Optical "gyroscopes"

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At present, there are several approaches to the measurement of inertial rotation by optical means that are under active consideration.[1] All the approaches are based on the Sagnac effect which predicts a non-reciprocal phase shift, $\Delta\phi$, along a closed path that is proportional to inertial rotation and is given by

$$\Delta\phi = \frac{8\pi A}{\lambda c}\Omega$$

where A is the area enclosed by the path; λ is the wavelength of the light; c is the velocity of light; and Ω is the component of inertial rotation perpendicular to the plane of the path.

For example, in order to measure earth rotation (approximately 10^{-4} radians/second) with an area of 100 cm^2 and $\lambda = 6328$ Å, one must detect a non-reciprocal phase shift of about 10^{-7} radians. It should be noted that for navigation and geophysics applications it is necessary to detect much smaller rotations, in the range 10^{-3} to 10^{-10} of earth rate.

To measure small phase shifts researchers have utilized active methods such as ring lasers, and more recently passive techniques such as ring resonators and multi-turn fiber-optic interferometers.

The paper will emphasize the fundamental limitations in the approaches taken so far, and discuss the various practical difficulties that must be overcome to reach the fundamental limits. Applications of optical gyroscopes to navigation, geophysics and relativity will be discussed.

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References

[1] "Laser Inertial Rotation Sensors", Editors: S. Ezekiel and G. E. Knausenberger, Society of Photo-Optical Instrumentation Engineers Volume 157, 1978.

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目前有好几种用光学方法测量转动惯量的方法在积极研究之中。所有这些方法均基于Sagnac效应，这个效应告诉我们，将有一个不可逆的、沿着闭合回路的、并与惯性转动成正比的位相改变 $\Delta\phi$：$\Delta\phi=\frac{8\pi A}{\lambda c}\Omega$，式中A是回路所围的面积；$\lambda$是光的波长；c是光速；$\Omega$是垂直于回路平面的惯性转动分量。

例如，为了测量地球的转动(大约为10^{-4}弧度/秒)，对于回路面积100厘米^{2}和$\lambda=6328$埃来说，人们必须检测大约10^{-7}弧度的不可逆相移。还应该注意到，对于导航和地球物理学应用来说，必须检测小得多的转动，是地球转速的10^{-3}到10^{-10}。

为了测量微小的位相改变，研究人员已经采用了许多主动方法，例如环形激光器，最近还采用了环形谐振器和多匝光纤干涉仪等被动技术。

本报告将着重说明迄今为止所采用的各种方法的主要限制，并讨论要达到这些基本极限所必须克服的各种实际困难，还得讨论光学陀螺在导航、地球物理学和相对论方面的应用。

这项工作是由空军地球物理实验室和军种联合电子学计划支持的。