Phase shift and frequency shift in Sagnac experiment

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Summary: ***Both a phase shift and a frequency shift have been obtained with the Sagnac experiment. The phase shift was discovered by Sagnac in 1913. It implies accelerations so that it can be explained only by the General Relativity theory. Attempts to explain this result by a Euclidian approximation failed as it leads to the Selleri's paradox.***

Sagnac favours an explanation by an ether motionless with regard to the laboratory.

Pr Stedman noticed that a frequency shift is also occurring enabling to detect the Sagnac device rotation.

This report is intended for explaining the frequency shift.

1. The experimental context.

It is well known that a phase shift is observed when the Sagnac device is set turning. This phase shift is independent of the medium index. It is proportional to the square of the device radius and to the angular speed of the device.

But it appears that there is also a frequency shift. It has been measured by Pr. Stedman with a laser ring Sagnac device using a CCD-heterodyne amplifier. This device allows for measuring frequencies and is based upon the spectroscopic devices.

A computerized system delivers the frequency although a conventional spectroscope delivers a line position. It shall be noticed that a CCD-heterodyne amplifier cannot measure a phase shift and that a phase shift can in no way causes a frequency shift. This is the result of the formulas for trigonometric combination.

2. Theoretical explanation of the frequency shift.

The signal delivered on the CCD by the Sagnac device is a sum of two trigonometric functions representing each light beam turning in the opposite directions within the device:

$$\cos(p) + \cos(q) = 2\ \cos\left(\frac{p+q}{2}\right)\cos\left(\frac{p-q}{2}\right)$$

where $p = \omega_1 t + \varphi_1$ and $q = \omega_2 t + \varphi_2$

The phase shift is measured through an interference fringes displacement. It may be measured only if $\omega_1 = \omega_2$

Nevertheless such fringes displacement may be observed even if there is a slight difference between both frequencies.

As the mirrors of the Sagnac device are moving a frequency shift should be observed as a result of the Doppler-Fizeau effect. They move in opposite directions so that the frequency shift is also opposite for each light beam. The combination of the light beams results in a frequency shift proportional to the number of mirrors and to the angular speed of the Sagnac device.

Within an optic fibre light propagate by a succession of reflections on the wall. The Doppler-Fizeau effect appears at each reflection because the walls of the fibres are moving with the fibre.

This effect is explained without any additional hypothesis by the Special Relativity theory.

It is also fully in line within the Sagnac hypothesis involving an ether fixed with regards to the laboratory.

Reference: ***http://www.ringlaser.org.nz/content/e_prof_geoff_stedman.php***