# Sagnac Effect Revisited

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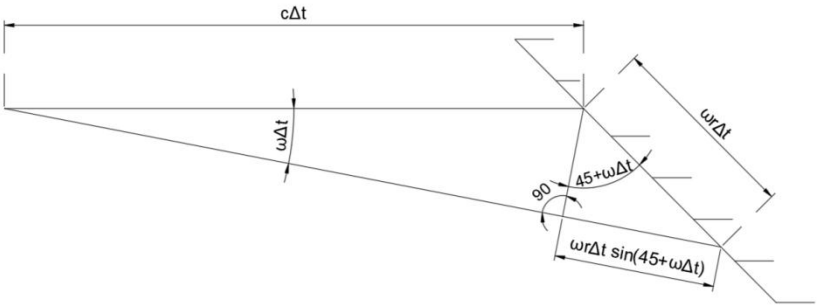
**Abstract**

In this paper an explanation of the Sagnac effect has been presented.
**Keyword :** Sagnac effect.

## 1 PATH DIFFERENCE

Let r be the distance from the center of the rotating platform to the respective centers (points of light incidence) of the mirrors and the beam splitter (partial mirror). Let the respective normals of the mirrors (at their respective points of incidence), except for the beam splitter, be directed towards the center of the rotating platform. Let the respective normals of the mirrors make an angle of 45$^o$ with the lines connecting the mirror with the adjacent mirrors (i.e., mirrors along with the beam splitter have been placed symmetrically about the center of the rotating platform). Let c be the speed of a light ray (or photons) with respect to the ground frame of reference and it will remain constant throughout its journey from the source to the interference screen assuming perfectly elastic collision of the photons with the mirrors (speed of approach = speed of separation ; effect of ωr on c will be negligible as ωr << c and consequently the effect of minute speed change of the light ray or the photons on the fringe shift will be negligible). Then, the path difference for a clockwise moving light ray in going from one mirror to the next mirror for counterclockwise rotating platform as compared to non-rotating platform in the Sagnac experiment

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$$\zeta_+ \approx \omega r \Delta t \sin\left(45^o + \omega \Delta t\right) \approx \omega r \Delta t \sin 45^o \qquad [\because \omega r << c]$$

$$\Rightarrow \zeta_+ \approx \omega r \sin 45^o \times \frac{L}{c}$$

where
ω = angular speed of rotation of the platform
L = distance between two consecutive mirrors

Similarly, the path difference for a counterclockwise moving light ray in going from one mirror to the next mirror for counterclockwise rotating platform as compared to non-rotating platform in the Sagnac experiment

$$\zeta_- \approx -\omega r \Delta t \sin 45^o$$

$$\Rightarrow \zeta_- \approx -\omega r \sin 45^o \times \frac{L}{c}$$

## 2 SAGNAC EXPERIMENT

The total additional path difference between a clockwise moving light ray (moving against the sense of rotation of the platform) and a counterclockwise moving light ray (moving with the sense of rotation of the platform) in travelling from the source to the interference screen

$$\zeta = 4\zeta_+ - 4\zeta_- = \left(4\omega r \sin 45^o \times \frac{L}{c}\right) - \left(-4\omega r \sin 45^o \times \frac{L}{c}\right)$$

$$\Rightarrow \zeta = 8\omega r \sin 45^o \times \frac{L}{c}$$

So, the fringe shift (additional optical path difference) for rotating platform as compared to non-rotating platform in the Sagnac experiment

$$\delta = \frac{\zeta}{\lambda}$$

$$\Rightarrow \delta = \frac{8\omega L r \sin 45^o}{\lambda c} = \frac{16\pi N L r \sin 45^o}{\lambda c} \qquad [\omega = 2\pi N]$$

$$\Rightarrow \delta = \frac{4\omega A}{\lambda c} = \frac{8\pi N A}{\lambda c} \qquad \left[A = 4 \times \frac{1}{2} L r \sin 45^o\right]$$

And the phase shift

$$\Delta\phi = 2\pi\delta = \frac{8\pi\omega A}{\lambda c} = \frac{16\pi^2 N A}{\lambda c}$$

## References


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