DESIGN AND TEST OF A DEVICE FOR MEASURING PULSE DURATIONS BETWEEN 0.1 AND 100 ps.[†]

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A compact self contained "Femtometer" of 0.03 ps resolution providing in a single measurement both linear and non-linear autocorrelation function is described and demonstrated with pulses of 200 femtoseconds.

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A compact and accurate device designed for measurement of pulse waveforms of mode locked lasers by nonlinear autocorrelation methods is described. The instrument has a resolution of 0.03 ps. Its performance is demonstrated by the measurement of pulses of 0.2 ps duration. It is versatile, since it can be used to measure pulse duration by three different methods of nonlinear autocorrelation measurements. To perform an intensity autocorrelation measurement the pulse to be measured is split into two equal portions, and an optical delay is adjusted in the path of one of the beams. The two beams are thereafter recombined onto a nonlinear detection system (using either second harmonic generation -SHG- or two-photon fluorescence) which measures the intensity cross-correlation function[1]. In order to obtain a resolution of 0.03 ps, the delay is maintained uniform over the entire beam cross section and adjustable with an accuracy of 10 μm. For measurements of subpicosecond pulses, the optical delay can be positive or negative with respect to the fixed optical path. Instead of using independent mirror mounts and beam splitters (which would require a tedious alignment of 8 angular degrees of freedom with corresponding loss of stability) we designed a compact structure of glass prisms sintered together[2] as shown in Fig. 1. For any wavelength range, the frustrated total internal reflection interfaces can be set to exactly equal reflection and transmission by adjusting the pressure P (Fig. 1). This guarantees excellent fringe contrast for the autocorrelation measurement. The faces of all prisms are polished to $\lambda/10$ and the right angles cut with an accuracy of a few seconds

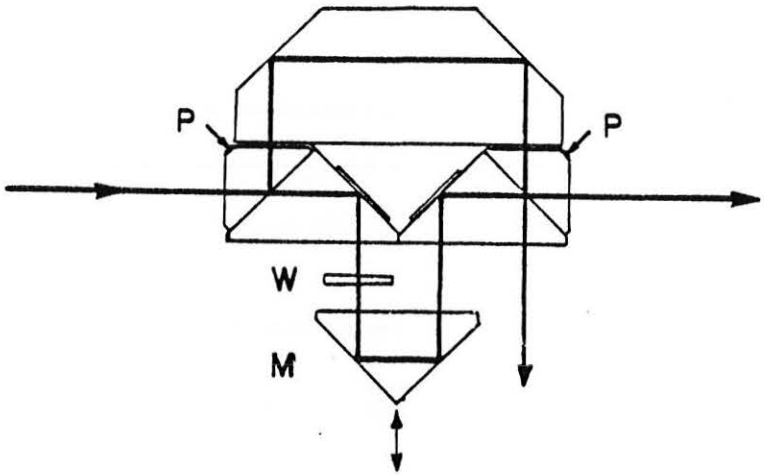

Figure 1: Top view of the prism assembly and the associated light paths.

of arc. The prisms of the fixed assembly are sintered together and glued on a support of the same type of glass. The movable prism M is mounted on a translation stage bolted to a tilt platform. The small cumulative error of the 90° cuts of the prisms is compensated by a small glass wedge W. Therefore, the only angular mechanical adjustment required is the tilt of the movable prism (M). The latter tilt is performed with one half second of arc accuracy by a reducing spring pivot assembly magnetically coupled to the outside of the sealed vacuum chamber containing the prism assembly. The parameter of the autocorrelation measurement, the optical path difference between the fixed prisms and prism M, can be set by adjusting the pressure of the gas in the region between the prisms. This changes the index of refraction along the path to adjust optical delays in the range 0 to 15 μm. The translation stage which supports prism M allows for delays in the range from 10 μm to 30 mm.

In autocorrelation measurement with type 1 (parallel polarization) second harmonic generation, the fine delay adjustment was used to determine the modulation depth of the interferences, yielding information on the electric field autocorrelation function, for various settings of the mechanical delay adjustment. A background free autocorrelation measurement can be made by inserting a $\lambda/2$ plate in the optical delay (next to the wedge W) and using a KDP crystal phase matched for type II SHG. The result of a third background free auto-

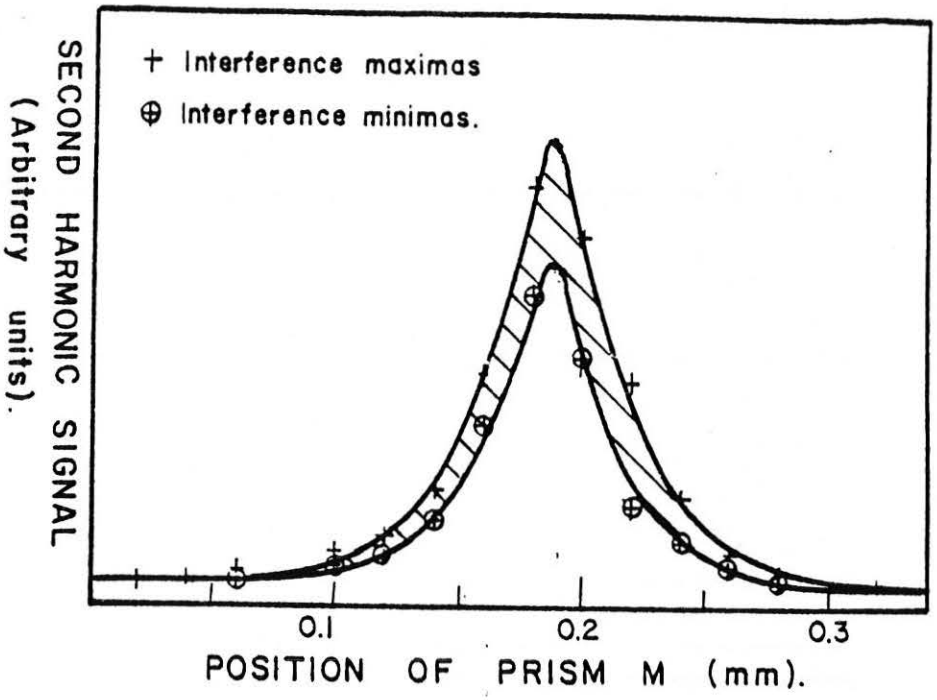

Figure 2

correlation method[1] is shown in Fig. 2. Prism M has been moved laterally to provide for 2 parallel output beams, which are then focused at a slight angle into a KDP crystal phase matched for type I SHG along the bissectrix. The small background observed in Fig. 2 is due to incomplete spatial filtering of the SHG of each individual beam. The FWHM of the autocorrelation curve shown in Fig. 2 is 0.34 ps, corresponding to a pulse duration between 0.22 and 0.24 ps.[1] For optimal adjustment of the laser parameters, an autocorrelation width of 0.30 ps was measured (corresponding to a pulse duration of 0.20 ps, assuming a Gaussian shape). It should be noted that the subpicosecond pulse durations measured with this device have to be corrected for the lengthening of the pulses caused by linear dispersion in the 11 cm of BK7 glass in each path.

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2. J.-C. Diels, Patent Anmeldung NbP. 2710 785.3, Germany (1977).
3. C.V. Shank and E.P. Ippen, Laser Focus 13 44 (1977).