

Final report on the short visit project ‘Detection of THz radiation from bacteriorhodopsin’

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Host: Prof. Eberhard Riedle, Chair of BioMolecular Optics, Ludwig-Maximillan University, Munich, Germany

Duration: 14 days

Purpose of the visit:

Light-induced proton transfer processes in bacteriorhodopsin (bR) have been well studied by direct electric methods up to the ~ 300 GHz region (1,2). Recently the sudden electron polarization of the retinal chromophore and subsequent coherent vibrational phenomena were observed in the 20-50 THz range (3). On the other hand, the 0.3-20 THz region of charge movement is still completely uncovered due to lack of proper experimental approach, although functionally important molecular processes involving charge motions (relaxation of the excited state, isomerization, further coherent vibrations, early proton motions) are expected to take place in this range. The aim of the project started by this visit is to apply the recently developed techniques of THz spectroscopy for reducing the above unexplored area.

Work carried out during the visit:

The host institute is equipped with a 1 kHz amplified fs Ti:sapphire laser system (Clark-MXR CPA-2001) and a home-built NOPA generating ~ 100 fs pulses of $\sim 5 \mu\text{J}$ in the 470-1600 nm range.

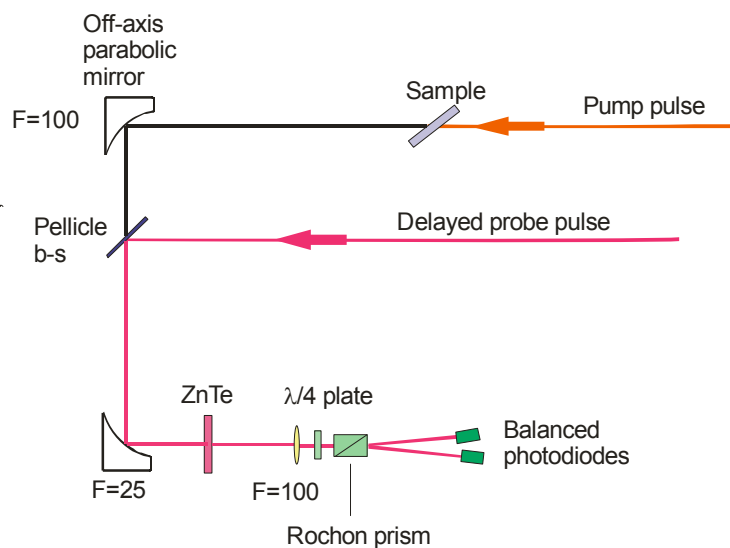


Fig. 1. Scheme of the THz detection set-up

The general scheme of the THz set-up we built up in the period of the visit is shown in Fig. 1. The pump pulse induces THz radiation from the sample. This is collimated by an off-axis parabolic mirror, then it is focused onto a ZnTe electro-optic sampling crystal by another parabolic mirror, having 4 times shorter focal length. The probe pulse monitors the birefringence taking place inside of the crystal created by the electric component of the THz field via Pockels effect. The change in the polarization is detected by the combination of a quarter-wave plate, a Rochon prism and a pair of balanced photodiodes.

To characterize the apparatus first a second ZnTe crystal was put in the place of sample and the 780 nm output of the amplifier was applied for both the pump and the probe beam. To study the THz radiation originated from bR we used a sample consisted of dried oriented purple membrane multilayers deposited onto a Si substrate. In this case the output of the NOPA tuned to 570 nm was served as pump.

A computer program based on a recently published protocol (4) was developed for the analysis of the THz signals.

Main results:

The construction, fundamental optimization and diagnostics of the THz spectroscopy set-up were mainly completed. A typical THz signal both generated from and detected by a ZnTe crystal is presented in Fig 2. That corresponds well to the published traces taken under similar conditions (4). Applying 3 scans the achieved signal to noise ratio was 100, which is quite

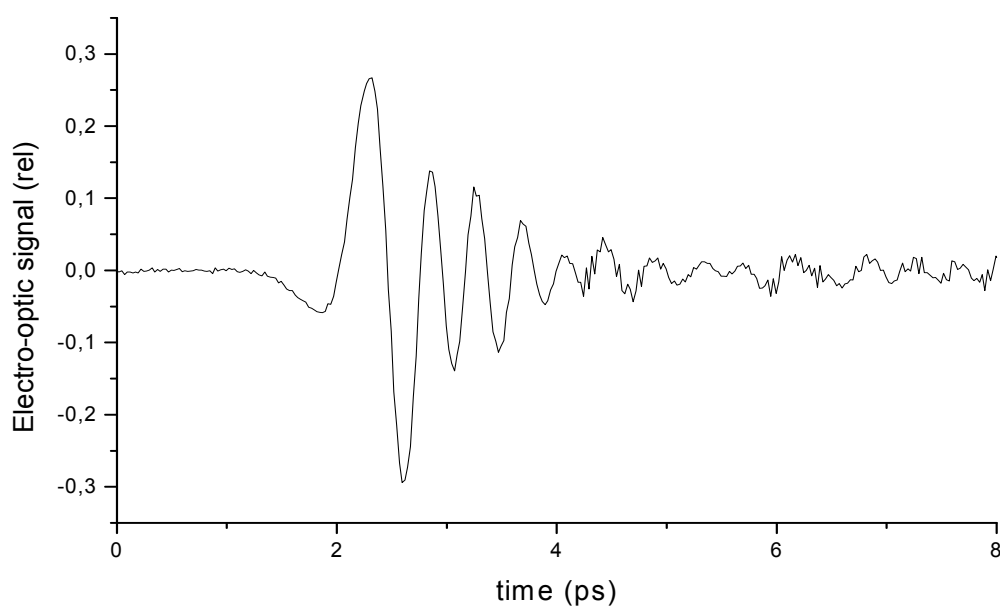


Fig. 2. THz signal from ZnTe crystal

well value for a low repetitions-rate system.

We also achieved preliminary results in detection of THz radiation from the bR sample as shown in Fig. 3. For this measurement we decreased the noise level by a factor of 10 by using a chopper to block every second pump pulse, and subtracting the signal value measured for the blocked case from the value measured when the pump was applied. Although the main

feature observable in the signal is well above the noise level, an extended period of work on is

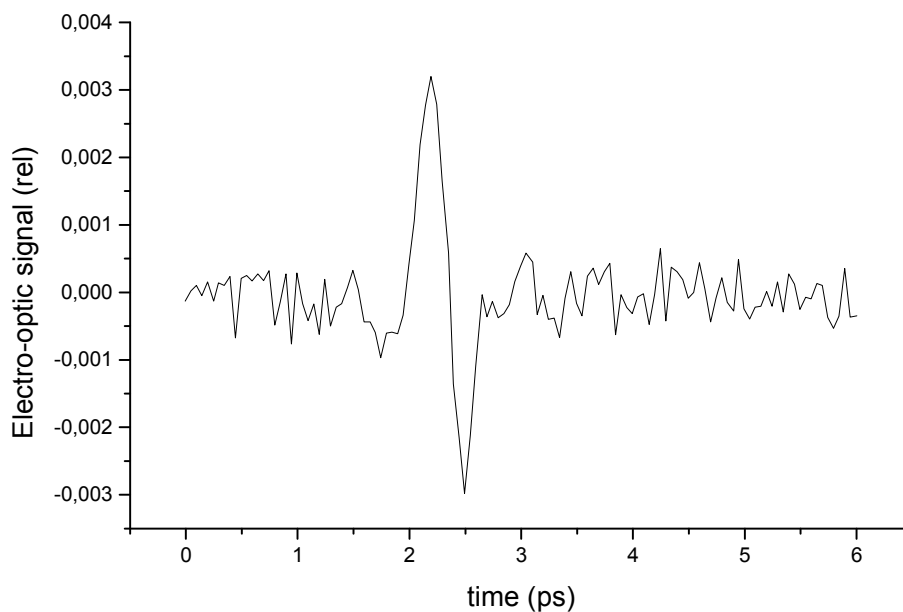


Fig. 3. THz signal from the bR sample

needed to optimize the circumstances of the measurement, exclude the possible artifacts and analyze the signals.

Future collaboration with the host institute:

This short visit has a very positive outcome and is considered as the beginning of a long-term collaboration among the laboratories of the visitors and the host institute in the above project. Further visits in the very near future are planned.

Other comments:

The results obtained during the visit are in early, unpublished state and required to handle as confidential.

Literature:

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3. Groma, G.I., Colonna, A., Lambry, J.-C., Petrich, J.W., Váró, G., Joffre, M., Vos, M.H., And Martin, J.-L. *Proc. Natl. Acad. Sci. USA*, 101:7971-7975 (2004)
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