Ultrashort Pulse Characterization

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Despite decades of rapid development, the response times of electronic detectors are still orders of magnitude behind the time scales achieved and dealt with in Ultrafast Optics and Photonics. In these fields, researchers routinely experiment on physical phenomena spanning picosecond femtosecond and attosecond time windows. As a result, special non-trivial characterization methods are needed for dealing with such extremely short durations. This demand has brought about myriads of ideas and methods for Ultrashort Pulse Characterization. The oldest ancestor of these methods is “autocorrelation”, which uses a short event to measure itself, yielding (usually but not always) good approximation of pulse duration. Despite its long history in use, autocorrelation has certain severe drawbacks. Fortunately, however, the field of ultrashort pulse characterization has gone much further beyond the limited estimates from simple autocorrelations. Today, we can extract the complete temporal / spectral evolution of ultrashort pulses, including both the intensity and phase information. Even further, space-time couplings and complete spatio–temporal electric fields can also be extracted with high sensitivity and reliability.

In this course, we will first review physics of ultrashort laser pulses and fundamental principles of ultrashort pulse characterization. We will then go deeper into particular commonly used methods such as Frequency-Resolved Optical Gating (FROG) and Spectral Phase Interferometry for Direct Electric-field Reconstruction (SPIDER), as well as their derivative methods. We will also discuss important recent developments and additional considerations for particular practical cases including multi-photon microscopy, near-single-cycle pulse generation.