# Apparatus for the lifetime measurement of Samarium excited states

by

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# CONTENTS

# Abstract

This thesis describes the construction of the apparatus for the measurement of the lifetime of the $^9F_1$ level of Samarium by the Hanle effect. The construction work involves the design and building of the vacuum system, the magnetic coils and the laser frequency stabiliser instruments. The project involved the assembly of the oven and the fluorescence signal detection system in addition to the direct calibration of the diode laser wavelength. A technique known as Optogalvanic spectroscopy was used to calibrate the laser wavelength. The basic properties of DC discharges and in particular the Samarium -Neon Hollow Cathode discharges are also reviewed.

The theory of Hanle effect in a three-level V-system is also presented.

A new method for the detection of the atomic beam of some materials is presented.

## DECLARATION

I certify that this thesis does not contain without acknowledgement any material previously submitted for the award of a degree or diploma; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

I give my consent to this copy of thesis being made available for photocopying and loan if accepted for the award of the degree.

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**Bahram Mojarrabi**

**BSc (Hon)**

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I am deeply grateful to my perfect wife my dear Yae and my beautiful mother, brother and sisters. My pen is unable to fully describe their beauty.

# Errata

abstract, line 2) '....the $^9F_1$ level....' should be changed to '....the $4f^6$ 6s 6p $^9F_1$ (14863.85 $cm^{-1}$)....'

page 11, line 8) '*It is the time in which ....*' should be changed to '*It is the rate in which.....*'

page 21, line 20) '..... *on the absorption coefficient.*' should be changed to '*....on the laser intensity .*'

page 27, lines 14-15) '*....depends on Lande g factor as well as hyperfine g factor.*' should be changed to '*....depends on the hyperfine g factor as well as Lande g factor.*'

page 28, last line ) '*....for the Earth's magnetic field.*' should be changed to '*....for the Earth's magnetic field as well as the stray magnetic field from the oven.*'

page 33, line 15) ' *....ionisation cross section....*' should be changed to ' *....ionisation probability....*'

page 87, line 6) ' *....steady state values of* $\sigma^{++},\sigma^{--},\sigma^{+-}$ *into....*' should be changed to ' *....steady state values of* $\sigma^{++},\sigma^{--}$ *into....*'

page 87, line 8) '*.....algebraic manipulation, one can....*' should be changed to '*....algebraic manipulation involving equation (A 1.4), one can.....*'

| | |
|---|---|
| h | Planck's constant |
| $\hbar$ | $\frac{h}{2\pi}$ |
| H | total Hamiltonian |
| I | laser intensity |
| $I_s$ | saturating intensity |
| $I_{nuc}$ | nuclear moment |
| i | current |
| J | total angular momentum |
| $J_e$ | electron current density |
| $J_{ion}$ | ion current density |
| $L_c$ | cavity length |
| L | inductance |
| $l$ | the length of the coil |
| $\lambda$ | wavelength of the transition |
| $\|m\rangle$ , m | Zeeman eigenstates |
| $m$ | magnetic moment |
| $m_e$ | electron mass |
| M | metastable level |
| M | magnetisation |
| $\mu_B$ | Bohr magneton |
| $\mu$ | magnetic permeability |
| $\mu_r$ | relative permeability |

| | |
|---|---|
| N | number of the turns of the coil |
| $\omega_l$ | Larmor frequency |
| $\omega$ | Laser frequency (angular) |
| P | pressure |
| P | power of the laser |
| R | mirror reflectivity |
| R | resistor |
| $R_B$ | ballast resistor |
| $R_g$ | generator resistor |
| r | coil radius |
| $\rho$ | density matrix |
| $\rho_r$ | reflection coefficient |
| S | cross section area of the coil |
| $T_e$ | electron temperature |
| $\tau$ | lifetime |
| $\theta$ | angular divergence of the atomic beam |
| $\eta$ | electron mean free path |
| $\upsilon$ | interaction Hamiltonian |
| V | Potential |
| $\upsilon_L$ | frequency of the laser |
| $V_{sn}$ | shot noise amplitude |
| $V_o$ | power supply voltage |

| | |
|---|---|
| Vref | reflected wave amplitude |
| $\vartheta$ | mean velocity of the atomic beam |
| $w$ | Rabi frequency |
| $\chi_m$ | magnetic susceptibility |
| $Z_l$ | load impedance |