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論　文　内　容　要　旨

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学位論文題目	Femtosecond Time-Resolved Single-Shot Optical Kerr Effect Measurements 単一レーザーパルス光カー効果によるフェムト秒時間分解測定		

内容要旨

Femtosecond time-resolved pump-probe optical Kerr gating (OKG) measurements, have many advantages, such as high time resolution (~100 fs), high signal-to-noise ratio, and without the need for phase matching. Therefore, they have been widely used in various areas, such as measurements of third-order nonlinear optical properties, ultrafast fluorescence spectroscopy, ballistic imaging, etc. Femtosecond time-resolved optical polarigraphy technique (FTOP), based on OKG, can be used to directly observe the instantaneous intensity distributions of ultra-short pulses propagating in transparent mediums with two-dimensional spatial distribution. However, the traditional pump-probe technique is not suitable for monitoring irreversible process owning to sample depletion, product accumulation or pulse fluctuation. Therefore, it is necessary to develop single-shot pump-probe techniques, which can also be used for single-shot imaging of ultrashort pulses propagation.

In this thesis, two ultrafast time-resolved single-shot imaging techniques of femtosecond pulse propagating in transparent media have been investigated, one based on supercontinuum probing, and the other by introducing an echelon into the probe path. The influence of response time of optical Kerr media on imaging has been investigated. Based on nonlinear ellipse rotation, we proposed an OKG measurement using an elliptically polarized probe beam, in which OKG signal is independent on the pump polarization. In addition, the pump power dependence of the spatial gating properties of femtosecond OKG was investigated. The main creative and innovative research results are listed as follows

1. We investigated the ultrafast time-resolved single-shot imaging of femtosecond pulse propagation using a supercontinuum and optical polarigraphy in transparent liquids. The supercontinuum probe senses the instantaneous birefringence induced by the laser pulse, and a polarigraphy image with different color distributions could be obtained. By comparing the wavelength distributions and the saturation variation of the images, the recorded polarigraphy images in two samples with different response time were analyzed. In the fast response sample, N-methyl-2-pyrrolidone (NMP), the spectral widths and the saturation values of the polarigraphy image at fixed positions were narrower and higher than those in CS_2. Due to the slow response of CS_2, the probe light sensed a long-lived birefringence and the polarigraphy image contained more wavelength components at every position along the pump pulse propagation direction.

2. We have demonstrated high-frame-rate observations of a single femtosecond laser pulse propagating intransparent medium using the optical polarigraphy technique and an echelon. The echelon produced a spatially encoded time delay for the probe pulse to capture directly four successive images of an intense propagating pulse with picosecond time interval and femtosecond time resolution. Using this method, we observed the propagation process of a single femtosecond laser pulse in fused silica with 280 fs time resolution and 1.05 THz frame rate. The influence of pulse-energy fluctuation on the spatial and temporal distribution of the single laser pulse was visualized using the single-shot measurements.

3. The pump power dependence of the spatial gating properties of femtosecond OKG was investigated using coaxial two-color optical Kerr measurements in CS_2. As the pump power increased, the spatial pattern of the optical Kerr signals changed from a Gaussian spot to a ring form, and then a spot surrounded by a concentric ring, successively. By comparing the experimental data with the calculation results and measuring the pump power dependence of the OKG signal intensity, we demonstrated that the spatial variation of OKG transmittance could be attributed to the non-uniform spatially distributed phase change of the probe beam, due to the transient birefringence effect induced by pump beam with transverse mode of a Gaussian distribution.

4. Based on light-induced polarization ellipse rotation effect, we proposed an ultrafast OKG in which an elliptically polarized probe beam was used by introducing a pair of crossed quarter-wave plates before and after the Kerr medium in a conventional OKG arrangement. When the probe beam passed through the Kerr medium, a rotation of the polarization ellipse of the probe beam would occur due to the transient birefringence induced by the pump beam, and parts of the probe beam would pass through the OKG. Theoretical calculations and experimental results indicated that the OKG signal intensity would reach an optimum value and be pump-polarization independent when the probe beam were circularly polarized.