New techniques for sensitive detection and estimation of chirp and pulse asymmetry of femtosecond laser pulses

Generation and application of ultrashort laser pulses requires reliable characterization techniques to determine various pulse parameters like duration, shape, chirp, pulse front tilt etc. The response of electronic photo-detection systems is limited to a few ps for fast photo-detectors and to a few hundreds femto-second for fastest streak cameras. Moreover, they cannot be used for detecting chirp or pulse front tilt present in the ultra-short laser pulse. Hence ultrashort laser pulses are characterized by indirect autocorrelation methods using slow electronic detectors for pulse duration of a few picoseconds and smaller. While diagnostic systems such as single shot second order auto-correlators are widely used for measurements of pulse duration, angular chirp and pulse-front tilt of ultrashort laser beams, they cannot provide information on the pulse shape and any temporal asymmetry in the laser pulse. Therefore many expensive diagnostic set-ups based on cumbersome correlation techniques are being used for detailed characterization of ultra short laser pulses. Development of simple and inexpensive diagnostic systems capable of real time characterization of ultra-short laser pulses and associated pre-pulses (if any) is therefore highly desirable.

In Laser Plasma Laboratory, we have worked on new techniques for sensitive detection and estimation of chirp and pulse asymmetry of femtosecond laser pulses. They are based on recording the interferometric auto-correlation signals in real time using a commercial grade audio speaker as a delay line and a commercial grade AlGaAs LED as a two photon detector in a Michelson interferometer configuration. In the first technique, balanced interferometric auto-correlation (IAC) [“balanced” means pulse split up into two *equal* intensity pulses] has been used for estimation of various order chirp [Ref.1]. It is shown that post-processing of the balanced IAC signals by spectrum modification can give precise values of linear, quadratic and cubic chirp, if any, present in the pulse. However, this does not provide any information about pulse asymmetry.

We have also proposed a new method for sensitive detection and estimation of any asymmetry present in the pulse through unbalanced interferometric auto-correlations (U-IAC) [“Unbalanced” means splitting the main pulse into two *unequal* intensity pulses]. Here the direction of time ambiguity in second order IAC signals is eliminated by unbalancing the intensities of the two interfering beams. It is shown that the sensitivity of the unbalanced IAC signals to pulse asymmetry can be significantly increased by modifying the spectrum content of the U-IAC signal [Ref.2].

References:

1) Estimation of higher order chirp in ultrashort laser pulses using modified spectrum auto-interferometric correlation
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2) A simple and sensitive method for visual detection of temporal asymmetry of ultrashort laser pulses
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