Observation of Precursor-like Behaviour of Ultra-fast Pulses Propagating in Water

A. Fox[1], **U. Österberg**[1], **X. Gu**[2], **and R. Trebino**[2]

[1]Dartmouth College, USA
[2]Georgia Institute of Technology, USA

We have measured temporal, spectral and absorptive characteristics of broadband optical pulses around 800 nm propagating through pure water. The bandwidth of our pulses varied between 10 nm to 100 nm and the temporal pulsewidth varied between 60 fs to 2 ps and the pulse repetition rates were either 1 kHz or 80 MHz. The distances the pulses propagated through water varied between 0.3 meters to 6.1 meters. All measurements were performed under strictly linear conditions.

Our absorption measurements showed non-exponential decay as a function of path length. Pulses of varying temporal widths, bandwidths, chirps, and repetition rates were compared with simulated classical absorption predictions for statistically significant deviations. Deviations occurred for low repetition rates and pulse lengths shorter than approximately 500 fs. For the 60 fs pulses we observed 2 orders of magnitude less absorption after approximately 6 meters of propagation through water compared to 2 ps long pulses which absorbed according to Beer's law.

The temporal and spectral measurements were performed using cross-correlation frequency-resolved optical gating (XFROG). The XFROG technique records a spectrogram which enables us to extract both amplitude and phase information of the short optical pulses exiting from the water tube. These spectrograms clearly showed the breakup of a Gaussian pulse into three distinct pulses with different arrival times. The pulses were also centered at different carrier-frequencies and they had developed different types of chirp.

Using the theory developed for calculating the temporal energy velocity of propagation in an absorbing and dispersive medium [1] in conjunction with proven experimental data for both the real and imaginary part of the dielectric function of water [2] we were able to qualitatively relate our pulse breakup with that of points of stationary phase.

These observations are believed to be the manifestation of precursor activity.

REFERENCES

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