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Using the Faraday Effect to find the Verdet constant of an unknown material

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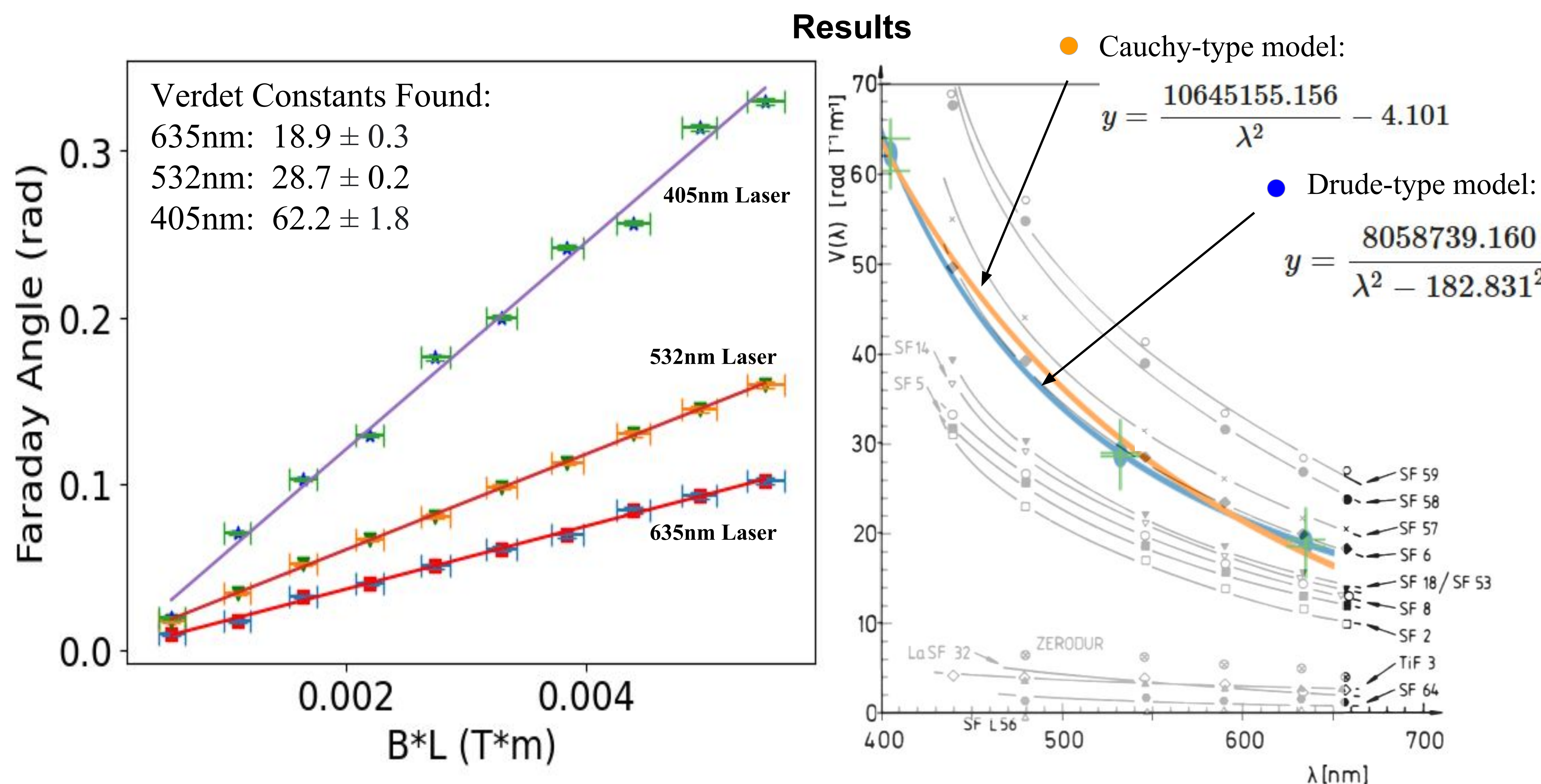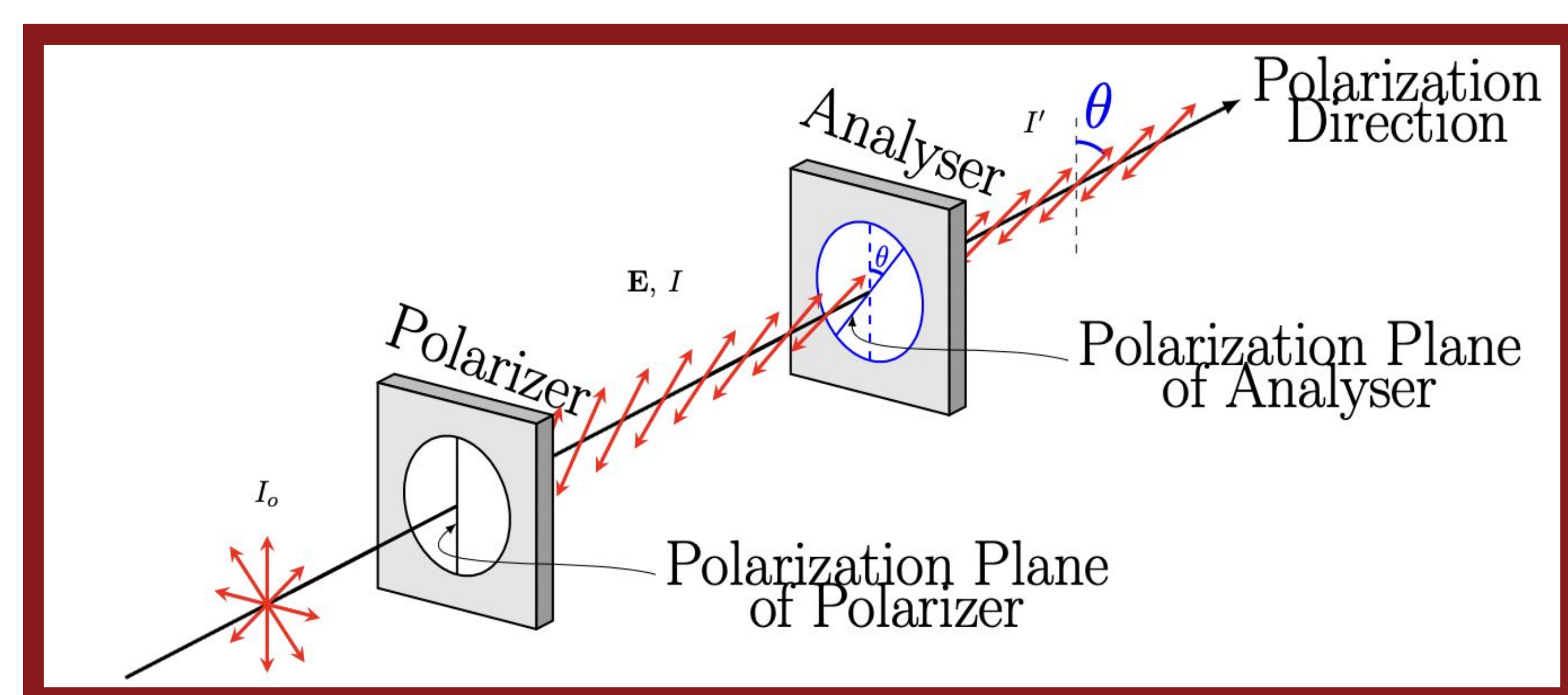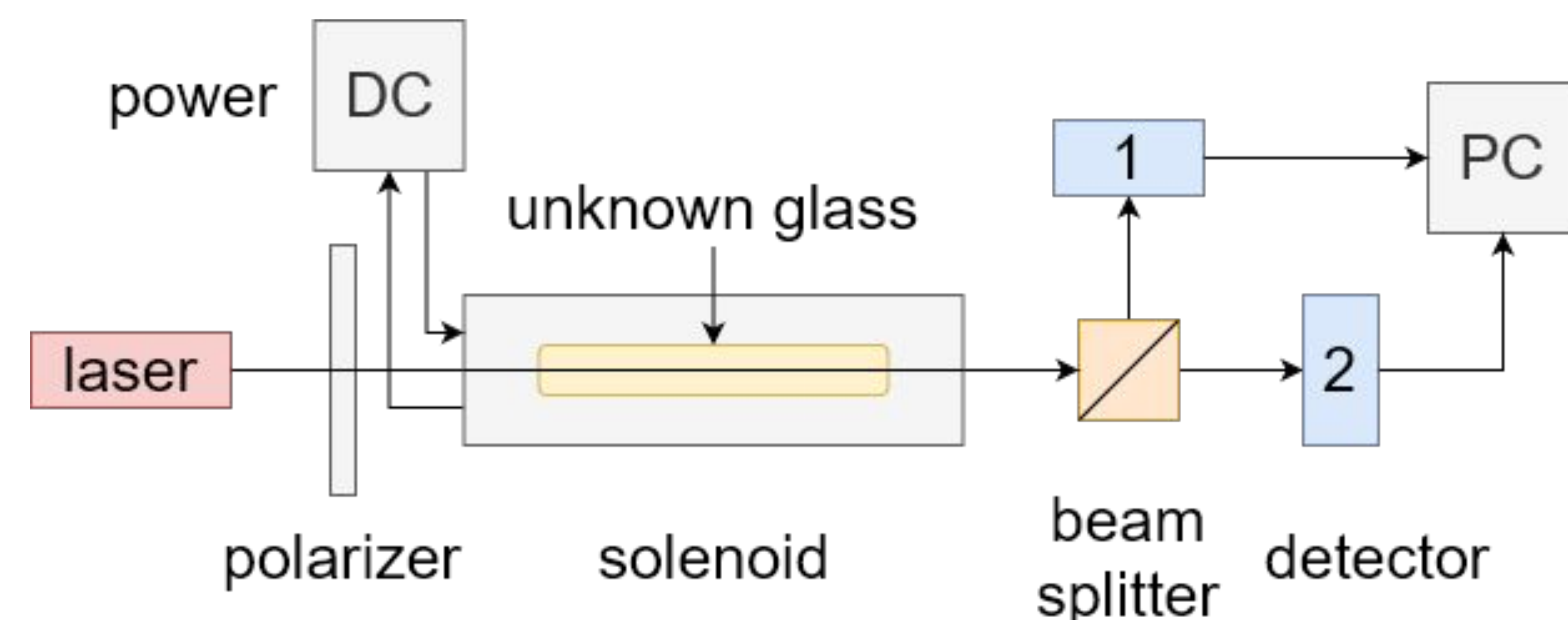
Introduction

The Faraday rotation experiment studies the interaction between light and magnetic fields in materials. By measuring the rotation of the polarization angle of the beam passing through the unknown substance relative to the reference beam, we were able to determine the Verdet Constant of the material.

Results

Verdet Constants Found:
635nm: 18.9 ± 0.3
532nm: 28.7 ± 0.2
405nm: 62.2 ± 1.8

405nm Laser

532nm Laser

635nm Laser

Cauchy-type model:
$$y = \frac{10645155.156}{\lambda^2} - 4.101$$

Drude-type model:
$$y = \frac{8058739.160}{\lambda^2 - 182.831^2}$$

Method

Beam Splitter Method: rotate the polarizer to " 45° "

Biot-Savart Law: $B = \frac{\mu_0 N I}{2R} = (11.1 \frac{\text{mT}}{\text{A}})I$

N: number of turns   R: distance from center
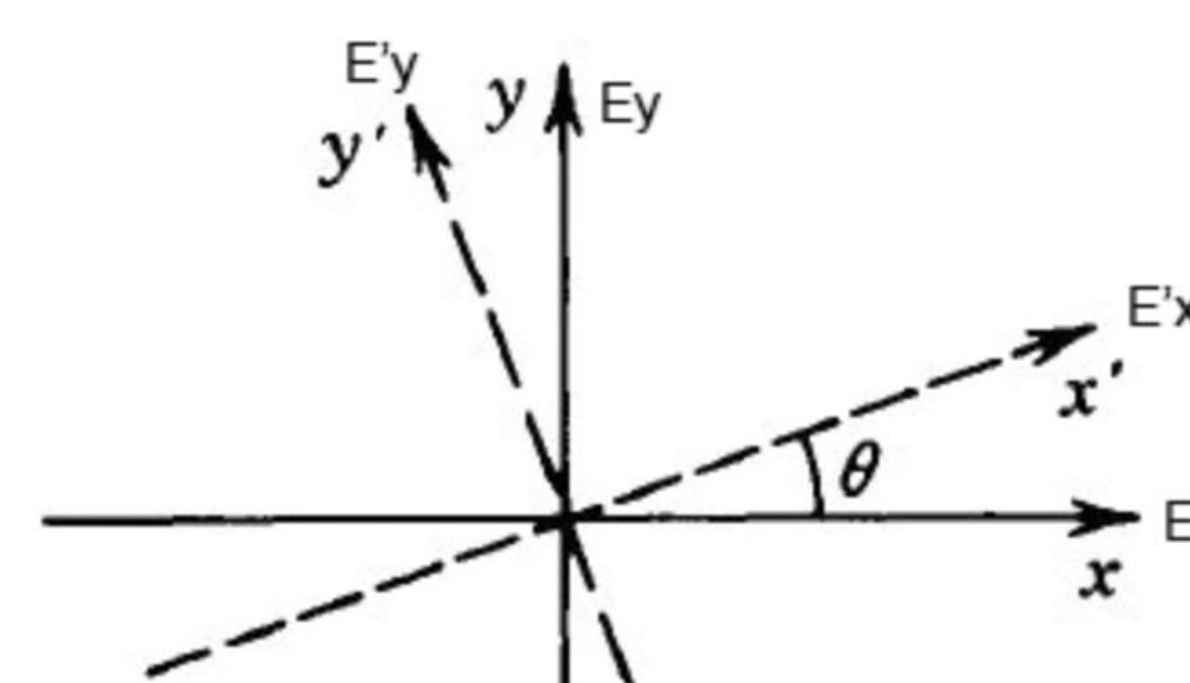I: current   11.1 : we get the result from manufacturer

Faraday Rotation Angle:

$$\theta_R = V \int_1^0 B \cdot dl = V Bl$$

Jones Matrix:

$$\begin{bmatrix} E_x{}' \\ E_y{}' \end{bmatrix} = \begin{bmatrix} J_{xx} & J_{xy} \\ J_{yx} & J_{yy} \end{bmatrix} \begin{bmatrix} E_x \\ E_y \end{bmatrix}$$

$$J_{ROT} = \begin{bmatrix} cos\theta & sin\theta \\ -sin\theta & cos\theta \end{bmatrix}$$

Malus' Law:

$$\frac{I}{I_0} = \cos^2 \theta$$

Conclusions

We used Beam Splitter Method to determine the verdet constant of an unknown material. We used Wavelengths of 635nm, 532nm, and 405nm. By using the Drude-type model: We compared these results with the current literature and the unknown material is compatible with SF - 6.

References

M. Januszewski, A. Kosiński, and K. Graff, "AI benchmark: Running deep neural networks on android smartphones," (2019)
Loeffler, Simple telescopes for undergraduate laboratory experiments," Am. J. Phys.51, 661 (1983)
Segovia, J. E. F., & Poker, D. B.The Verdet constant of optical glasses. Journal of Modern Optics, (2016).