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(G*) POS-E35 – Novel Methods for Pulse Compression

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Strong field physics, femtosecond (1 fs = 10^{-15}), and attosecond (1 as = 10^{-18}) science require intense ultrashort laser pulses for excitation and measurement. Although fs pulses can be generated directly from a laser amplifier, durations necessary for ultrafast science require spectral broadening and compression. The most common spectral broadening technique exploits the nonlinear interaction of intense pulses focused into gas-filled hollow-core fibres [1]. These fibres allow for a long interaction length to generate octave-spanning spectra while maintaining a near Gaussian spatial distribution. However, these fibres can be 1 –3 metres on an optical table with additional 1 m focusing and collimating optics, and require continuous backfilled gas flow. More recently, the self-phase modulation in thin crystals broadens the spectrum and uses a self-focusing relay to maintain the beam quality [2]. A combination of solids and gases to generate a supercontinuum has been used to generate attosecond extreme ultraviolet (XUV) pulses [3]. Ultrashort pulses can have a wide variety of applications, including disrupting biological processes for medical procedures, observation of electronic processes on an attosecond scale, and generating XUV and soft X-ray pulses via high harmonic generation or terahertz via difference frequency generation [4]. Here, we compare numerically and experimentally the spectral broadening in solvents and crystals to demonstrate the potential for a compact setup for generating octave spanning pulses for ultrafast experiments.

We find that passing a beam through several cm of methanol produces a supercontinuum spectrum that can support few-fs pulses. Similar to the multi-plate thin crystal method, we place a series of 1 cm cuvettes of methanol around two foci in order to reduce self-focussing effects and to avoid filamentation within the material. We compress these pulses using dispersion compensating mirrors, and characterize the resulting pulses using frequency resolved optical gating (FROG) and a novel measurement scheme. Our simulations and models predict a sub-10 fs bandwidth-limited pulse resulting from two subsequent compressions using a total of 4 cm of methanol to generate a supercontinuum. Using this method, experimentally, we have achieved a broad spectrum capable of supporting sub-30 fs pulses.

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