The Development of a Second-Order Autocorrelator for Measuring the Duration of Ultrashort Laser Pulses

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High-power laser technology is based on ultrashort pulses, which enables research into particle acceleration, non-linear vacuum properties, or electron-positron pair production. Power=Energy/Time, so to maximize power with limited energy, time must be minimized. Real-time measuring of such short pulses' duration is challenging. In this project, a device was designed and experimentally tested that measures events faster than any existing time-scaling equipment. Called a second-order autocorrelator, it uses a replica of the initial beamline to generate a non-linear optical phenomenon, thus doubling its frequency, then a CCD detector measures the pulse duration. An 800 nm laser pulse was split by a 100 micrometer-thick beam splitter into two replicas, which then passed through a 5 mirrors system and recombined in a non-linear optical crystal. At zero difference between the two beams' optical paths, the second-order harmonic is produced in the crystal and a new beam of 400 nm is emitted. At the system's exit, a CCD camera connected to a computer recorded the ultrashort pulse signal. The pixels width of the second harmonic beam signal was correlated to the duration of the initial laser pulse, both being proportional. The pulse duration benchmarks were 49 fs, respectively 82 fs after amplification. Any result obtained within the +/- 15% range should be considered valid. After optimal calibration, the new device's pulse duration was recorded at 42 and 74.4 fs, confirming its feasibility. Further device development addresses a straightforward technique for eliminating the measuring error caused by the pulse front tilt, which increases its innovation.