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Improved FROG algorithm and single-shot complete spatiotemporal measurement of high-intensity amplified ultrashort laser pulses

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We report recent developments in the measurement of ultrashort laser pulses, including the development of an ultra-reliable pulse-retrieval algorithm for frequency-resolved optical gating (FROG) and the first single-shot complete spatiotemporal intensity-and-phase measurement of a highly amplified pulse.

The ultra-reliable FROG algorithm involves several innovations, but the main one of which is the direct retrieval of the pulse spectrum from the measured FROG trace. This yields a much better initial guess for the algorithm. We have tested the algorithm for the second-harmonic-generation, polarization-gating, and transient-grating versions of FROG. The result is that, in simulations, it converged well for more than 50,000 different randomly generated pulses with time-bandwidth products as high as 100 and with noise added to the traces. It never failed to converge. It is also faster than previous algorithms.

More recently, we have also demonstrated the first single-shot, complete spatiotemporal measurement of a low repetition rate (10-12 shots/hour), terawatt-scale laser source. The measured complex electric field E(x,y,z,t) of the ultrashort laser pulse was shown to have high-order spatiotemporal dependencies and distortions accruing from the multi-stage-amplified system. The measurements were accomplished using wavelength-multiplexed digital holography, a technique known as Spatially and Temporally Resolved Intensity and Phase Evaluation Device: Full Information from a Single Hologram (STRIPED FISH). Furthermore, this device is highly flexible to measure ultraintense laser pulses with durations from femtoseconds up to ~10 picoseconds.