

# Sagnac Effect and Fiber Optic Gyroscopes

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## 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  $2\pi R$  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.

$$F = \sum (y_i - k_1 x_i)^2$$

From this

$$dF/dk_1 = 0 \text{ get:}$$

$$k_1 = (\sum x_i y_i) / (\sum x_i^2)$$

$$k_1 = (\sum x_i y_i) / (\sum x_i^2) = 73807 / 2238425 = 0.0333 \text{ } F_1 = \sum (y_i - 0.0333 x_i)^2$$

$$k_1 = 0.033 \text{ Calculate the sum of the squared deviations: } F_1 = 330$$

## Quadratic regression (QuadReg)

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

$$F = \sum (y_i - k_2 x_i^2)^2$$

From this  $dF/dk_2 = 0$  get:

$$k_2 = (\sum x_i^2 y_i) / (\sum x_i^4)$$

$$k_2 = (\sum x_i^2 y_i) / (\sum x_i^4) = 81.46 \times 10^6 / 2.36 \times 10^{12} = 2.06 \times 10^{-5} \text{ } F_2 = \sum (y_i - k_2 x_i^2)^2$$

$$k_2 = 0.0000346 \text{ } F_2 = 2.06$$

## Conclusion

$F_2 \ll F_1$  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.  $y = 0.0000346 \times 5000^2 = 856$ . Bias is  $0.00058^\circ/h$ , 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

$$n = [0.5 / (\text{Bias})] \times [0.027 / (\text{Scale f})]$$

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

$x_i$	$y_i$	$x_i y_i$	$x_i^2$	$y_i - 0.033 x_i$	$(y_i - 0.033 x_i)^2$
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]	$y_i$	$x_i^2$	$x_i^2 y_i$	$x_i^4$	$y_i - k_2 x_i^2$	$(y_i - k_2 x_i^2)^2$
205	1	42025	62500	$3906 \times 10^6$	-1.16	1.35
300	2.5	90000	225000	$8100 \times 10^6$	-0.61	0.372
420	5.6	176400	9877840	$31117 \times 10^6$	-0.5	0.25
700	15	490000	8183000	$240100 \times 10^6$	-0.2	0.04
1200	50	1440000	72000000	$2073600 \times 10^6$	-0.23	0.053

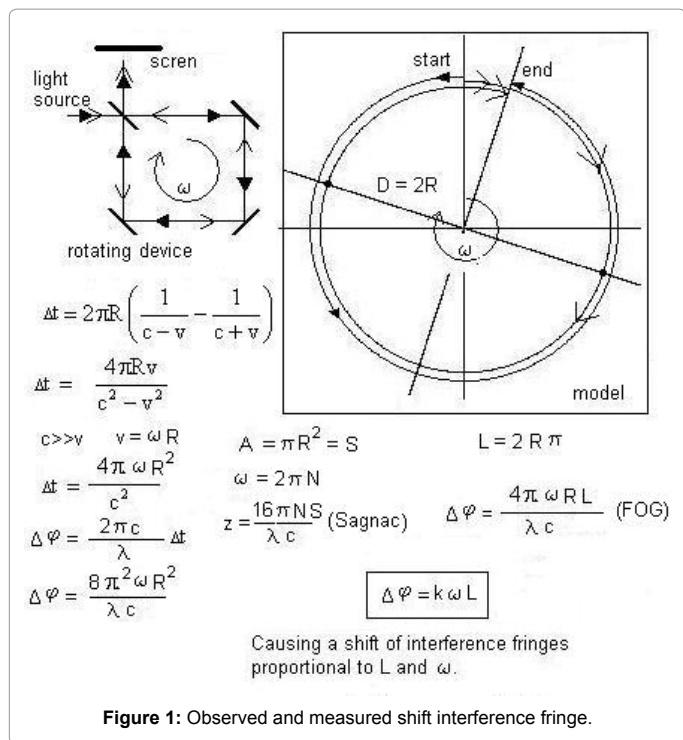
**Table 3:** illustration of quadratic regression.

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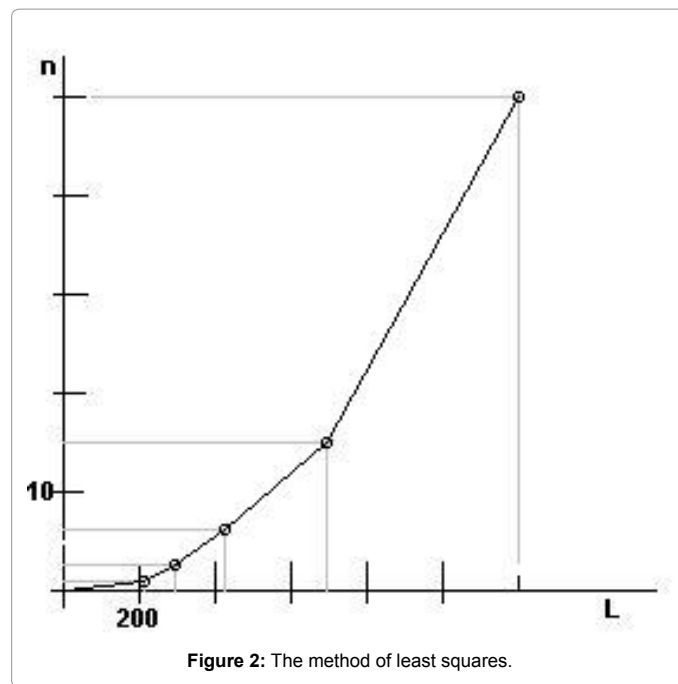
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sensitivity on the length of the fiber. Additional experimental design is also essential. Serious hypothesis will be given.

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