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# Sagnac Effect and Fiber Optic Gyroscopes

**Kecman M***

*Independent Researcher, Poland*

**Abstract**

Sagnac effect (Sagnac interference) is well described by the author Anderson. There is the original paper translated into English. The generally accepted interpretation is based on different trails (The difference in the length of roads caused by peripheral speed). Interference fringes are evenly lined with dark stripes, move with the changing angular velocity. Theoretical calculations given significant deviations from the experimental results. Experimental data suggest: Sensitivity (accuracy) of the device is proportional to the square of the length of optical fiber. The official interpretations (and others) argue: Sensitivity is proportional to the length of the optical fiber. Exposed is a mathematical analysis of the experimental data.

**Keywords:** Sagnac; Optical gyroscope; Quadratic regression

## Introduction

Sagnac experiment was published 1913 years by the Author which is precisely described device and method of measurement [1,2]. The calculation and experimental results are consistent. Figures 1 and 2 show a model for calculating the phase shift. Sagnac has introduced a surface A due to deviations of the measurement results. On his drawing device is a hatched area [2]. It is better to agree with the measurement of 2π R to model. Sagnac wrote:" After many runs, I have always observed the sense to change as expected (Table 1).

At the end of the twentieth century made sophisticated optical gyroscope. The device had no moving parts (elements). Optical cable, laser, electronics, and software enable high-precision devices.

## Experimental Data

It gives an insight to the technical characteristics. There is no reliable data sensitivity of their devices. Data obtained by experimental methods [3,4].

## Linear regressions

$y=k_1 x$

Calculate $k_1$ give us a sum of squared deviations is minimal.

$F=\Sigma (y_i-k_1x_i)^2$

From this

$dF/dk_1=0$ get:

$k_1=(\Sigma x_iy_i)/(\Sigma(x_i)2)$

$k_{1=}(\Sigma x_iy_i)/( \Sigma(x_i)^2)$ $\Sigma x_iy_{i=}73807$ $\Sigma(x_i)^2=2238425$ $F_1=\Sigma(y_i-0.033x_i)^2$

$k_{1=}0.033$ Calculate the sum of the squared deviations: $F_1=330$

## Quadratic regression (QuadReg)

$y=k_2x^2$ calculate $k_2$ give us a sum of squared deviations is minimal as shown in Tables 2 and 3.

$F=\Sigma(y_i-k_2x_i^2)^2$

From this $dF/dk_2=0$ get:

$k_{2=}(\Sigma x_i^2y_i)/( \Sigma(x_i)^4)$

$k_2=(\Sigma x_i^2y_i)/( \Sigma(x_i)^4)$ $\Sigma x_i^2y_{i=}81.46*10^6$ $\Sigma(x_i)^4=2.36*10^{12}$ $F_2=\Sigma(y_i-k_2x_i^2)^2$

$k_{2=}0.0000346$ $F_2=2.06$

## Conclusion

F2 << F1 from which it follows that the quadratic regression much better fit with the experimental data.

Predict the sensitivity of optical fiber length L=5000 m.y=0.0000346*5000²=856. Bias is 0.00058°/h, and this is one revolution in 70 years. Is necessary revision of theoretical explanations for Sagnac effect? The new theory must contain a square dependence of

| | EMP-1 | EMP-1 | EMP-1 | EMP-1 | EMP-1.2K |
|---|---|---|---|---|---|
| Fiber Length[m] | 205 | 300 | 420 | 700 | 1200 |
| Bias (Typical)[°/h] | 0.5 | 0.2 | 0.2 | 0.03 | 0.01 |
| Scale Factor | 0.027 | 0.027 | 0.012 | 0.03 | 0.027 |
| $x_i$ (L) | 205 | 300 | 420 | 700 | 1200 |
| $y_i$ (n) | 1 | 2,5 | 5.6 | 15 | 50 |

n=[0.5/(Bias)] × [0.027/(Scale f)].

**Table 1:** Bias data is reduced to the same peripheral speed, and on the same scale factor.

| $x_i$ | $y_i$ | $x_iy_i$ | $x_i^2$ | $y_i$-0.033$x_i$ | ($y_i$-0.033$x_i$)$^2$ |
|---|---|---|---|---|---|
| 205 | 1 | 205 | 42025 | -5.765 | 33.23 |
| 300 | 2.5 | 750 | 90000 | -7.4 | 54.76 |
| 420 | 5.6 | 2352 | 176400 | -8.26 | 68.22 |
| 700 | 15 | 10500 | 490000 | -8.1 | 65.61 |
| 1200 | 50 | 60000 | 1440000 | 10.4 | 108.16 |

**Table 2:** Sum of squared deviations.

| $x_{i\,[m]}$ | $y_i$ | $x_i^2$ | $x_i^2y_i$ | $x_i^4$ | $y_i-k_2x_i^2$ | $(y_i-k_2x_i^2)^2$ |
|---|---|---|---|---|---|---|
| 205 | 1 | 42025 | 62500 | 3906 × $10^6$ | -1.16 | 1.35 |
| 300 | 2.5 | 90000 | 225000 | 8100 × $10^6$ | -0.61 | 0.372 |
| 420 | 5.6 | 176400 | 9877840 | 31117 × $10^6$ | -0.5 | 0.25 |
| 700 | 15 | 490000 | 8183000 | 240100 × $10^6$ | -0.2 | 0.04 |
| 1200 | 50 | 1440000 | 72000000 | 2073600 × $10^6$ | -0.23 | 0.053 |

**Table 3:** illustration of quadratic regression.

***Corresponding author:** Kecman M, Independent Researcher, Poland, Tel: +38765680971; E-mail: mkecman@blic.net

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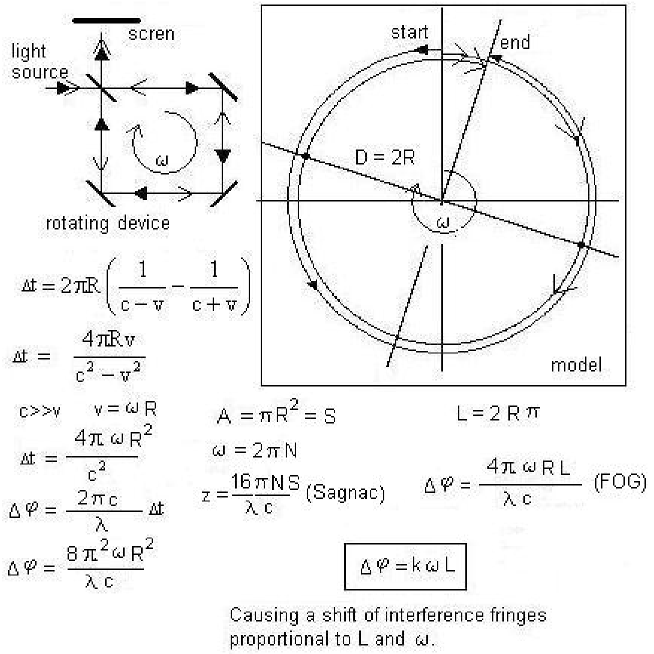


**Figure 1:** Observed and measured shift interference fringe.

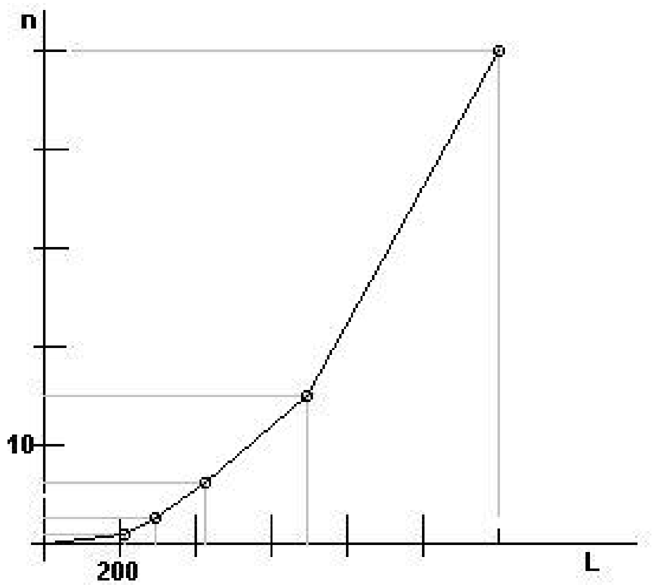


**Figure 2:** The method of least squares.

sensitivity on the length of the fiber. Additional experimental design is also essential. Serious hypothesis will be given.

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