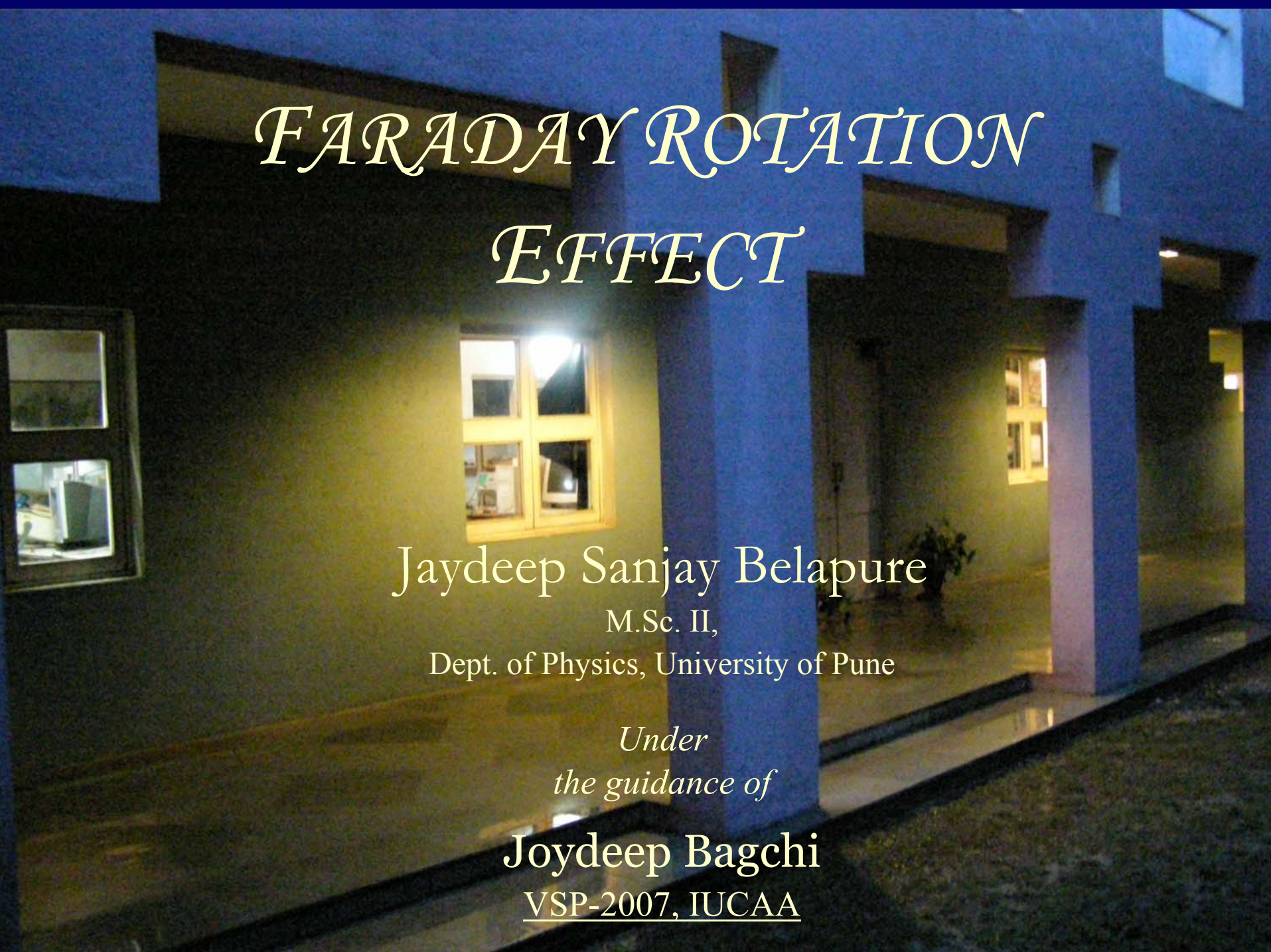

# FARADAY ROTATION EFFECT


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*Under*

*the guidance of*


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VSP-2007, IUCAA

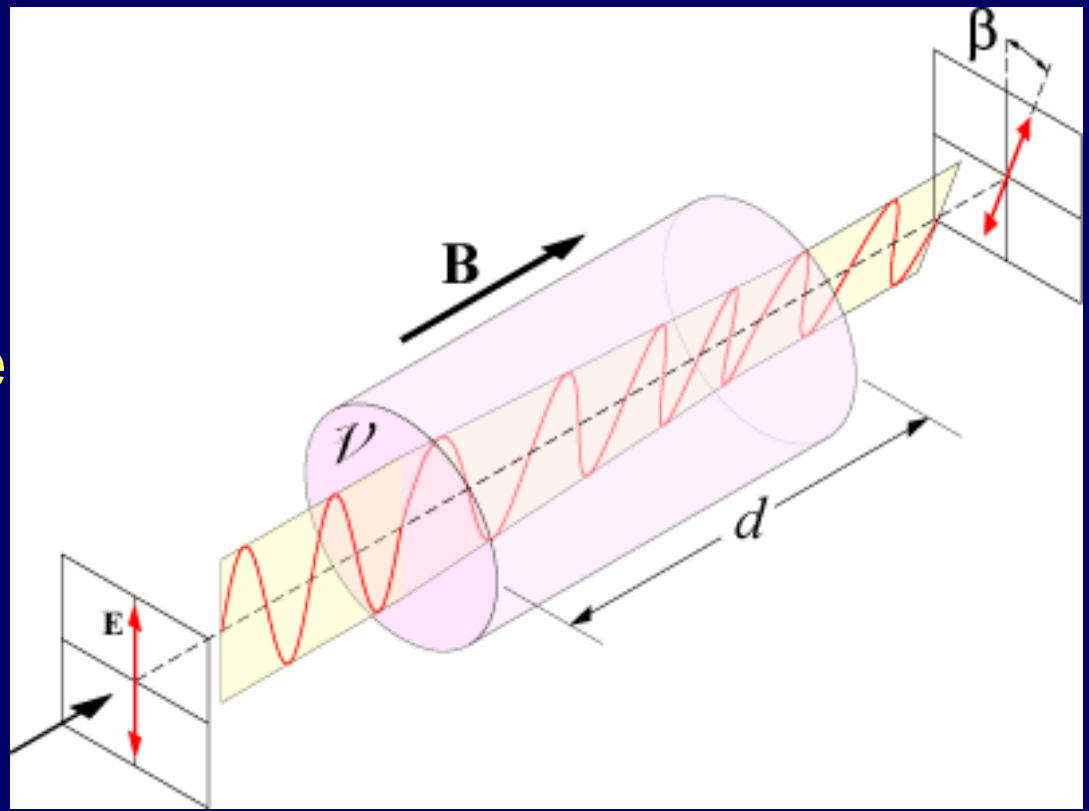
# Introduction

- **Michael Faraday (England) :**
  In 1845 Discovered
  the First effect
  connecting **Magnetism**
  and **Light**,

***"The Faraday Rotation Effect".***

# Faraday Rotation Effect

- The incident Plane of linearly polarized light Rotates by an angle when it passes through the medium.




**"Magnetic Birefringence"**

# Rotation Angle

- The faraday rotation ‘θ’ is proportional to Magnetic field and the length traversed.

$$\theta = \frac{\pi d}{\lambda}(n_R - n_L)z$$

Where, $(n_R - n_L) \propto B$

$$\theta = VBz$$

$$V = \frac{4\pi N e^3 \omega^2}{m^2 c^2 (\omega^2 - \omega_0^2)}$$

V = Verdet constant

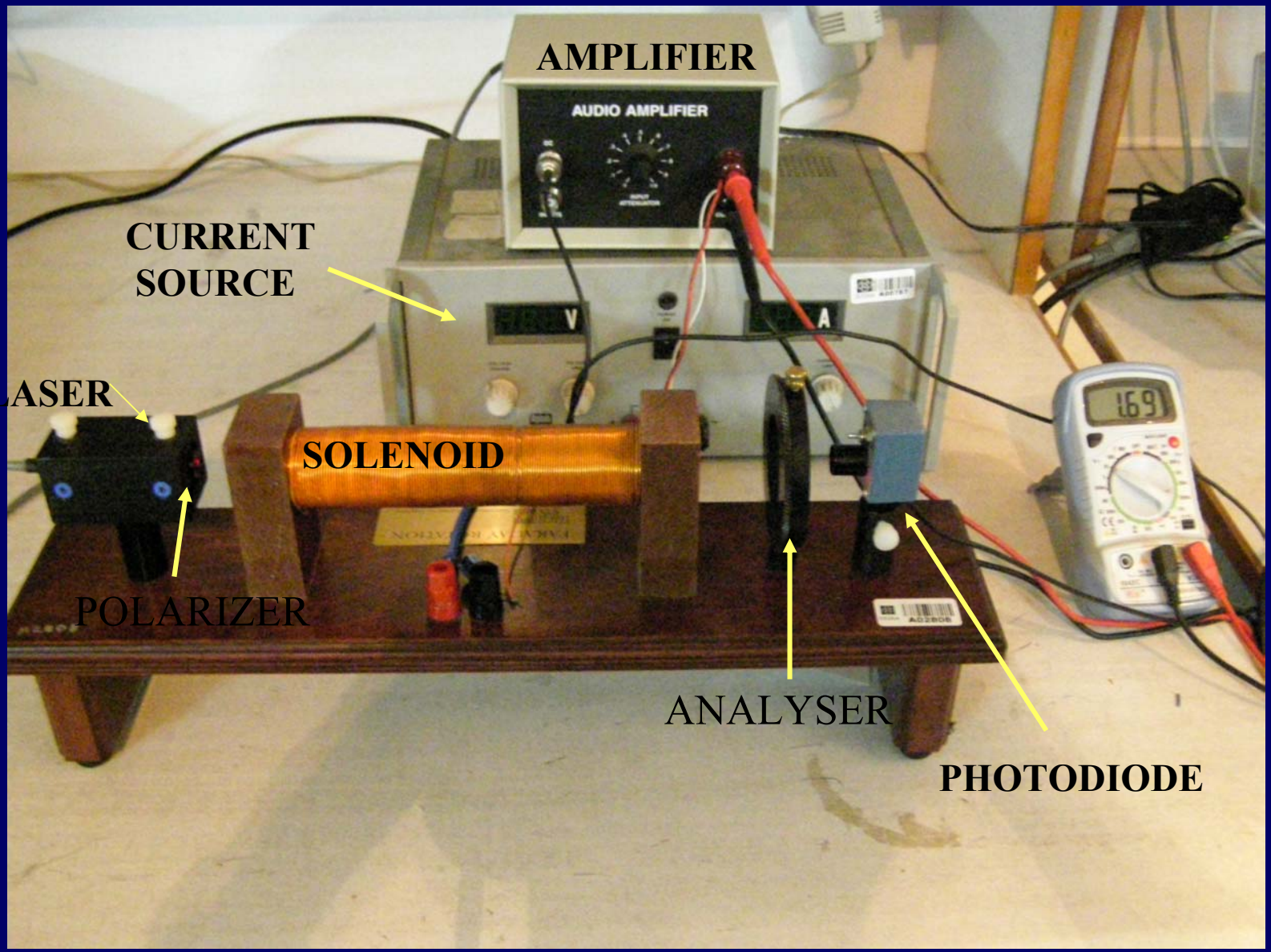
$n_R$ = Refractive Index for Right Circular light

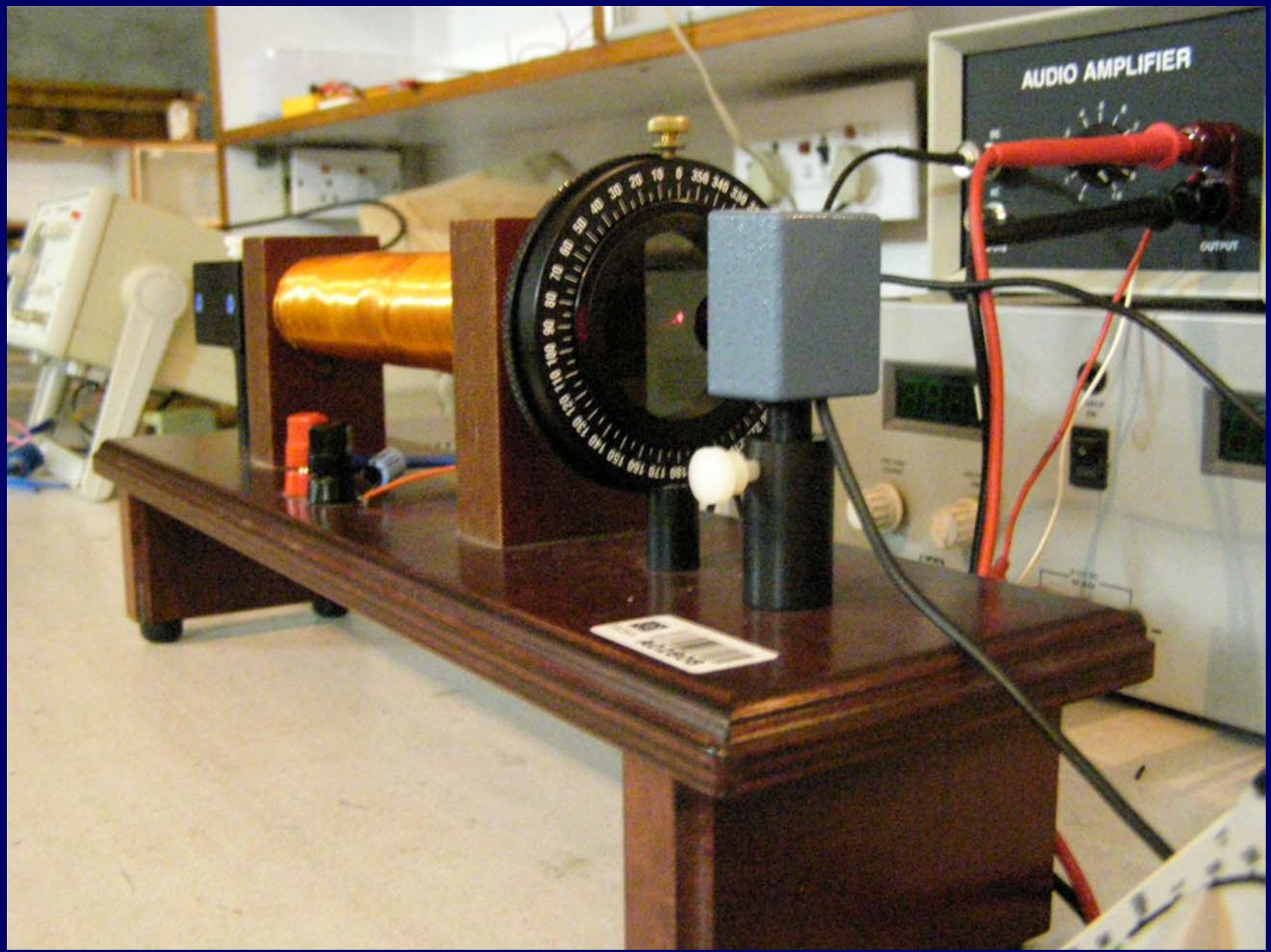
$n_R$ = Refractive Index for Left Circular light

$\omega_o$ = Resonance frequency

N = Number density of electrons

# EXPERIMENTAL SETUP

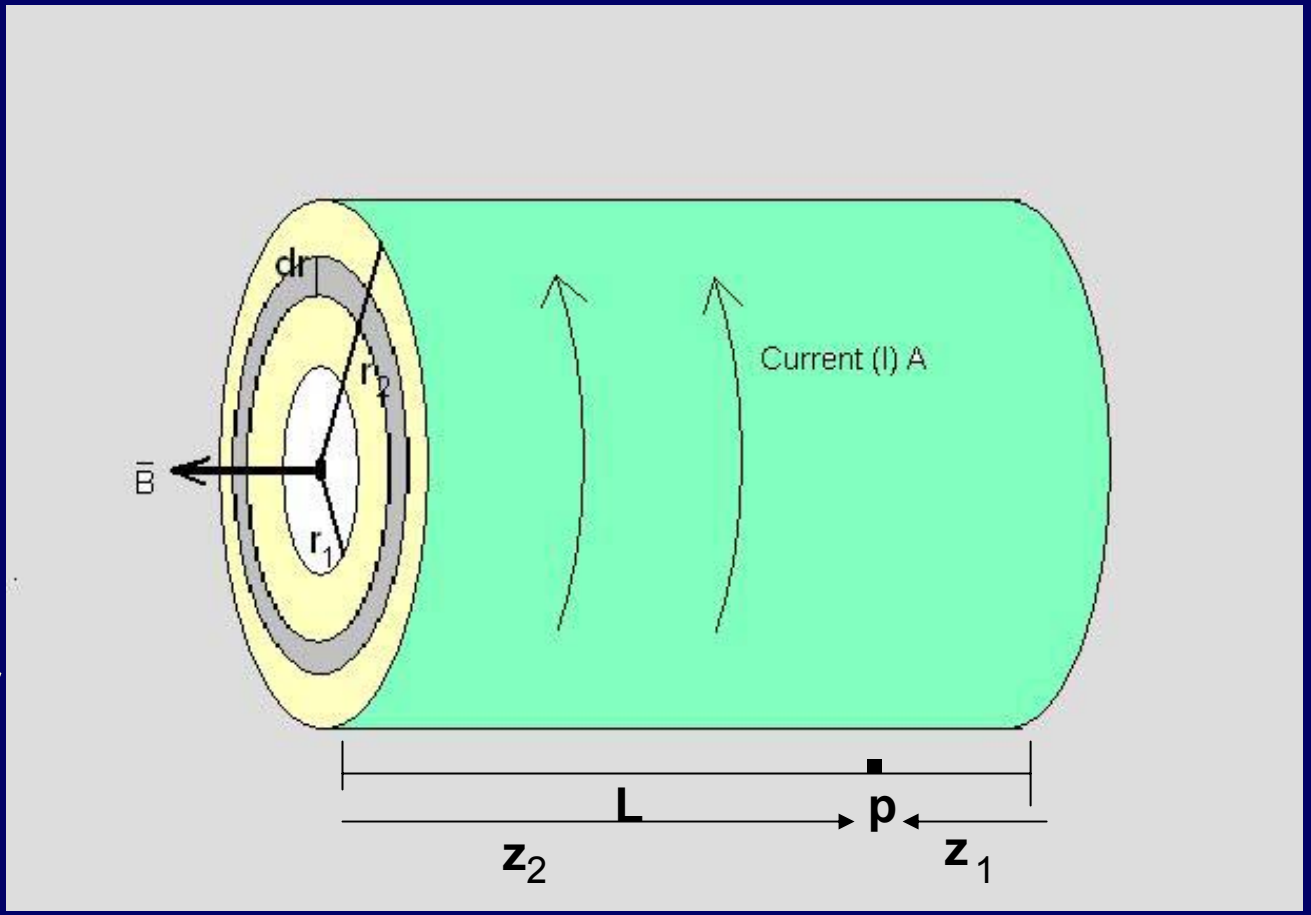



AUDIO AMPLIFIER
OUTPUT

# Solenoid

- L: 15 cm
- $r_1$ : 0.88 cm
- $r_2$ : 1.87 cm

- 160 turns/layer
- 10 layers

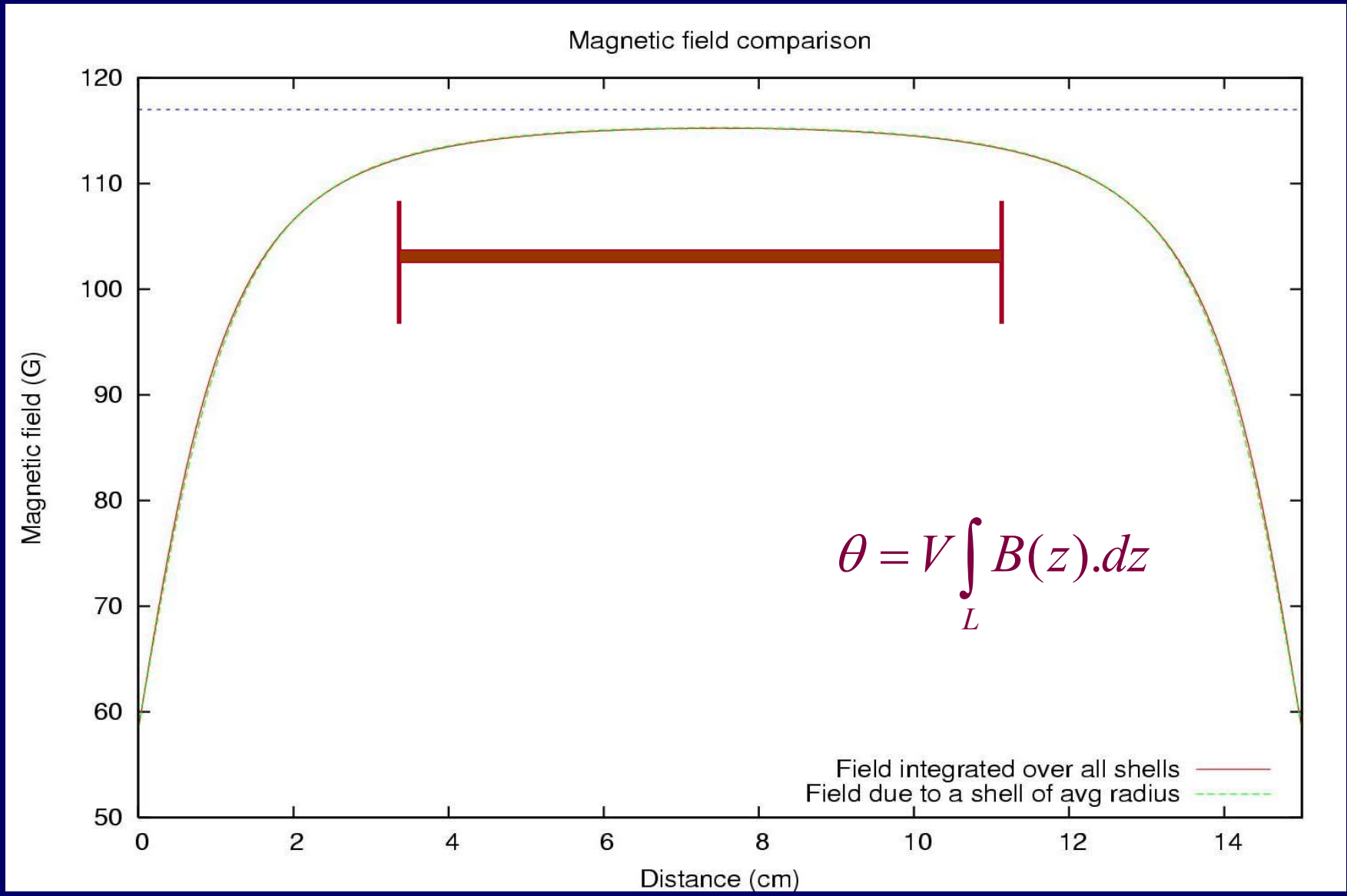



**Finite length (shell) :**

$$B = \frac{\mu_0 iN}{2L}\left[\frac{z_2}{\sqrt{z_2^2 + r^2}} - \frac{z_1}{\sqrt{z_1^2 + r^2}}\right]$$

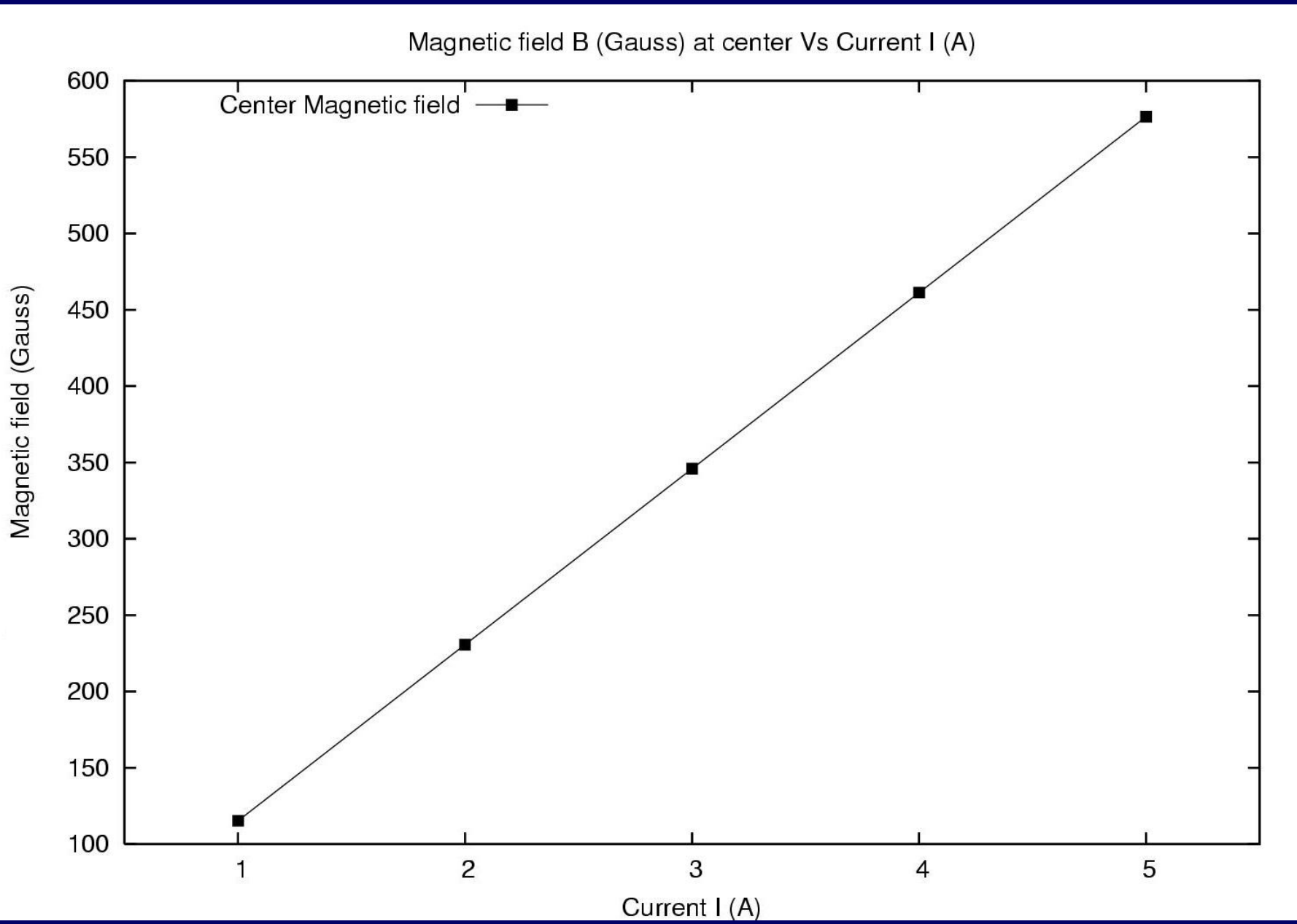
**Finite Thickness :**

$$B = \frac{\mu_0 iN}{2(r_2 - r_1)L}\left[z_2 \ln\frac{\sqrt{z_2^2 + r_2^2} + r_2}{\sqrt{z_2^2 + r_1^2} + r_1} - z_1 \ln\frac{\sqrt{z_1^2 + r_2^2} + r_2}{\sqrt{z_1^2 + r_1^2} + r_1}\right]$$

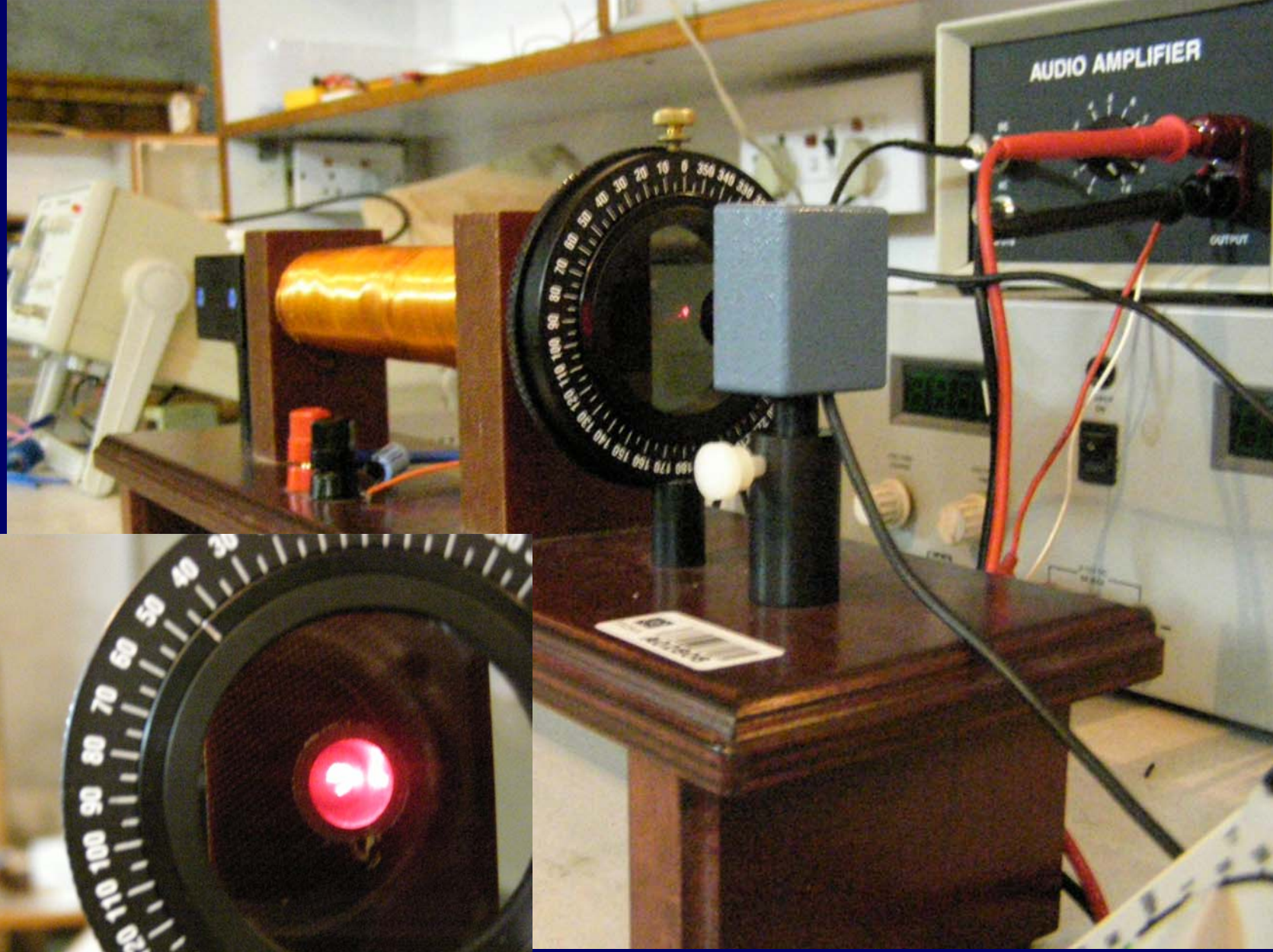


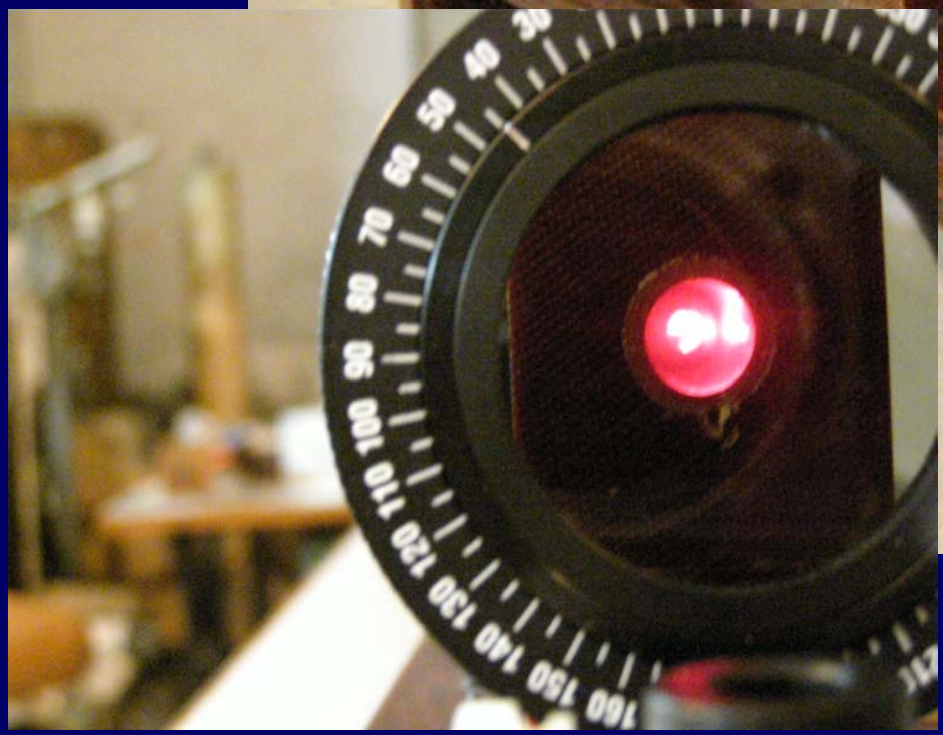

Magnetic Field along the solenoid length.

We consider a shell of average radius r = 1.38 cm, with same total current



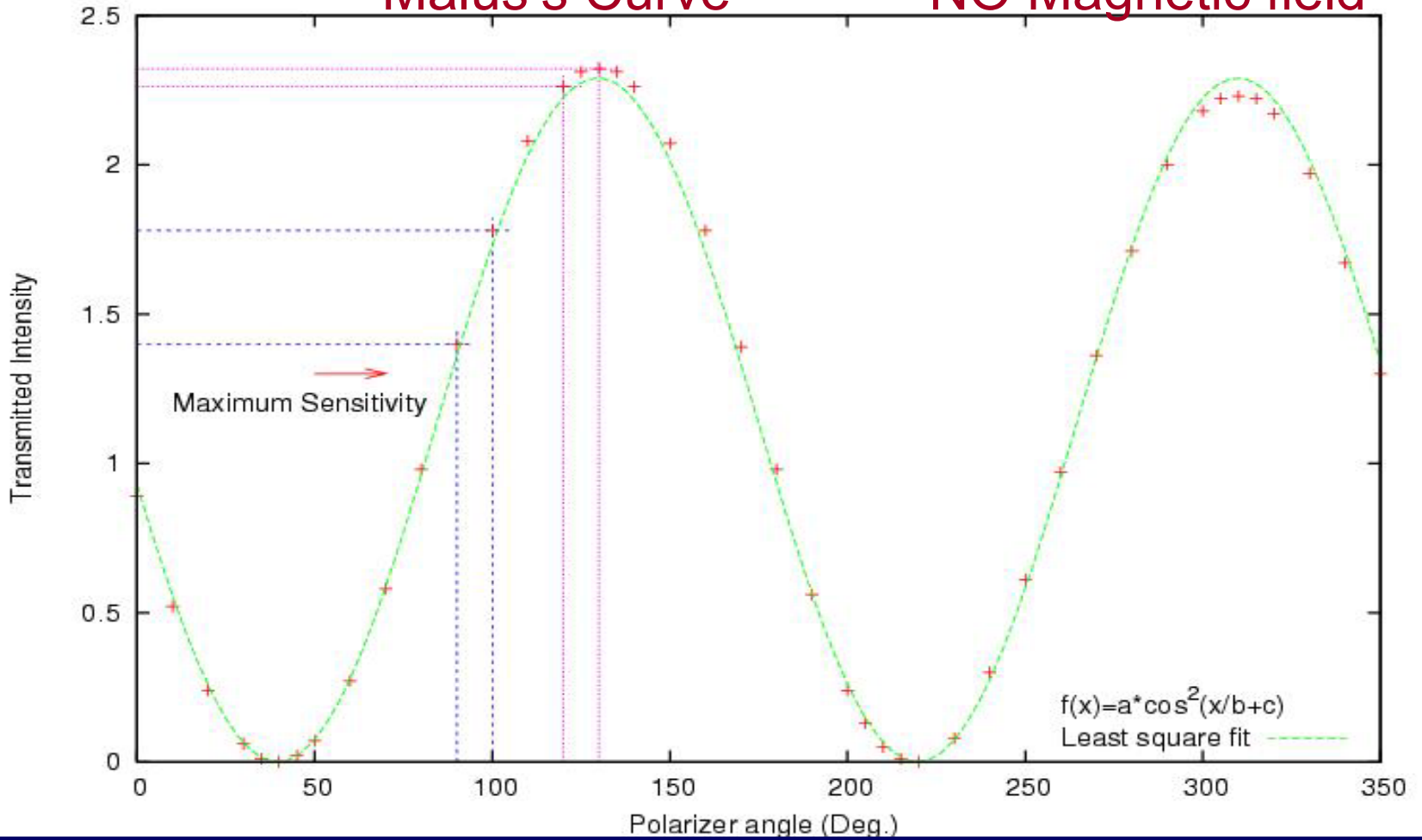

Central Magnetic field as a function of current


AUDIO AMPLIFIER
OUTPUT

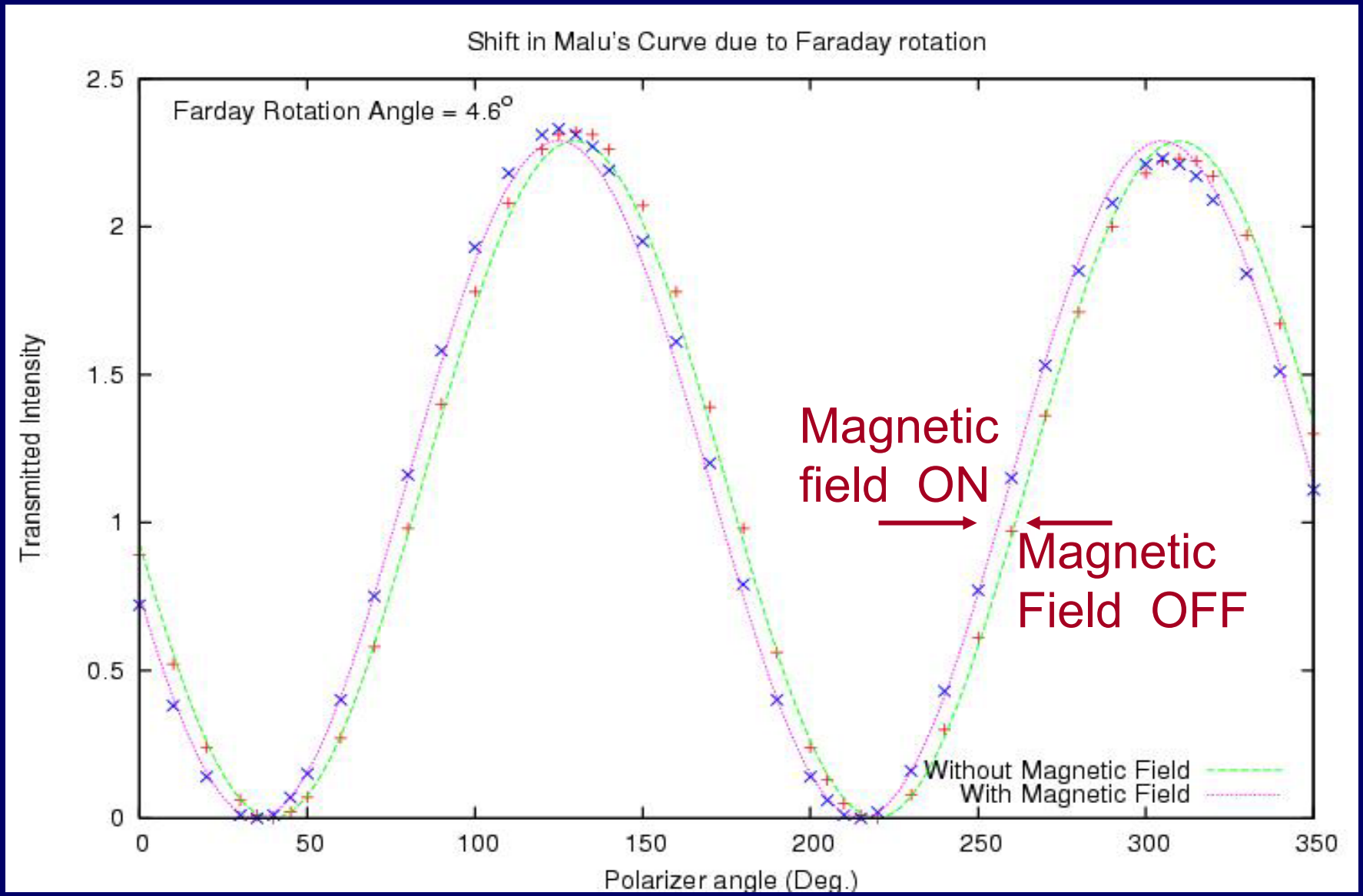


# Observation Method

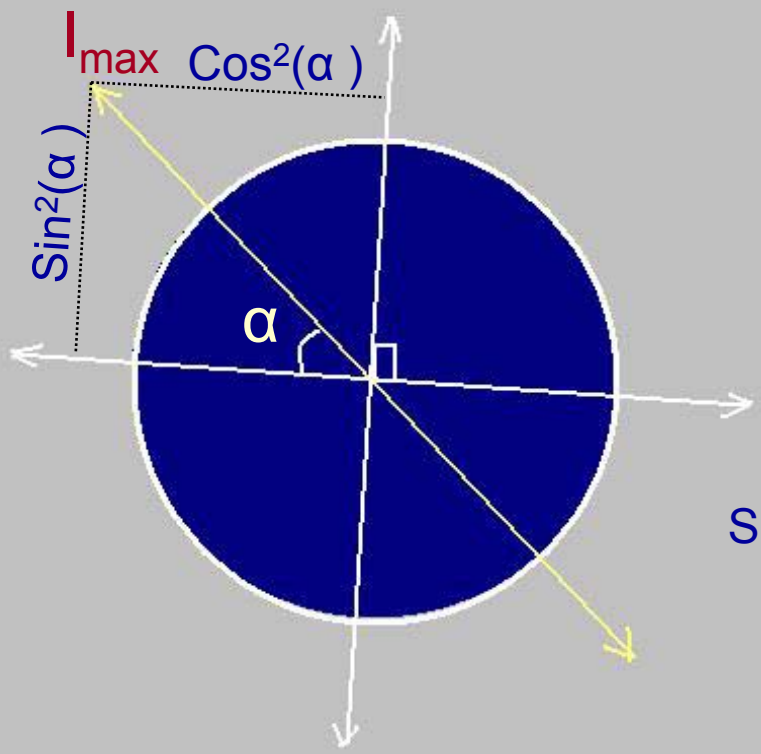
Malus's Curve NO Magnetic field



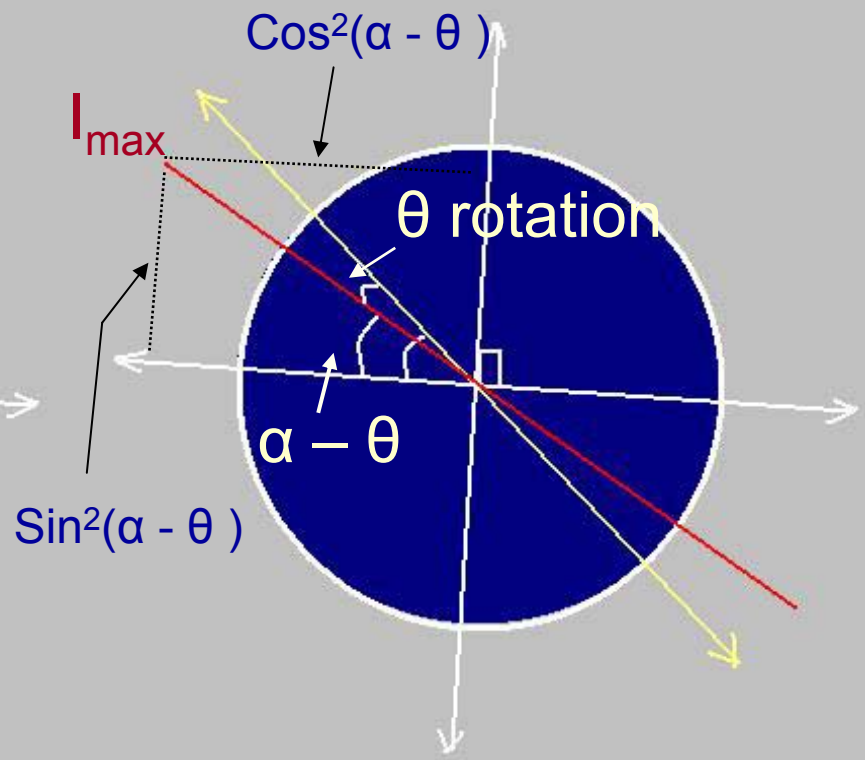
# Faraday Rotation



# New Observation Method



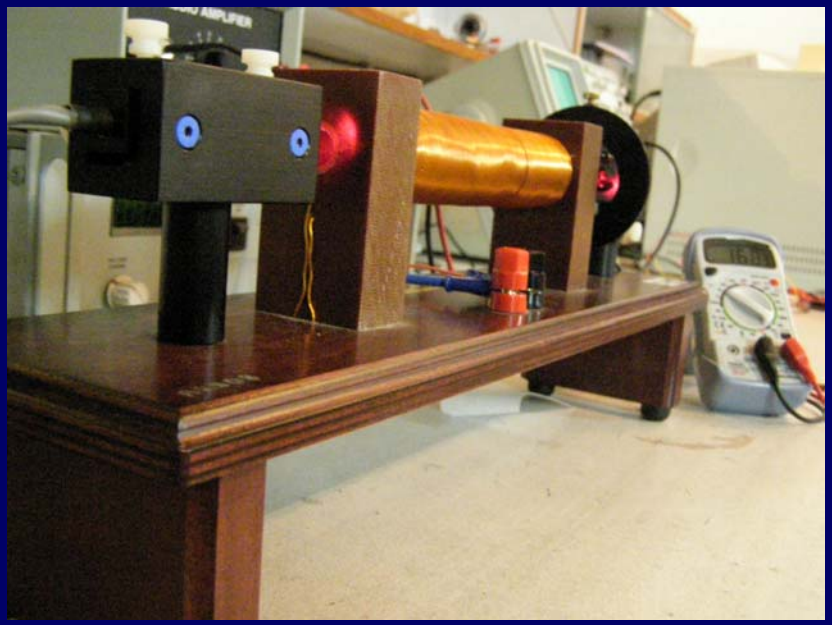

Without Magnetic Field




With Magnetic Field

$$\alpha = \tan^{-1}\left(\sqrt{\frac{y}{x}}\right)$$

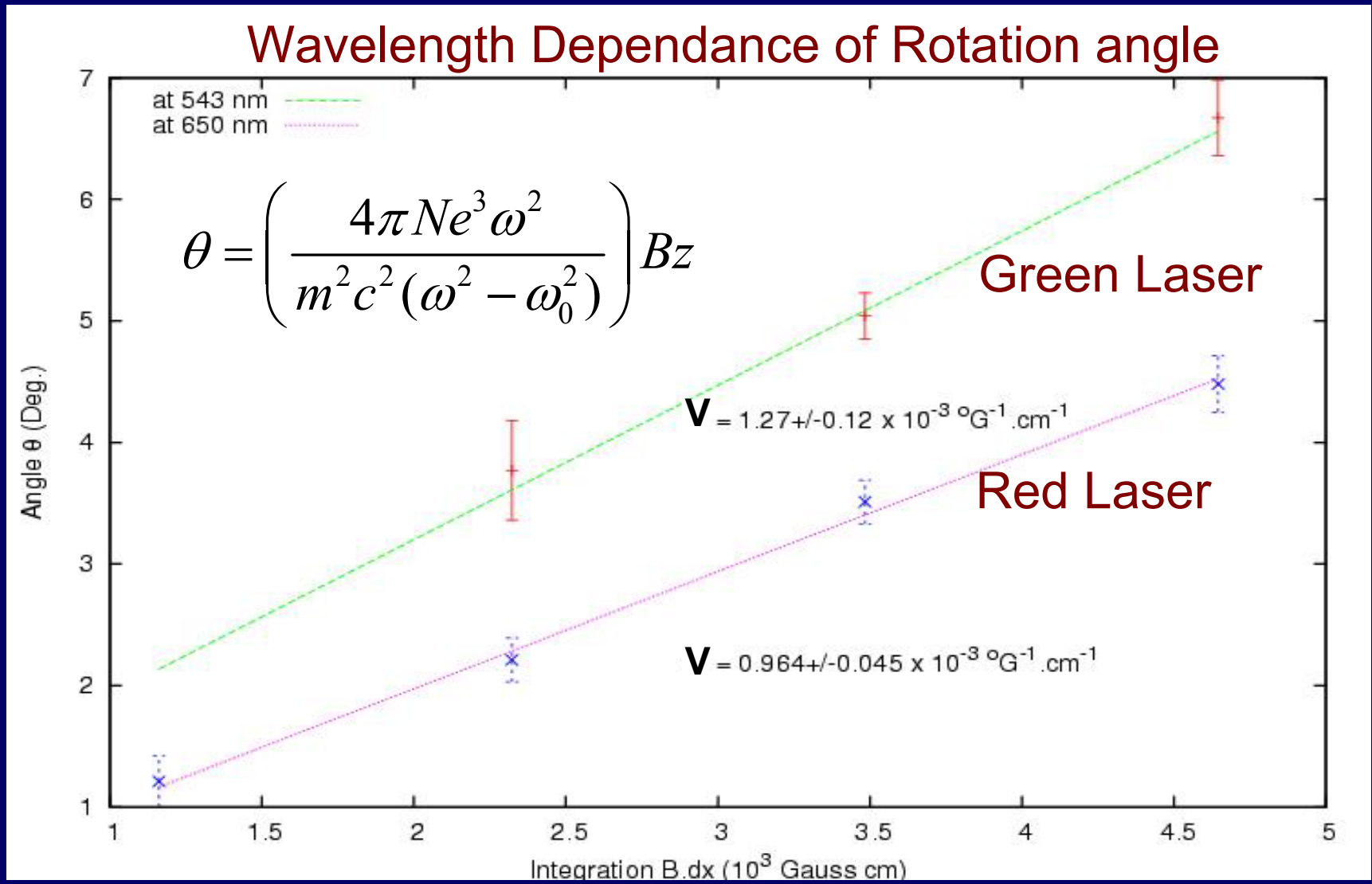
$$\theta = \alpha - \tan^{-1}\left(\sqrt{\frac{y_{rot}}{x_{rot}}}\right)$$



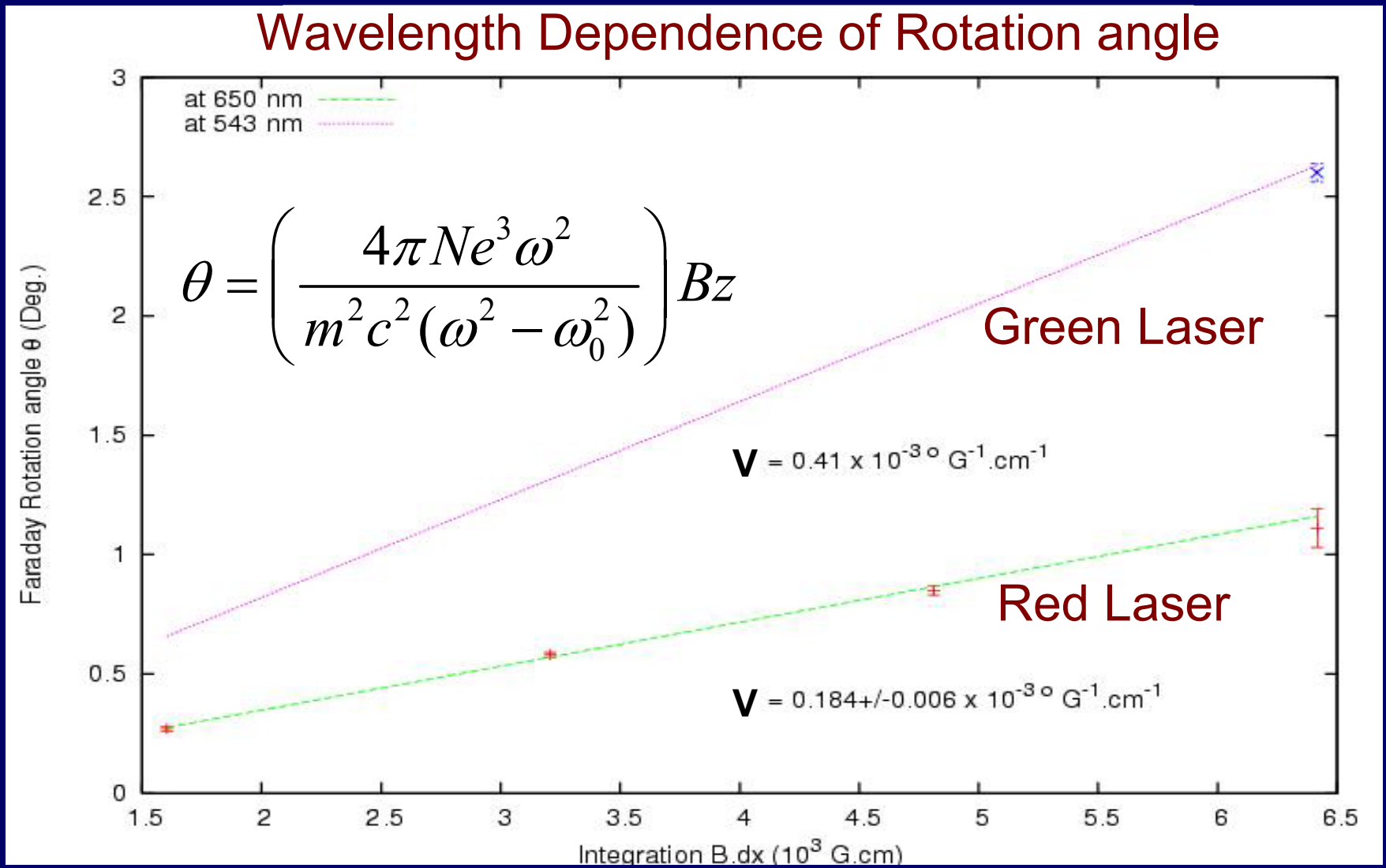
# Observations

- We use the New Method to Measure ***"Faraday Rotation Angle"***
- ***WITH –***
  - ***Different  Magnet fields***
  - ***Materials:*** **Lead silicate glass, Water, Benzene**
  - ***Laser sourses : Red (650 nm), Green (543 nm)***

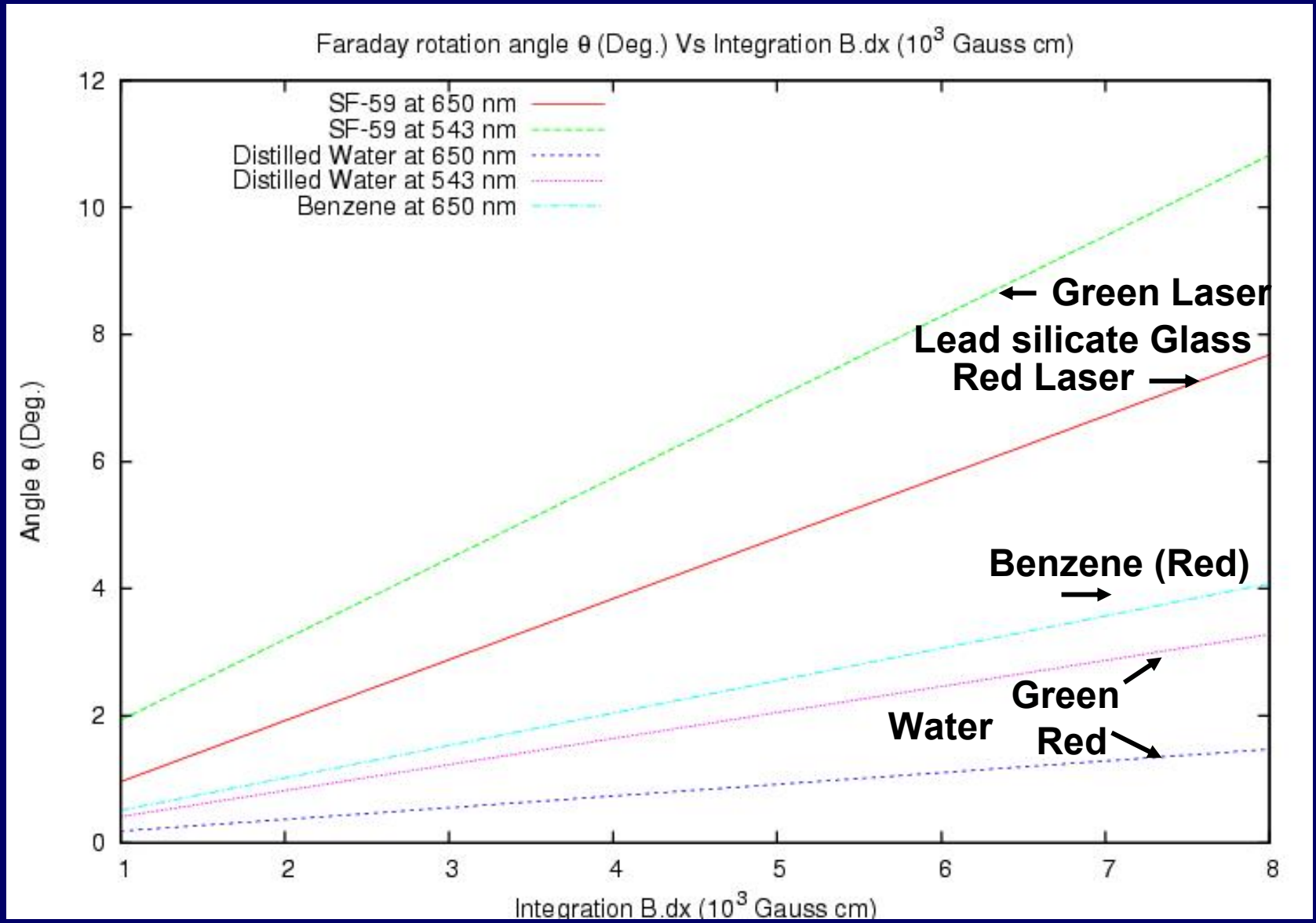
# Faraday Rotation Measured for Lead Silicate Glass



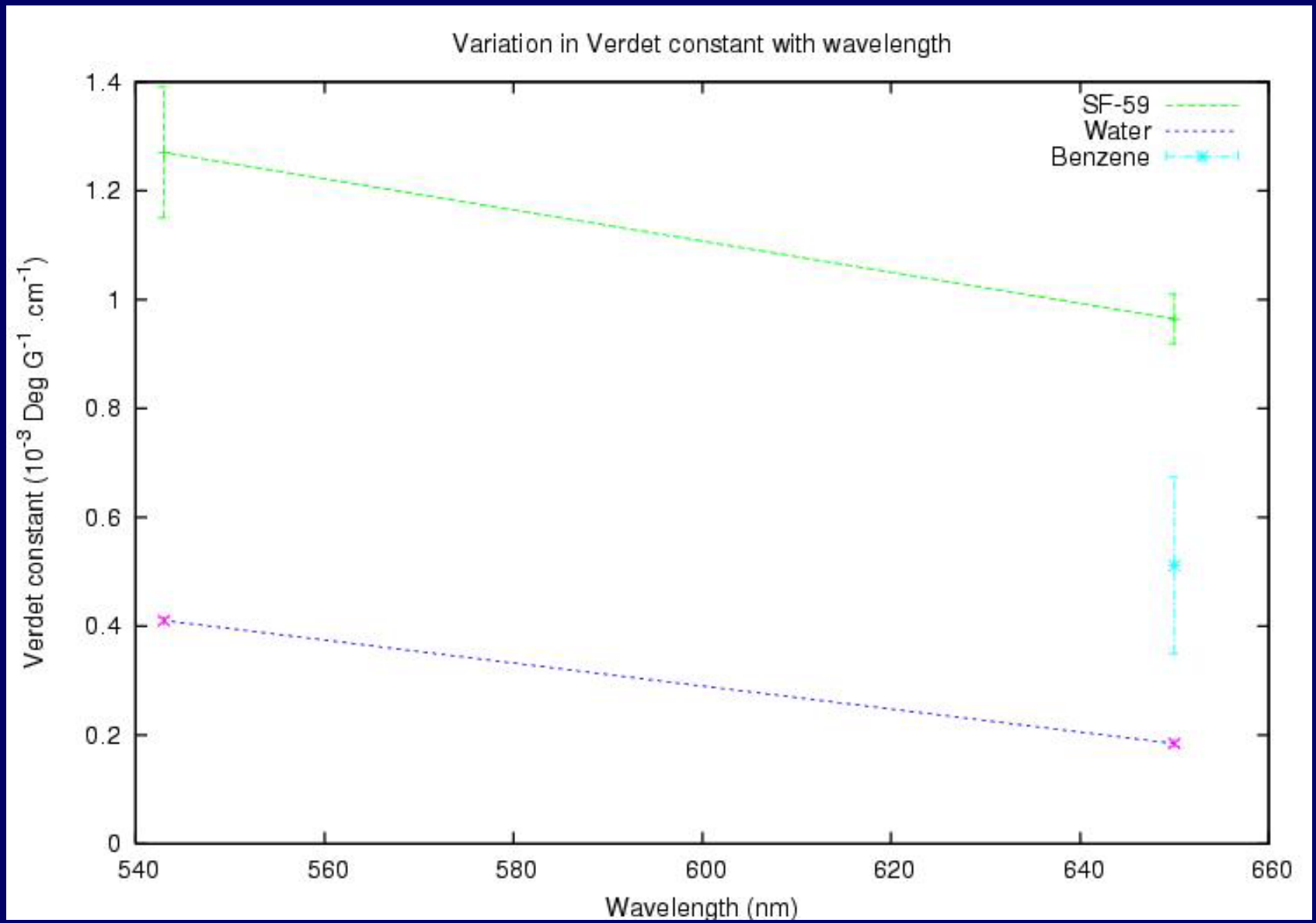
# Faraday Rotation Measured for Water



# Comparing Verdet Constants



# Wavelength Dependence of Verdet



# Astrophysical Application of Faraday Rotation Effect

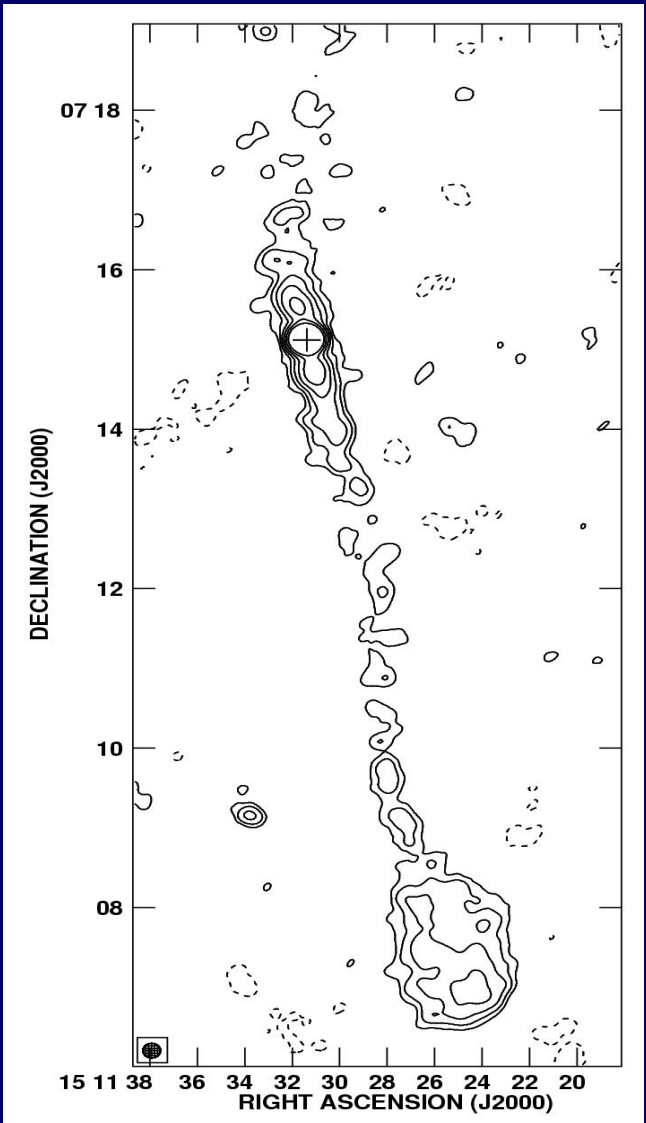
$$\Psi_{obs}(\lambda) = \Psi_{\text{int}}(\lambda) + \Delta\Psi$$

$$\Psi_{obs}(\lambda) = \Psi_{\text{int}}(\lambda) + \lambda^2 \left( \frac{e^3}{2\pi m_e^2 c^4} \int_o^L n_e(l) B_{||}(l) dl \right)$$

Plotting Y= C + X*RM

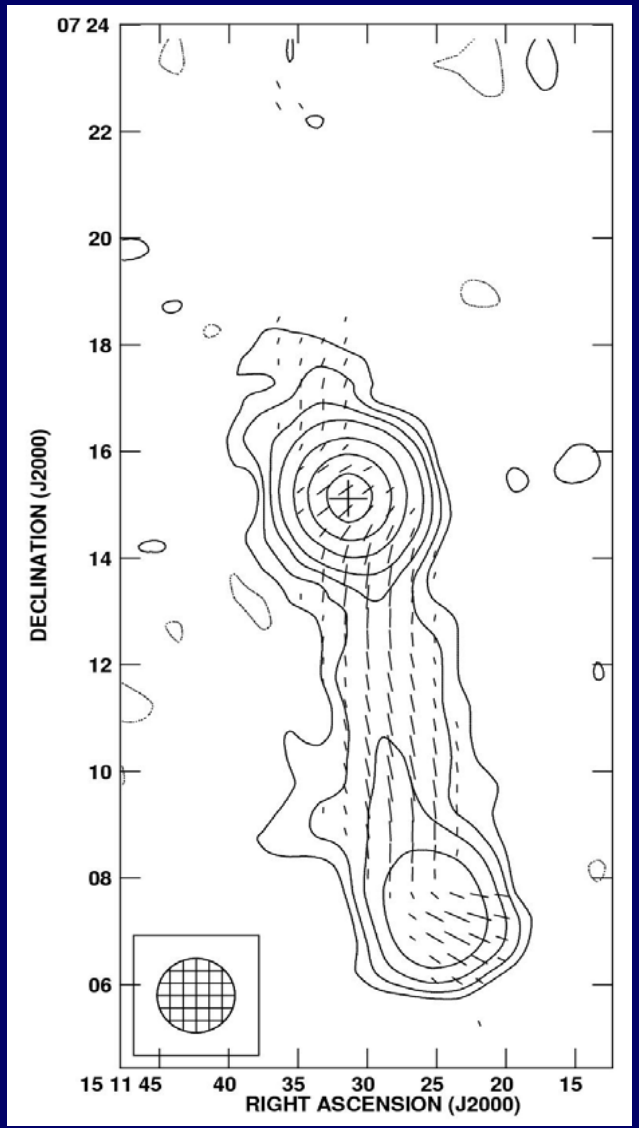
Rotation Measure (RM) (rad/m$^2$)

# Radio Jet CGCG049-033



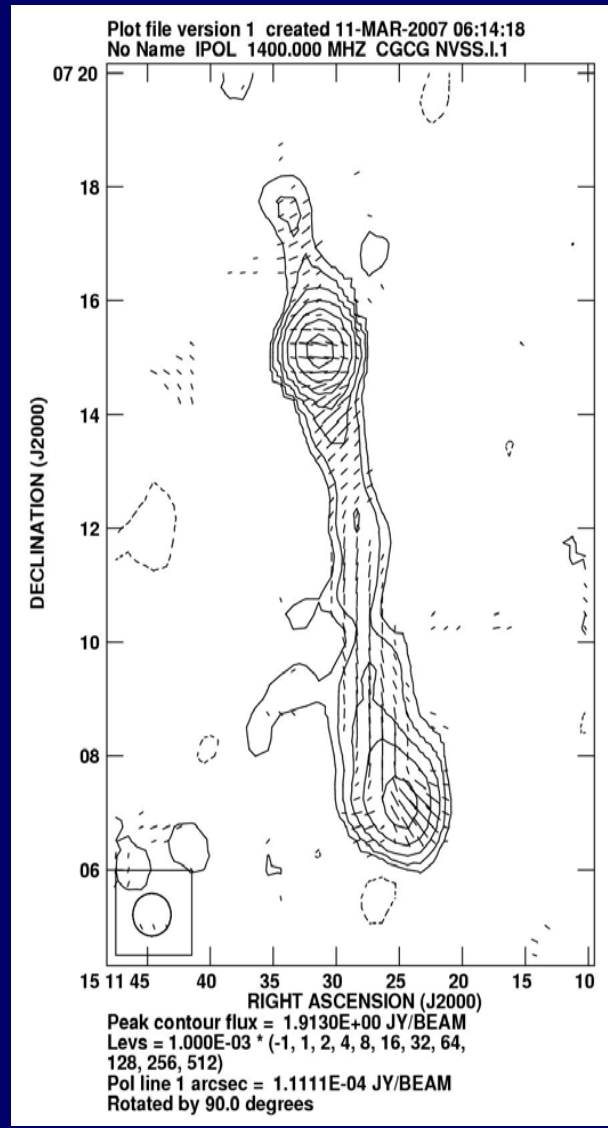

- GMRT
- 1.3GHz
- Resolution: 11 arc sec

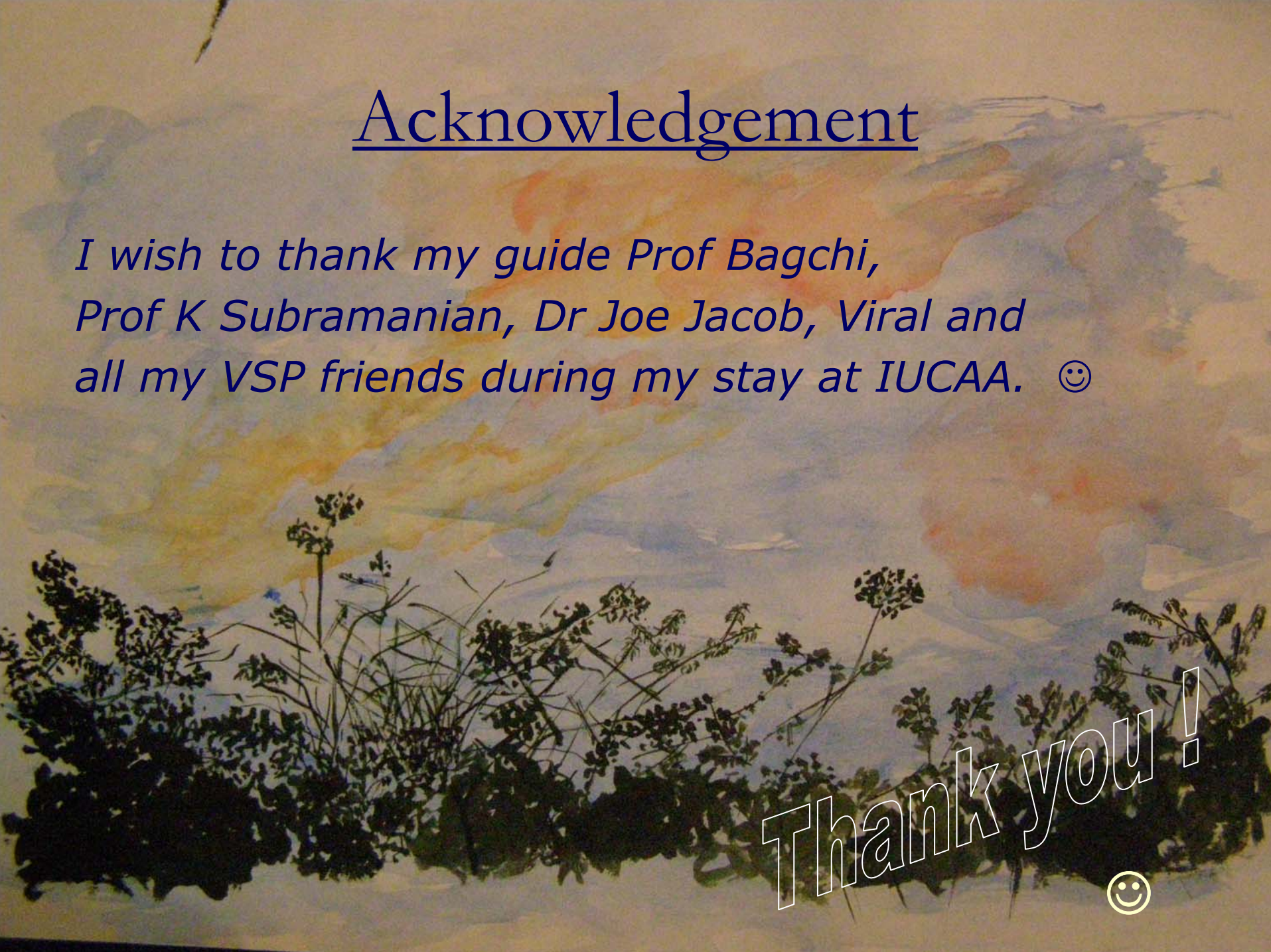
The largest and highly collimated radio jet ~400kpc large




- VLA
- 1.4GHz
- Resolution = 45 arc sec

- Max Planck 100m
- 8.4GHz
- Resolution = 84 arc sec



# Acknowledgement

*I wish to thank my guide Prof Bagchi, Prof K Subramanian, Dr Joe Jacob, Viral and all my VSP friends during my stay at IUCAA.* ☺