1)

Notes for Paper 45, Part 1

THE SAGNAC EFFECT IN EVANS FIELD THEORY.

The Sagnac effect is reviewed by:
M. W. Evans, Adv. Chem. Phys., vol. 119 (2)

and by:
M. Meszaros and P. Molnar, ibid., vol. 119 (3).

It is explained straightforwardly as an effect of general relativity as follows.

Consider the rotation of a beam of light around a circle in the XY plane at angular frequency ω_1. This sets up the potential:

$$\underline{A}^{(1)} = A^{(0)} \underline{q}^{(1)} \quad (1)$$

where $\underline{q}^{(1)}$ is the tetrad:

$$\underline{q}^{(1)} = \frac{1}{\sqrt{2}} (\underline{i} - i\underline{j}) e^{i\omega_1 t} \quad (2)$$

The rotating beam of light is therefore the rotation of spacetime as described by the rotating tetrad (2).

2)

Now spin the platform mechanically at an angular frequency Ω.

Spinning to the left produces:

$$\underline{A}_L^{(1)} = \frac{A^{(0)}}{\sqrt{2}} \left(\underline{i} - i\underline{j} \right) e^{i(\omega_1 + \Omega)t} \quad - (3)$$

Spinning to the right produces:

$$\underline{A}_R^{(1)} = \frac{A^{(0)}}{\sqrt{2}} \left(\underline{i} - i\underline{j} \right) e^{i(\omega_1 - \Omega)t} \quad - (4)$$

This generates the time difference:

$$\Delta t = 2\pi \left(\frac{1}{\omega_1 - \Omega} - \frac{1}{\omega_1 + \Omega} \right) \quad - (5)$$

$$\boxed{\Delta t = \frac{4\pi\Omega}{\omega_1^2 - \Omega^2}} \quad - (6)$$

i.e. the beam rotating with the platform takes less time to go around the circumference of the platform than the beam rotating against the platform.

<u>THIS IS THE SAGNAC EFFECT</u>

3)

From eq. (183), p. 119 of vol. 119(2) of Advances in Chemical Physics, and eq. (12), p. 397, vol. 119(3) we obtain:

$$\Delta t = \frac{4\Omega Ar}{c^2} = \frac{4\pi R v}{c^2} \quad -(7)$$

where Ar is the area of the platform enclosed by the light beam, R is the radius of the area if a circle, and v is the tangential linear velocity of the rotating platform's rim.

Eq. (7) was obtained in vol. 119(2) from o(3) electrodynamics. The experimental result (Sagnac, 1913) is also eq. (7).

From eqs. (6) and (7):

$$\frac{4\pi\Omega}{\omega_1^2 - \Omega^2} = \frac{4\pi\Omega Ar}{c^2} \quad -(8)$$

If $\Omega << \omega_1$:

$$\boxed{\omega_1 = \left(\frac{\pi c^2}{Ar}\right)^{1/2}} \quad -(9)$$

This is the angular frequency of the rotating tetrad in the Sagnac effect.