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INFRARED SHORT PULSE MEASUREMENTS WITH TELLURIUM

E. H. HASELHOFF, R. J. M. BONNIE, G. J. ERNST and W. J. WITTEMAN
Department of Applied Physics, University of Twente, Enschede, The Netherlands

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Measurement of ultra short light pulses as generated by a mode-locked laser system, requires an overall detection bandwidth of more than 3 GHz. For the visible and the NIR, detection systems, capable of handling pulses in the order of several picoseconds, are available. In this regime nonlinear optical methods have proven to be very suitable. Especially in the visible region they have been very successful. The methods are based on either multi photon fluorescence or second harmonic generation. In the IR region the development of this technology is hampered by the lack of suitable nonlinear materials. A promising and relatively inexpensive technique—but not used anywhere—for background free measurements in the IR is based on second harmonic generation in Tellurium, using type II phase matching of noncollinear beams. The geometry at the crystal is schematically shown in Fig. 1.

A proper matching of the phase conditions is very sensitive with respect to the angle $\psi_0(\psi_0 = \pi - 2\psi)$ between the two fundamental beams and the exact orientation of the crystal, whose y-axis should coincide with the bisector of the angle between the incoming beams. A careful analysis of the geometry used and some vector calculus yield that for good operation the angle between the two fundamental beams should be within 0.2° from the theoretical value, which is a very stringent condition. However, it is fairly easy to meet these requirements by just rotating the crystal around the z-axis. In this way, a proper tuning of the angle between the fundamental beams and thus a proper phase matching is easily achieved. This is demonstrated in Figs 2 and 3.

In these figures, the squares represent experimental data, and the solid curves are the results of computer calculations. From Fig. 2 we see that a misalignment in ψ_0 of only 0.2° already yields a signal-drop of 80%. The tremendous effect caused by a mismatch of only 1.65° is easily compensated by rotation of the crystal around the z-axis over an angle γ of about 23°, as is demonstrated in Fig. 3.

Guided by these results, we constructed an autocorrelator of standard design, using a noncollinear setup. Using this device, we were able to measure pulses emerging from a mode-locked multi-atmosphere CO_2 laser. We fired the entire pulse train, thus measuring the averaged pulse length, weighted over the intensity of the individual pulses. The measured autocorrelation function

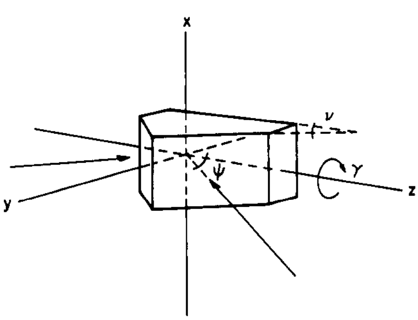

Fig. 1. Definition of crystal coordinate system.

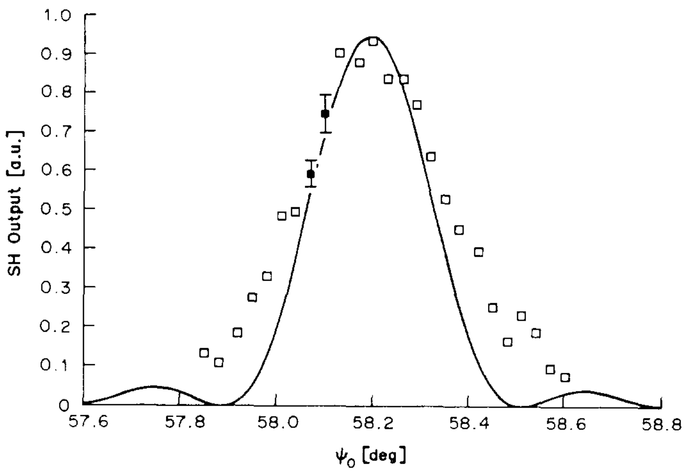

Fig. 2. Dependence of the second harmonic signal on the angle between the fundamental beams.

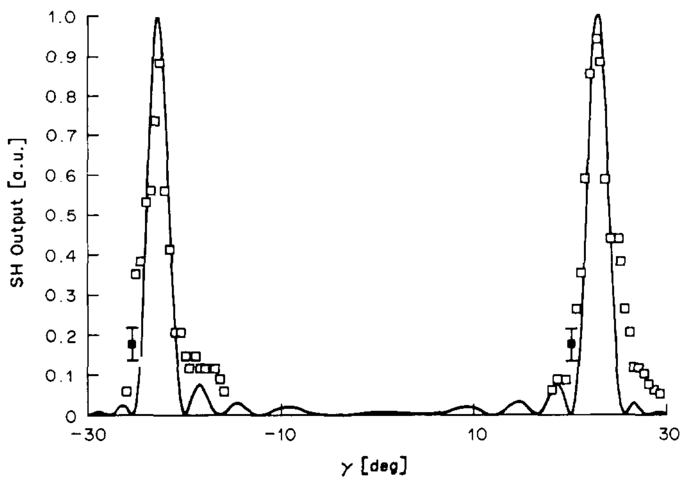

Fig. 3. Mismatch correlation by rotating the crystal over the angle γ.

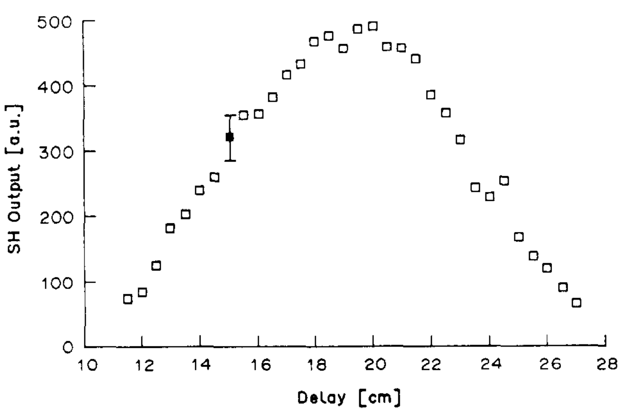

Fig. 4. Autocorrelation trace representing a Gaussian of 420 ps (FWHM).

of Fig. 4 represents a Gaussian having a FWHM of 420 ps. So far, we have measured pulses down to 300 ps (FWHM); the device itself is estimated to function well down to pulses of about 50 ps.

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