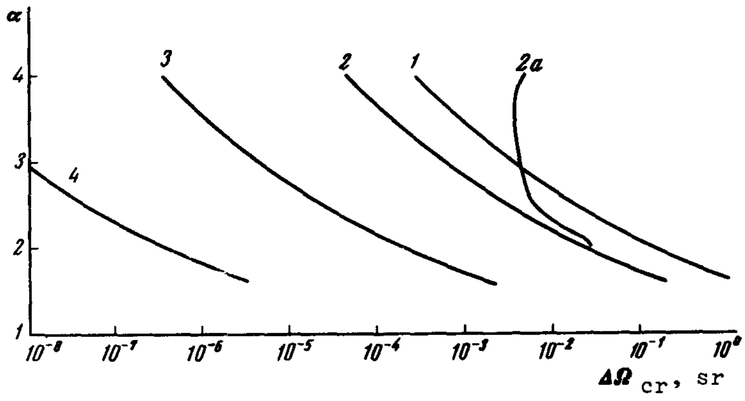

Fig. 2

for $\Delta\Omega_{cr}$ the expression

$$\Delta\Omega_{cr} = 2\pi\left[1 - \cos\left(\frac{2\epsilon f(a)\,\mathrm{tg}\,\frac{\theta}{2}}{f(a) - a\dfrac{\partial f(a)}{\partial a}}\right)\right]. \tag{13}$$

A curve of this type, delimiting the region of apertures, is also given in Fig. 2 (curve 2a) for a scattering angle $\theta = 90°$ and $\epsilon = 0.1$.

The calculation shows that the critical values of $\Delta\Omega$ are much lower than the observation angles usually encountered in experiments. This in particular may explain why the temperatures calculated from the characteristics of the spectra are much higher than expected [2 - 4].

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SHIFT OF LIGHT FREQUENCY IN AN ACCELERATED ROTATING RING LASER

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Submitted 25 April 1968
ZhETF Pis'ma 7, No. 12, 497-498 (20 June 1968)

The generation of a ring laser is made up of two waves traveling in opposite directions, whose frequencies ν_1 and ν_2 become equal when the laser is rotated. The relative frequency shift $(\nu_2 - \nu_1)/\nu$ can be measured accurate to 10^{-15}. Indeed, the technical frequency fluctuations connected with vibrations of the resonator mirrors, the pump power, etc. are correlated in both waves, and drop out when the frequencies are subtracted. The accuracy with which $\nu_1 - \nu_2$ is measured, which is determined in this case only by the natural line width and amounts to $\leq$ 1 Hz, makes it possible to observe the change of the energy of a photon in a gravitational field or in an accelerated coordinate system. Such a measurement accuracy was heretofore available only in the Mossbauer effect.

Let us consider the propagation of two oppositely traveling waves in an accelerated rotating ring laser. According to the equivalence principle, it is possible to go over from the accelerated moving system to a system without acceleration by introducing a definite gravitational field. In our case the field intensity g will be numerically equal to $R\beta$ (R is the radius of the circle along which the light rays propagate and β is the angular acceleration of the laser), and is tangent to the circle at each point. The frequency of the wave, in the coordinate frame connected with the laser, increases or decreases, depending on whether the field propagates with or against the field. Since one of the traveling waves propagates along g and the other in the opposite direction, their frequencies ν_1 and ν_2 will differ, and a difference Ω, proportional to the field intensity g, appears against the background of the Doppler shift usually observed in a ring laser. Let us find the value of Ω, assuming for simplicity that the acceleration g is constant. The change of the energy $h\Delta\nu$ of the induced photon is determined by the expression $\hbar\Delta\nu = \pm mgH$ ($m = \hbar\nu/c^2$ is the photon "mass," H is the path covered by the photon in the field during its mean lifetime in the resonator, and c is the speed of light). This expression is the consequence of the formula $\hbar\Delta\nu = \hbar\nu[(\phi_1 - \phi_2)/c^2]$ for the red shift (see, e.g., [1]) of light propagating in a gravitational field between points with potentials ϕ_1 and ϕ_2. Thus, when $g \neq 0$ the frequency of the photons in the wave, which is equal to ν in the absence of g, changes by an amount $\Delta\nu = \pm (\nu/c^2)gH$; accordingly, the difference of the frequencies of the traveling waves is

$$\Omega = 2|\Delta\nu| = 2\frac{\nu}{c^2}2\pi Rng, \tag{1}$$

where $n = H/2\pi R$ is the average number of the photon revolutions during its lifetime in the resonator. (Actually Ω is the frequency whose intensity $I(\omega) \sim \omega\exp(-\omega/\Omega)$ is maximal in the spectrum of the beat frequencies that arise if the photons are assumed to escape from the resonator in accordance with the law $\exp(-t/\tau)$ rather than have an average lifetime $\tau = H/c$ in the resonator). Let us estimate the value of Ω. For a typical ring laser ($\nu = 10^{15}$ Hz, $R = 10^2$ cm, $N = 100$) and for g equal to free-fall acceleration ($g \approx 10^3$ cm/sec^2) we get $\Omega = 250$ Hz, which can be readily measured with an absolute accuracy of 5 Hz.

[1] L. D. Landau and E. M. Lifshitz, Teoriya polya, M., 1967 [Classical Theory of Fields, Addison-Wesley, 1962].

ERRATUM

Article by V. S. Letokhov, Vol. 7, No. 9, p. 272

The figures on p. 274 should be interchanged, but the figure captions should remain in place.