Supplementary Information for Time resolved core level spectroscopy reveals light-induced structural changes in $GdTe_3$.

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1. Supplementary Information.

1.1. Pump-probe detection scheme.

Figure 1 shows the pump-probe detection scheme at the ALOISA beamline for an experiment using a 385.67 kHz optical pump. The synchrotron operates in a hybrid bunch filling mode, shown in grey and pink, where the pink pulses indicate the 1.157 MHz X-ray pulses to which the optical pump is synchronized. For each pump pulse, the analyzer detection window is triggered to record two probe pulses and one full multibunch.

Data acquisition was carried out by measuring the electrons emitted from the pumped X-ray pulse and from the X-ray pulse delayed by 864 ns, while discarding those emitted by the multibunch pulses (bunches separated by 2 ns that mainly contribute to the synchrotron current), as detailed in [1]. Thanks to the delay-line detector mounted on the analyzer, electrons originating from the single hybrid pulses can be unambiguously identified. Electrons emitted from the first probe pulse correspond to the pumped (excited) sample and are referred to as the pumped pulse, while those from the second probe pulse, detected at 864 ns delay, serve as a reference to correct for synchrotron beam intensity fluctuations and are referred to as the late delay reference pulses, resembling the unpumped condition. Measurements at 192.83 kHz were carried out using the same detection scheme, with the detection window synchronized to the pumped pulses.

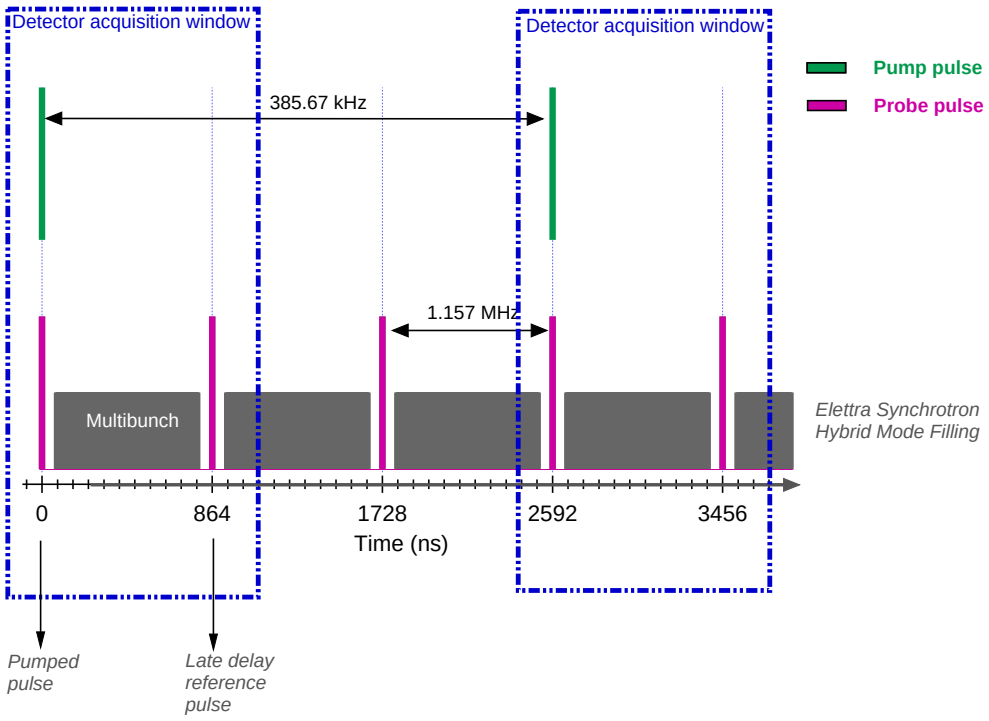

Figure 1: Detection scheme for X-ray/optical pump–probe experiments using a 385.67 kHz optical pump.

1.2. Echelon set-up characterization.

The pulse burst in the Echelon configuration was characterized by measuring two-photon photoemission from a 2H-$MoTe_2$ sample. The sample was excited with 250 nm pulses from an APE-Berlin Mango optical parametric amplifier and probed by the 515 nm pulses from the Echelon configuration. The delay between the beams is set by a mechanical delay line. The figure displays the photoemission measurements at the secondary cut-off of the 2H-$MoTe_2$ sample. The results indicate that the generated pulses are separated by 5.6 ps. The sample bias was set to 2.5 V, and the signal corresponds to the integrated intensity within the kinetic energy range of 4.2 eV to 5.4 eV.

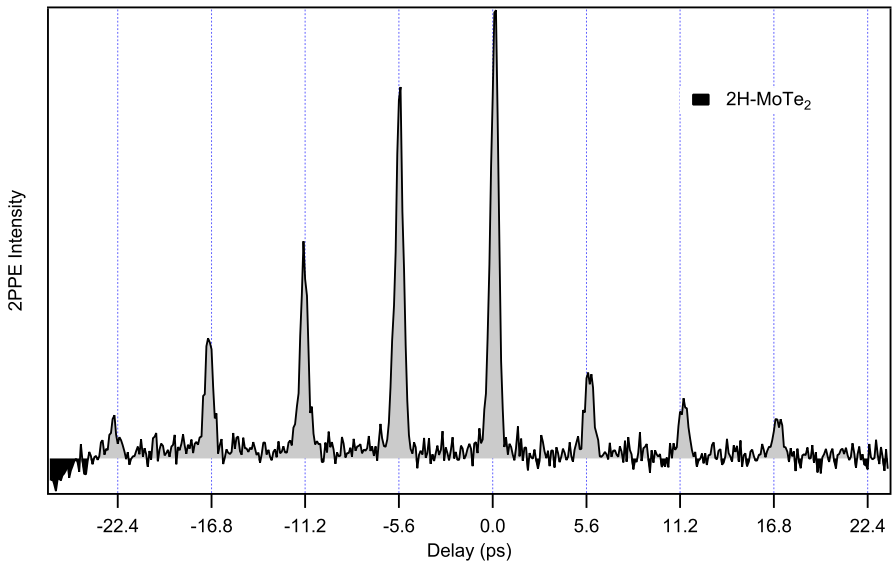

Figure 2: Photoemission Intensity at the secondary cut-off for a 2H-$MoTe_2$ sample measured with the Echelon confguration.

References

[1] Costantini R., Stredansky M., Cvetko D., Kladnik G., Verdini A., Sigalotti P., Cilento F., Salvador F., De Luisa A., Benedetti D., Floreano L., Morgante A., Cossaro A. & Dell'Angela M. ANCHOR-SUNDYN: A novel endstation for time resolved spectroscopy at the ALOISA beamline. *Journal Of Electron Spectroscopy And Related Phenomena.* **229**, 7-12 (2018), https://doi.org/10.1016/j.elspec.2018.09.005