Short Course 1: Ultrashort Pulse Characterization

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Temporal characterization of transient events typically relies on the availability of a shorter gating transient that can be used for temporal sampling. This customary approach is prone to fail for few-cycle laser pulses, which constitute the shortest controllable events in nature. The only remaining option therefore appears to use the pulse under test also as the gate pulse, and it is obvious that such self-sampling is rather problematic as it can only deliver very limited information about the pulse structure. After an introduction on autocorrelation techniques, this short course addresses the major full pulse characterization methods FROG and SPIDER, which allow simultaneous retrieval of amplitude and phase structure. Particular emphasis will be on the measurement of extremely short pulses (<10 femtosecond duration) and of very weak pulses. Time-stretch Fourier transform techniques for real time characterization of MHz pulse trains will be addressed as well single-shot measurement techniques.

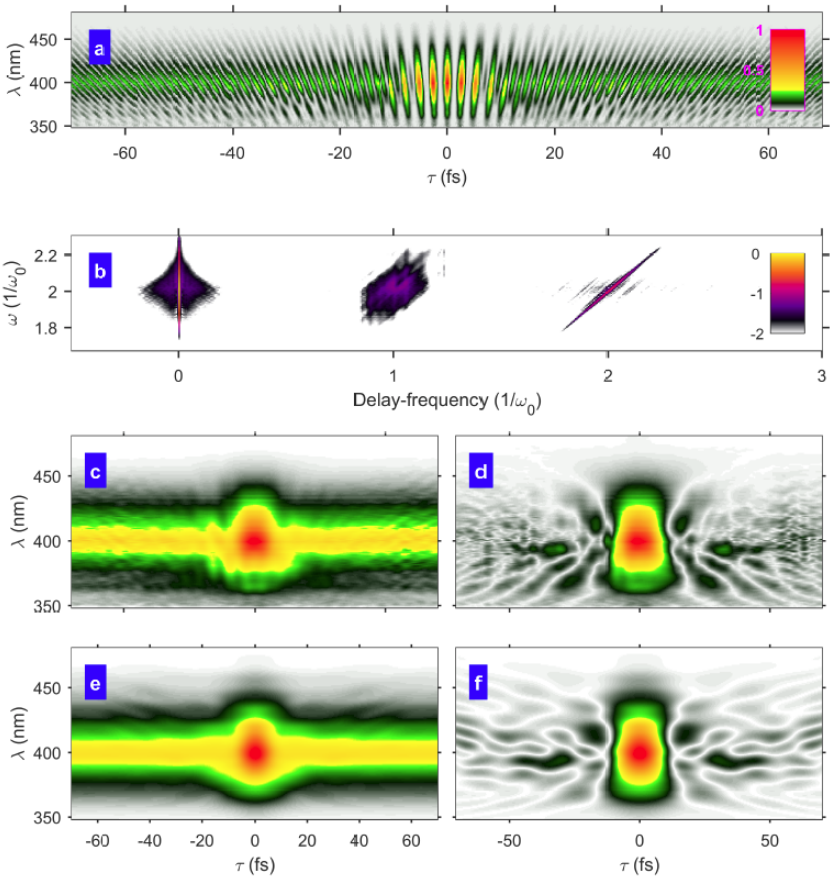

Fig. 1: Interferometric FROG trace of a 7.5 fs Ti:sapphire laser pulse and its retrieval. (a) measured raw data. (b) Fourier decomposition of sub-traces. (c) Isolated dc-trace. (d) Isolated fundamental modulation FROG trace. (e) Retrieved dc-trace. (f) Retrieved fundamental modulation trace.

Detailed instructions on the experimental setup and on phase retrieval methods are given, including some promising recently developed retrieval algorithms (ptychography and differential evolution). The course will then also introduce some more recently developed techniques, including dispersion-scan, MIIPS, and interferometric FROG. Instructions will be given on a detail level that should allow the attendee to build their own characterization setup suitable for their experiments and to understand common limitations of commercial devices. The course will finally address several advanced problems, including the coherent artifact, spatio-temporal characterization, measurement of the carrier-envelope phase, and use of pulse characterization devices as a spectroscopic tool with few-femtosecond temporal resolution.