ends of the fibers are carefully cleaved with a fresh razor blade to achieve maximum light transmittance. Proper cleaving is crucial. The fibers are aimed at a quartz or sapphire disk whose opposite face is coated with a thin (100–200 Å) semitransparent zinc film, which acts as the photoemitter. To achieve good electrical contact to the zinc, the edges are overcoated with thick gold electrodes, also shown in Fig. 1. There are no additional electrical connections since the zinc now forms part of the top plate electrode of the cell. (The zinc films should be kept in an inert atmosphere since their photoefficiency degrades upon oxidation.) The gun is energized by focusing the light from a 1000-W xenon-mercury arc lamp into the end of the fiber bundle at room temperature, and biasing the emitter a few volts negative relative to the lower plate electrode. The total length of fiber is typically ∼10 feet.

We tested the source under normal operating conditions ($T \approx 1$ K) and found it easy to achieve currents of a few picoamps. The helium surface was charged to electron densities of $10^7/\text{cm}^2$ in a few seconds. With the cell filled with roughly 10 cm^3 of liquid, slight heating was observed. This problem could be surmounted with a filter at room temperature, since most power is poured into unwanted visible light. Since the photoemitter is, under equilibrium conditions, covered by a helium film several hundred angstroms thick, it is possible that electrons might be trapped in bubble states beneath the film surface. For the biasing voltages used in our experiments, the trapping time would be < 1 s.[3] However, it may be that some of the light energy heats the emitter sufficiently to locally burn off the film during emission.

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Simple scanner for measuring laser beam size

D. P. Shelton

Department of Physics, University of Toronto, Toronto, Ontario, Canada M5S 1A7

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A simple and inexpensive device for measuring the spot size of a laser beam is described. The device is constructed from a clock motor and scans wires of various diameter through the beam. It is most useful for beams of about 0.1 to 2 mm diameter.

The apparatus described here is designed to measure the spot size of laser beams such as those typically obtained from cw gas lasers. The diameter of such a laser beam is of order 1 mm, and the intensity distribution is usually described by a lowest-order (TEM_{00}) Gaussian mode.[1] When weakly focused, the spot size will be of order 0.1 mm. There are commercial devices available for measuring laser beam profiles, but they are expensive or cannot survive a focused beam of a few watts. The device described below is both inexpensive and robust, and will allow rapid measurements of moderate accuracy.

The construction of the scanner is illustrated in Fig. 1. The main component is the synchronous motor of a household clock. The rotor of the motor has the form of a shallow, flat-bottom cup. The scanning wires and a counterweight are affixed to the flat face of the rotor near the rim with epoxy cement. The motor is mounted tilted up at an angle of about 30°, on a suitable bracket which is in turn attached to a standard optics mounting post. Tilting the motor ensures that the wires make only a single pass through the beam for each revolution of the rotor. Wires of several diameters are used so that a range of beam sizes may be accurately measured. The finest wire cannot simply be supported at one end, but must be held taut by a bow, conveniently made from piano wire, and also serving as the intermediate diameter scanning obstacle. Drill rod is suitable for the largest size obstacle.

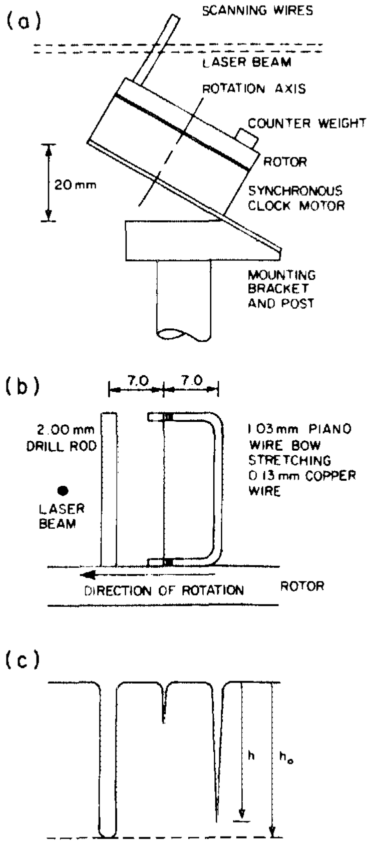

FIG. 1. Construction and operation of the beam scanner. The side view of the scanner is shown in (a), while the details of the scanning wires are shown in (b), viewed along the direction of travel of the laser beam. Dimensions are in mm. A typical oscilloscope trace, as three wires scan through a laser beam, is shown in (c). The detector output drops each time a wire obstructs the beam. The fractional depth of the dip is $T = h/h_0$.

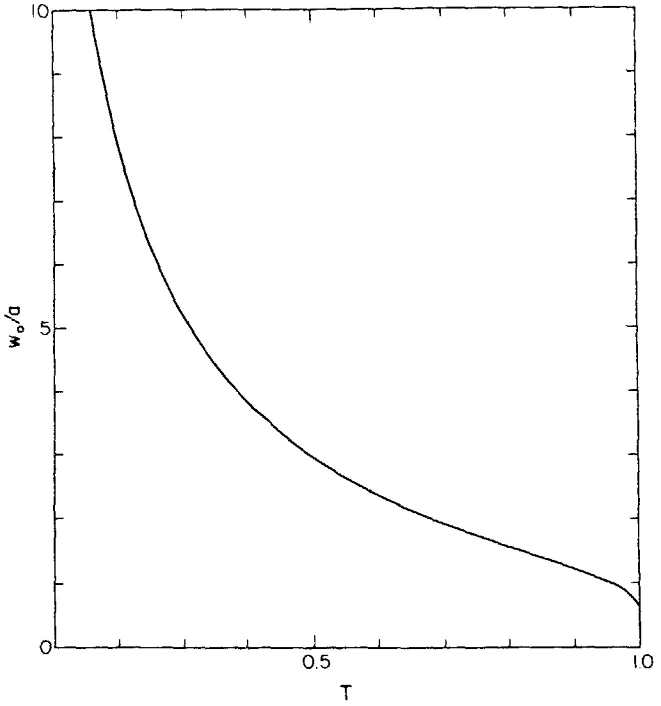

FIG. 2. The relation giving the beam radius as a function of the fractional depth of dip T is graphed. The beam radius w_0 is expressed in units of the obstructing wire radius a.

The wires should be mounted as parallel to each other as possible.

The scanner is used in conjunction with a detector placed in the laser beam after the scanner, and the detector output is displayed on an oscilloscope. The trace obtained by scanning a beam of about 1 mm diameter is depicted in Fig. 1(c). For a Gaussian laser beam the simplest means for determining the beam spot size involves measuring the fractional depth of the dip, $T = h/h_0$ [see Fig. 1(c)], as a wire passes through the beam. (T is also the transmission of a slit of the same width as the wire.) The beam waist may be located by translating the scanner to find the position where the depth of the dip is maximal. The spot radius w_0 of the Gaussian intensity profile

$$I(r) = (2\pi)^{-1} \exp[-2(r/w_0)^2] \tag{1}$$

may be determined from a measurement of $T = h/h_0$ through the relation

$$T(w_0/a) = 2F(2a/w_0) - 1, \tag{2}$$

where the function

$$F(x) = (2\pi)^{-1/2} \int_{-\infty}^{x} dt \exp(-t^2/2) \tag{3}$$

is given in tables,[2] and where $2a$ is the wire diameter. The function w_0/a vs T is plotted in Fig. 2. This method is most sensitive when the laser spot size is a few times the wire size, and requires the beam profile to be Gaussian. Note that scanning a wire across a Gaussian beam [Eq. (1)] gives a Gaussian profile because of separability [i.e., $\exp(-r^2) = \exp(-x^2)$ $\exp(-y^2)$].

An alternative measurement technique, which does not require assumptions about the intensity profile, is based on the width of the dips displayed on the oscilloscope screen. The spacing between dips on the screen calibrates the width of the dips since the spacing between the wires is known. Thus, the apparent width of the beam may be read directly from the screen. The apparent beam width is of course broader than the true width because of the finite width of the wire. If the beam radius is a few times larger than that of the wire, and if the apparent beam radius w_0' is measured at $1/e^2$ of the maximum depth of the dip for a Gaussian beam, then the deconvolved radius w_0 is approximately given by

$$(w_0/a) \doteq (w_0'/a)[1 - (w_0/a)^{-2}]. \tag{4}$$

In principle, the best results for this method are obtained by using the finest possible scanning wire, but in practice there is a limit. With too fine a wire the dip becomes small compared to the noise from the unobstructed laser beam. A scanning slit would remove this inherent difficulty but would not be as simple and cheap to implement.

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