L.8: Automation of femtosecond laser pulse shaping experiments

Modulated femtosecond laser pulses are used in many ultrafast spectroscopy experiments to control and study molecular photo-processes. PC based automation is carried out for pulse shaping of femtosecond laser pulses. A setup consisting of Jenoptik make Spatial Light Modulator (Model SLM-S640d) was developed to modulate the laser pulses. SLM is comprised of two liquid crystal arrays with 640 independently controllable strip electrodes in each array. The SLM is placed at Fourier plane in the 4-*f* (where *f* is the focal length of the lens) configuration as shown in *Fig.L.8.1* to achieve amplitude and phase modulation in the optical pulse. Ocean Optics make spectrometer (model HR400) to record the spectrum of the laser pulse. We have developed software in labview for producing the desired pulse shape by controlling the instruments involved in the experiment and applying real time corrections.

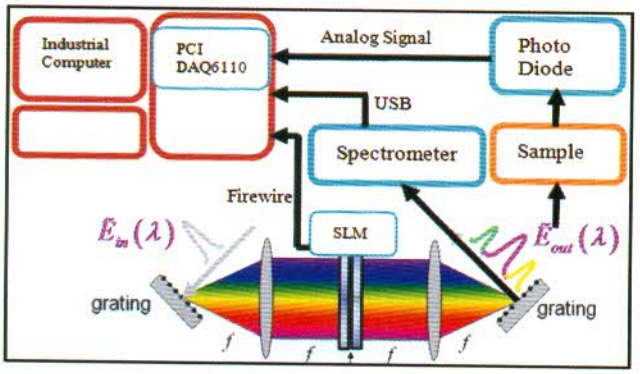

Fig.L.8.1. Laser Pulse Shaping Experimental Setup

The automation software provides real-time laser pulse shaping in open loop as well as closed loop. The user can define functions such as Gaussian, parabola, triangle, well & step to be applied on the spectral content of the input pulse. The software converts these functions in voltage patterns with 1024 discrete points. These voltage patterns are then applied on dual array liquid crystals of SLM for pulse shaping of the laser pulse.

In closed loop mode, the feedback from spectrometer and analog signal from photodiode is used to correct the shape of the laser pulse. The spectral content of the feedback signal is compared with the desired spectral content; with help of genetic algorithm required excitation for SLM to correct laser pulse shape towards amplitude and phase modulation in the spectral content is computed in real time. This correction is applied on SLM to check its effect. This process is continued till the desired pulse shape is achieved. All this process is iterative and performed in real time.

Software performs auto calibration of SLM. This is an important procedure in pulse shaping. Calibration of SLM is performed in two parts. In first part voltage dependent phase variation is recorded. In second part wavelength variation with pixel numbers is recorded. This calibration data is used while performing closed loop control of laser pulse shaping.

In addition to fixed shapes, custom pulse shaping functions are also provided in software for other experiments. A stand alone GUI for control and operation of the SLM and Spectrometer are also provided as shown in Fig.L.8.2. Thus the complexity of achieving optimized laser output is taken care by automation.

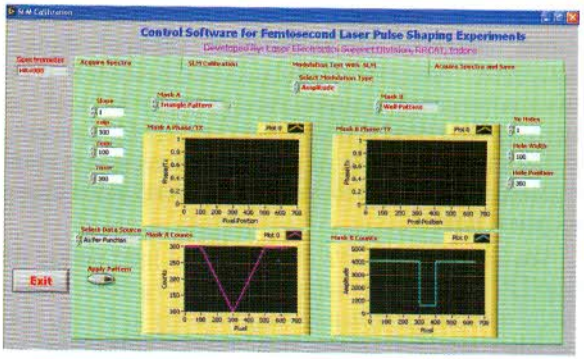

Fig.L.8.2. Amplitude Modulation Panel Image

With this automated setup optimized output of shaped femtosecond laser pulses is achieved which can be used for various experiments in ultrafast spectroscopy. One of the applications of pulse shaping is for conducting coherent control studies. In these experiments, time broadened pulse after propagating through optical fiber can be compressed with help of pulse shaping setup in a feedback loop.

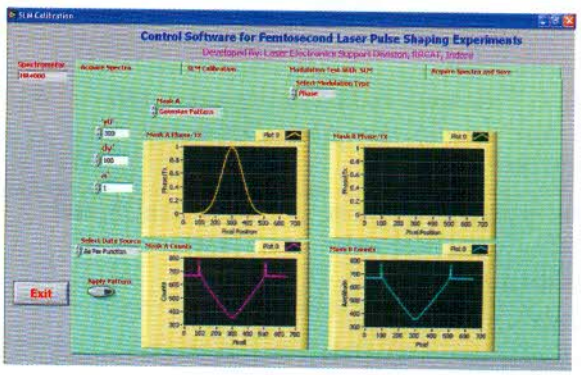

Fig.L.8.3. Phase Modulation Panel Image

The system is currently being used in Laser Physics Application Section to perform amplitude and phase modulation *(Fig.L.8.3)* of femtosecond laser pulses. These pulses are used to study the effect of shaped pulses on linear and nonlinear optical processes in molecular systems.

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