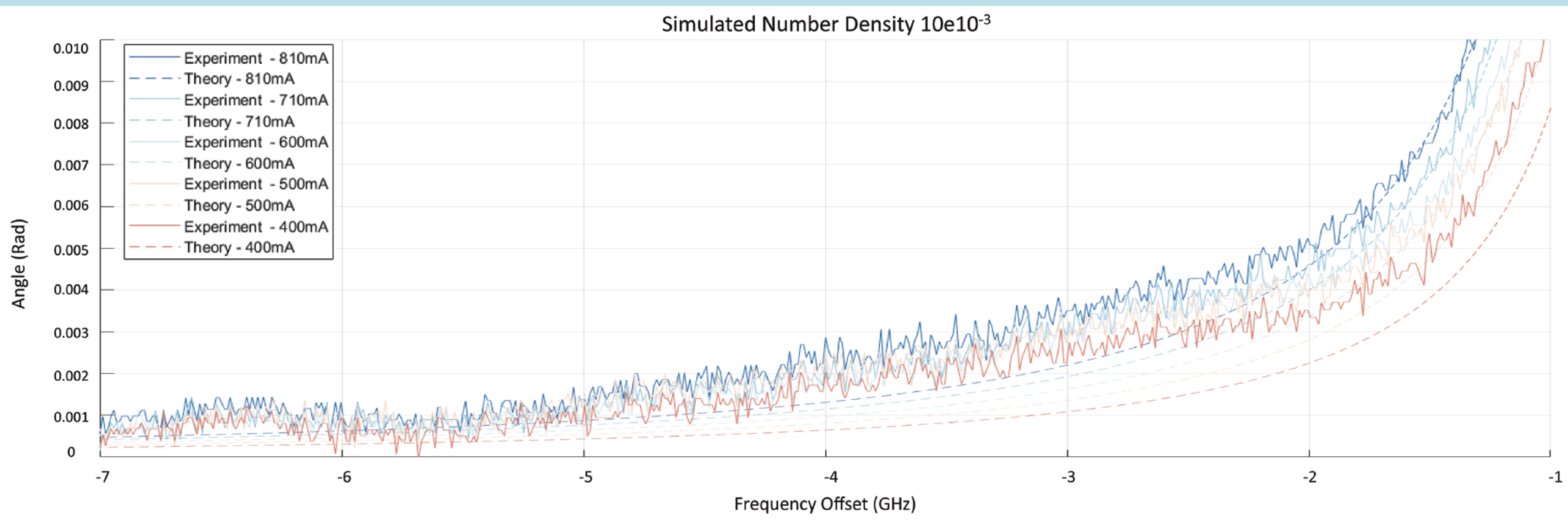
Two Significant Peaks Observed:
larger peak = Rubidium 85 F3 Transition [6]
smaller peak = Rubidium 87 F2 Transition [7]
This is a basic verification of spectral accuracy

Raw Spectral Graph (with field)



- Prominent differences between channels near resonance, confirming calculated theory
- Polarisation interference with Zeeman observed in blue-detuned frequencies, pivoted to red detuned frequencies

Faraday Rotation and Frequency



Graphs indicate a good fit between experimental & literature values, especially at higher laser frequencies. Laser was red-detuned, but near to resonance

Maximum Rotation Angle:
0.0715 rad

Experimental Rubidium Density:
10×10^{10} cm^{-3} – 12×10^{10} cm^{-3}

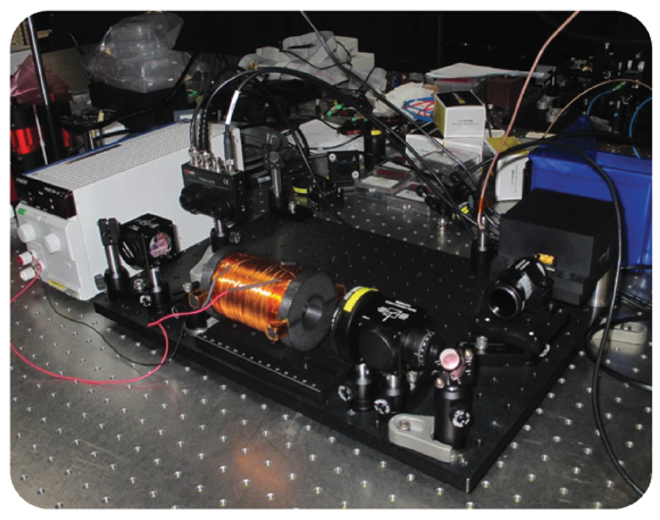
Conclusion

a. Small Laser Detuning:
Increased the observed Faraday rotation angle by one to two orders of magnitude compared to similar studies [3]

b. Empirical Formula:
Observed a deviation of about one order of magnitude from empirical formula, congruent with similar studies. [8]

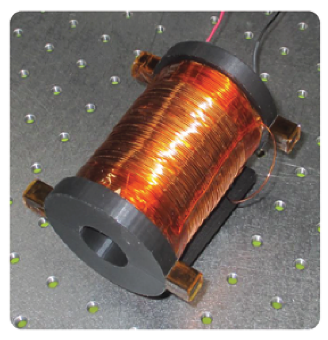
c. Precise:
10^8 times more precise than a mol/dm^3 measurement, verified across 5 bias fields with different magnitudes and 2 distinct theoretical calculations

The method is practical & achieves the goals of greater rotation angle, simple configuration, and maximum deviation.



Future Work

- Differentiating between Rb 85 and Rb 87 isotopic density
- Replacement of 800 coil hand-wound solenoid with machine-produced Helmholtz Coils
- Testing Experimental Setup with high Rb density (optically thick) samples



References:
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