# The Elastic and Photoelastic Constants of Fused Quartz

K. VEDAM
*Department of Physics, Indian Institute of Science, Bangalore, India*
March 27, 1950

EVEN though numerous investigations have been carried out on the various physical properties of fused quartz, the only known work on its photoelastic properties is that of Heymans and Williams,[1] who have determined the value of $(p-q)$ from bending experiments on a bar of fused silica, $p$ and $q$ being Neumann's strain-optical constants. In the present investigation the absolute values of $p$ and $q$ have been determined, and the results obtained are given below. The details of the method adopted will be published elsewhere.[2] The specimen studied was obtained from the Thermal Syndicate Ltd., England, and was in the form of a rectangular block of dimensions $2.7 \times 1.6 \times 0.85$ cm.

The elastic constants of fused quartz were determined by Hiedemann's method;[3] i.e., by observing the diffraction patterns produced by standing ultrasonic waves in the medium itself. Mueller[4] has shown that this method, with slight modifications, can be used to determine the value of $p/q$ for isotropic substances. Using incident light polarized at 45° to the sound wave front, the light diffracted by the longitudinal waves is viewed through an analyzer. Then the analyzer is rotated through an angle $\theta$, from the initial crossed position, to get the extinction of the first-order longitudinal pattern. By plotting the angle $\theta$ against the sound amplitude and extrapolating, it is possible to obtain "$\theta_{max}$" corresponding to zero amplitude, which is given by the relation [Eq. (25) of reference 4]

$$\tan(\theta_{max}+45°)=p/q.$$

By this method the value of $p/q$ for fused quartz was determined by the author and was found to be 2.85.

The value of $(p-q)$ was also determined by the well-known compression method[5] using a lever arrangement and a Fuess-Babinet compensator. The value of $(p-q)$ obtained by the author is equal to 0.135. This is about 50 percent too large, as compared with the value obtained by Heymans and Williams. However, repeated measurements have yielded consistently the same result within the limits of experimental error. As the original paper of Heymans and Williams dealing with this measurement was not available to the author, it is not possible to explain this discrepancy between the results. It is possible that the discrepancy may be due to the different natures of the specimens used.

The values of the Pockels' elasto-optic and piezo-optic constants of fused quartz calculated from the measured values of $p/q$, $(p-q)$, and the elastic constants are listed in Table I. All of the measurements were carried out using λ5893A.

TABLE I. Constants of fused quartz.

| | | |
|---|---|---|
| Density = 2.213 g/cc, $n_D = 1.4585$ | | |
| Young's modulus = $7.445 \times 10^{11}$ dynes/cm² | | |
| Modulus of rigidity = $3.195 \times 10^{11}$ dynes/cm² | | |
| $p = 0.208$ | $p_{11} = 0.100$ | $q_{11} = 0.078 \times 10^{-13}$ |
| $q = 0.073$ | $p_{12} = 0.285$ | $q_{12} = 2.98 \times 10^{-13}$ |
| (a pressure of 1 dyne/cm² is taken as the unit of stress) | | |

It is seen on comparison with the corresponding values for the various silicate glasses,[2] that the values of $p/q$ and $(p-q)$ are maximum for the vitreous silica. The addition of metallic oxides has the effect of reducing the value of $(p-q)$ and thus the birefringence produced by any fixed stress.

In conclusion the author wishes to express his indebtedness to Professor R. S. Krishnan for his kind interest and guidance during the progress of the above work.

1 Heymans and Williams, J. Math. Phys. Mass. Inst. Tech. **2**, 216 (1923).
2 Vedam, Proc. Ind. Acad. Sci. (to be published).
3 Heidemann, Naturwiss. **24**, 60 (1936).
4 Mueller, Zeits. f. Krist. (A) **99**, 122 (1938).
5 Pockels, Ann. d. Physik (4) **7**, 745 (1902).