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DATA SHEET 703

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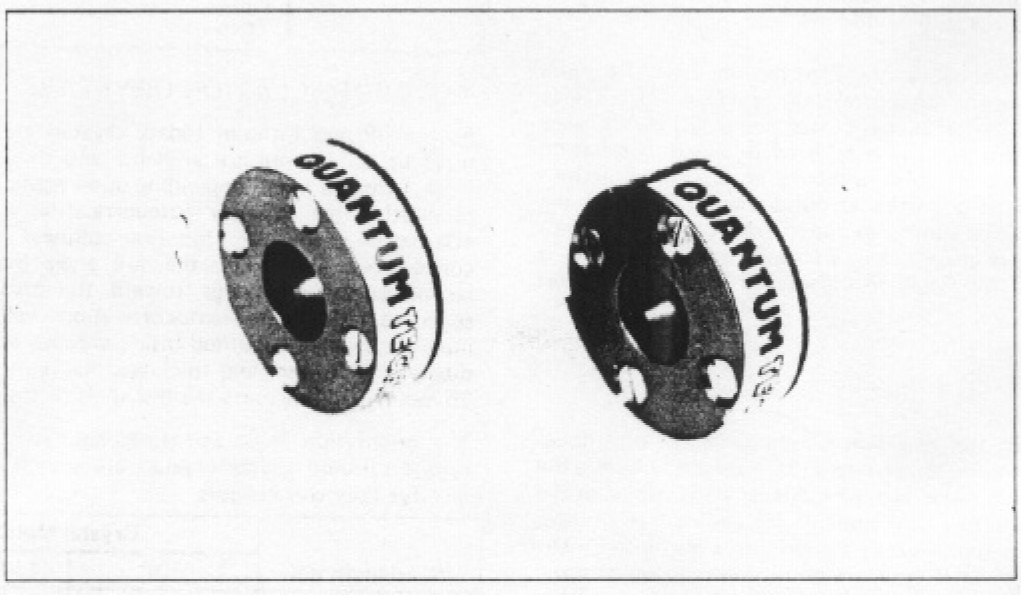
AUTOCORRELATION CRYSTALS and CELLS



FEATURES

- Crystals of KDP or $LiIO_3$
- Picosecond Pulse Widths
- Thin Crystal Cells
- Cost-Effective Design

INTRODUCTION:

The narrow pulse widths of a synchronously pumped dye laser are beyond the resolution of even the fastest detectors such as avalanche photodiodes. Although these pulses can be measured in real time using expensive streak camera, the most convenient and cost effective measurement is carried out by the use of second harmonic generation (SHG). For this purpose, the two most popular crystals are KDP and Lithium Iodate.

The autocorrelation method was first described by Maier, Kaiser and Giordmaine.[1] Ippen and Shank[2] used this autocorrelation scheme to determine the width of picosecond pulses. In one arrangement, the pulse train from the laser is divided into two beams by a beam splitter. The two beams then follow different paths in a modified interferometer and emerge parallel but not quite collinear. Unless the two arms are equal, one pulse will be delayed with respect to the other. The recombined pulses are then focussed into a phase matched SHG crystal and its output is detected by a photomultiplier tube. Since the efficiency of SHG is proportional to the square of the instantaneous intensity, the SH signal is higher when the two pulses overlap than when they are separate. Therefore a plot of the SH signal vs delay gives the non-linear correlation function which consists of a sharp peak centered at zero delay and superimposed on a constant background. The peak results from the enhanced SHG efficiency due to the pulse overlap.

This measurement does not directly describe the pulse shape but rather the autocorrelation function G (τ) due to the overlap of two identical pulses. This SHG device used expressly for this purpose is referred to as autocorrelation device. The ratio of pulse-width to correlation-function-width is fixed for a particular pulse shape. Therefore the actual pulse width can be extrapolated from the width of non-linear correlation scan. For example, this ratio is 0.707 and 1.0 for Gaussian pulses and rectangular pulses respectively.

COLLINEAR SCHEME:

In earlier work the two pulses arrived at the non-linear crystal along the collinear paths. In the later scheme, the pulses are not collinear but are focussed to converge on the crystal from different directions. In the collinear technique, the pulses from the dye laser are fed into a Michelson interferometer. Each pulse is separated into two pulses of equal intensity which travel up and down the two arms of the interferometer and recombine at the beam splitter. A time delay is introduced between the two beams by moving one of the mirrors. The SH output is detected after filtering the fundamental. Although this technique is very simple, it has two disadvantages. First, it requires a filter for fundamental beam from the collinear SH output. Second, and more important, each beam will generate a background level of second harmonic even if the beams are totally separated in time.

If the beams are orthogonally polarized and the SH is generated by a type II KDP crystal then the background can be eliminated. KDP type II autocorrelation device can be angle-tuned at fundamental wavelengths longer than 731.2 nm as compared to 517 nm for type I KDP device.

NON-COLLINEAR SCHEME:

This eliminates the two disadvantages of collinear scheme. In this case, the flat mirrors in the Michelson interferometer are replaced by retroreflecting corner cubes. The output of the interferometer consists of two parallel but non-collinear beams. The two beams are focussed into a non-linear crystal phase-matched at a direction along the bisector of the angle formed by the two primary beams, and the second harmonic is detected in the same direction. A scan of the output intensity vs corner cube displacement generates a correlation curve but without the D.C. background. The non-collinear scheme is shown in Fig. 1.

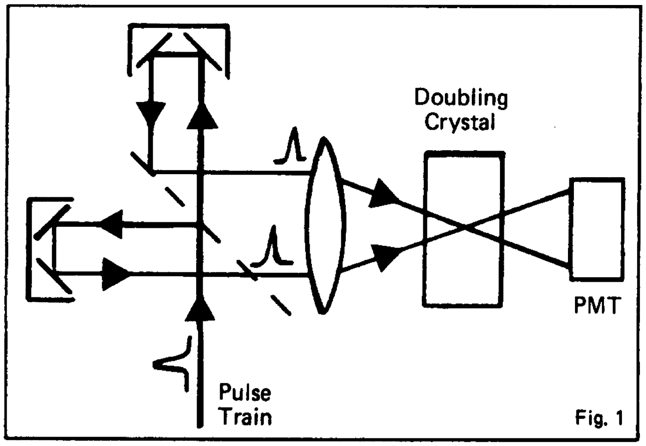


Fig. 1

AUTOCORRELATION CRYSTALS:

Both KDP and Lithium Iodate crystals are offered. Apertures up to 10 mm are available and thickness may vary from 1 mm to 5 mm depending upon application. Standard orientation for collinear autocorrelation is similar to SH orientation. However, for non-collinear technique, the convergence angle, i.e., the full angle between the two beams as they converge toward the crystal, should be specified. Complete autocorrelation cells with index matched crystals mounted inside are also available. Typical diameter is 25 mm and thickness may vary from 8 mm to 25 mm depending upon the thickness of the crystal.

The orientation angle and wavelength for type I KDP and type I Lithium Iodate crystals are shown in table I, for a few dye laser wavelengths.

Wavelength nm	Crystal Material	
	KDP	**Lithium Iodate**
517.4	90°	–
520	84°	–
550	70°	–
570	65°	–
600	60°	62.8°
670	52°	56°
700	49.7°	52°
750	47°	47°
800	44.7°	41.7°

REFERENCES

(1) Maier, Kaiser and Giordmaine: Phys. Rev. Letters 17, 1275, 1966.

(2) Ippen and Shank: Phys. Rev. Letter 27, 488, 1975.