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MICHELSON INTERFEROMETER USED AS A TUNABLE MIRROR IN LASER RESONATORS

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The Michelson interferometer can be regarded as a tunable mirror, whose reflecting ability and transmission depend on the difference in the optical lengths of the interferometer arms and on the wavelength. When one of the reflecting mirrors of a laser is replaced by the interferometer, internal modulation of the initial intensity is obtained.

THE Michelson interferometer can be regarded as a tunable mirror with complex reflection coefficient R_a and transmission coefficient T_a. The absolute values of R_a and T_a are expressed in the following form:

$$|R_a| = R_1T_0^2 + R_2R_0^2 + 2R_0T_0\sqrt{R_1R_2}\cos\frac{4\pi}{\lambda_a}(d_2 - d_1),$$

$$|T_a| = 1 - |R_a|,$$

where R_0 is the reflection coefficient and T_0 is the transmission coefficient (with respect to intensity) of the splitting mirror at the wavelength λ_a; R_1 and R_2 are the reflection coefficients of the interferometer mirrors, and $d_2 - d_1$ is the difference in the optical lengths of the arms. Assuming "quasi-lossless" splitting of the beam (reflection from the air-glass interface or from dielectric mirrors), we obtain $T_0 \approx (1 - R_0)$, and thus

$$|R_a| \cong R_1(1 - R_0)^2 + R_2R_0^2 + 2R_0(1 - R_0)\sqrt{R_1R_2}\cos\frac{4\pi}{\lambda_a}(d_2 - d_1).$$

This means that, neglecting the phase shift, when the arm-length difference $d_2 - d_1$ changes by $\lambda_a/2$ the reflection varies sinusoidally between the maximum and minimum values.

The reflecting ability of the interferometer for another wavelength λ_b will be different, and it can be chosen to be small even in the case when broadband mirrors are used. By suitable choice it is possible to make the reflecting ability maximal for a definite wavelength λ_a and simultaneously suppress for all other wavelengths.

We used this method in experiments with a cavity for a He-Ne laser operating at λ = 6.328 Å (see Fig. 1). The laser was fed with dc. The splitting mirror was an uncoated quartz plate 3 mm thick with n = 1.4675, placed in the cavity

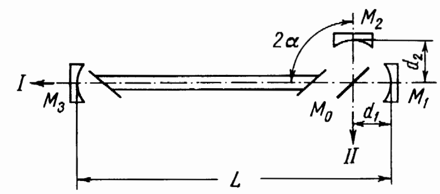

FIG. 1

at an angle 2α = 93°. The coefficient of reflection from the air-quartz interface was R_0 = 0.055. The radius of curvature of the resonator mirrors was r = 500 mm, and the reflection coefficients were R_1 = 0.985, R_2 = 0.974, and R_3 = 0.980. The interferometer armlengths were $d_1 = d_2$ = 40 mm and the resonator length was L = 540 mm.

If the mirrors M_1 and M_2 are mounted perpendicular to the resonator axis, then the output intensity of the laser in direction I experiences a large depth of modulation when the mirror M_2 is moved[1)] (see the left side of Fig. 2). (The output signal was measured also in the direction II (Fig. 1), but here its amplitude was not constant.) When the diffraction loss is increased by slightly tilting the mirror M_3, the reflection is reduced and total modulation is attained (see the right side of Fig. 2).

Part of the light emerging from the resonator in the direction II can also be reflected back into the cavity with the aid of a fourth mirror; in this case the expression for the resultant reflection coefficient assumes a complicated form.

The foregoing method is useful for feedback control and for intensity stabilization, in investigations of dynamic processes induced by a laser, in measurements of the cavity losses, in measure-

[1)]The position of the mirror M_2 is varied either mechanically or, in the case of a large repetition rate, by piezoelectric means.

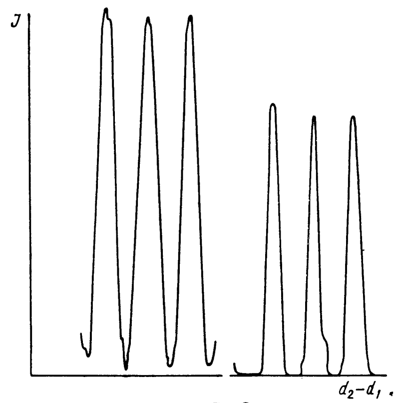

FIG. 2

ments of gain saturation without moving the cavity or changing the excitation, and also in elimination of undesirable laser operation at other wavelengths or at undesirable axial modes. We are now getting ready for measurements of this type.

A recent paper by Smith[1] describes a setup which at first glance is similar but actually is different, in which a Fabry-Perot interferometer is used for internal modulation.

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[1] P. W. Smith, IEEE, J. Quantum Electronics 1, 343 (1965).

Translated by J. G. Adashko
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