same model of polydispersive cylinders as considered by Liou in Fig. 8 of Ref. 4, namely, elevation angle $\epsilon = 60°$, wavelength $\lambda = 0.7\ \mu m$, mode radius $a_m = 4\ \mu m$, and refractive index $m = 1.310$. The phase functions $P(\Theta,\Phi)$ are not normalized and are shown as a function of the scattering angle Θ in different Φ-planes. The azimuthally averaged phase function is also shown by the solid line. One of the prominent differences between the present phase function and Liou's phase function is observed in the backward scattering regions. The backscattering is much more intense than Liou's phase function, and it comes from the direct backscattering by cylinders with $\beta^* = \pi/2$ (or $\zeta = \pi/2$) and $\phi = \pi$.

Finally, the author would like to correct a few typographical errors in the paper[1]: (1) $\epsilon = 30°$ in the fourth line in the right-hand column in p. 1391 should be $\epsilon = 45°$; (2) the right-hand side of the first equation in Eqs. (5) should be $\pi - \theta(\beta)$; (3) Ref. 10 should read Y. Takano and S. Asano, J. Meteorol. Soc. Jpn. **61,** 289 (1983); (4) Ref. 20 should read S. Asano, J. Meteorol. Soc. Jpn. **61,** 402 (1983).

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5. Equation (1) can be derived from Eq. (9) in Ref. 3 together with Eqs. (1) and (2) in Ref. 1 and the condition $\theta = \zeta$.
6. The author wishes to thank Y. Takano (Tohoku U.) for providing the computer program of the light scattering by an infinitely long circular cylinder.

Intracavity power measurement by Rayleigh scattering

Lloyd W. Hillman, Jerzy Krasinski, John A. Yeazell, and C. R. Stroud, Jr.

University of Rochester, Institute of Optics, Rochester, New York 14627.

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Accurate measurement of intracavity laser power is a necessity in the study of intracavity nonlinear interactions, intracavity saturation spectroscopy,[1] and intracavity harmonic generation.[2] In this Letter, a method for this measurement is described which may offer major advantages over the usual methods.

The method was devised to solve the problem of measuring intracavity laser power in a high-Q laser cavity. Indirect measurement of the intracavity power, i.e., measurement of the power transmitted through the end mirrors, in a cavity of this type makes measurement of their losses and transmittance difficult. Furthermore, the transmittance may vary greatly over the surface due to mirror damage or dust. Direct measurement, insertion of a measuring device directly in the cavity, usually degrades the Q of the cavity. Even a thin glass plate inserted at the Brewster angle can cause substantial losses. In such a cavity one form of loss is always present which couples out a constant fraction of laser power: Rayleigh scattering from air. The scattered power is easily measured even for modest laser powers.

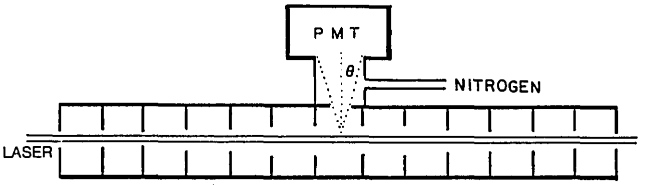

Fig. 1. Longitudinal cross section of apparatus indicating the path of the laser beam, the location of the baffles, and the photomultiplier.

We have constructed a simple apparatus to measure this scattered power and thus determine the intracavity power in a high-Q laser cavity. The apparatus is illustrated in Fig. 1. The laser beam, whose power is to be measured, passes through a series of baffles to eliminate all extraneous scattered light. In the central chamber the scattered light is measured using a photomultiplier. The apparatus is purged with nitrogen to eliminate scattering from dust particles.

The apparatus can be calibrated absolutely using the well-known formulas of Rayleigh scattering (see, for example, the book by Fabelinskii[3]). However, due to the difficulty of determining the collection efficiency of the detection system it is easier and more accurate to simply calibrate the system using a beam of known power. We carried out such a calibration using a laser beam with power of 100 mW and a wavelength of 5980 Å. With a collection angle θ of 17° and an RCA 1P21 photomultiplier operating at 600 V, we obtained a current of 0.014 μA. Clearly, much lower powers could be measured without difficulty.

It should be noted that two properties of Rayleigh scattering are important in making these measurements. First, the scattered power depends on the angle between the polarization vector of the incident beam and the detector according to the familiar $\cos^2\theta$ law. Second, the scattering cross section scales as the fourth power of the wavelength. One can scale the calibration to take these factors into account or, in the case of a high-Q laser cavity, use the transmitted laser beam which can be measured directly for calibration.

The apparatus has some highly desirable properties. It works with both narrowband and broadband beams; it operates over a large range of powers including high powers where the breakdown of the air is the limiting factor. Its primary advantage is that it makes the measurement without introducing additional losses.

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