論文の内容の要旨
Abstract of Dissertation

論文題目
Title of Dissertation
THz Vector Beams : Generation and Applications
(テラヘルツベクトルビームの発生と応用)

氏　名　　郑　渚
Name of Author　Zheng　Zhu

It has been proved in recent years, besides phase and amplitude features, polarization offers another dimension to manipulate electromagnetic field. Because of the great application potential in imaging, information processing, bio-sensing, security, and etc., on the topic of light modulation, polarization features attract a growing attention. Particularly, a new type of inhomogeneous polarized optical beams, which is so-called “vector beams”, were theoretically and experimentally realized, and proved to be pivotal in many application fields.

“Vector beams” exhibit affluent characteristics, these features are tightly related to fundamental physical phenomena, including sharp focusing, strong longitudinal electric and magnetic components in the foci, new type of optical angular momentum, and etc. These specialties will deepen the understanding of light, and pave a new way on controlling of light.

Although “vector beams”are important, in so-called “terahertz (THz) gap”, the researches related to “vector beams” are very limited. Transplanting the concept of “vector beams” to “THz gap” is beneficial for exploring the nature of THz gap, and digging more possibilities in THz applications.

Because of the spectral features of “THz gap”, i.e. relatively broad bandwidth, the generation of THz vector beams is till now a challenging topic. The present methods to generate THz vector beams suffer from complicated structures, narrow bandwidth and low frequency region, mode imperfections, and difficult to switch between two fundamental modes of THz vector beams - radially, and azimuthally polarized beams.

The first aim of present thesis is to develop a convenient and stable method to generate broadband and high-quality THz vector beams. To achieve this goal, optical nonlinear crystals with three-fold rotational symmetry were selected to be the THz emission medium. By designing and making a segmented half wave-plate mode converter, or an axis-spatial-variant segmented nonlinear crystal, THz radially and azimuthally polarized beams were realized in the experiments. In this method, the elements are stable and easy to make, and by only rotating the crystals, both radially and azimuthally polarized THz beams can be obtained. Moreover, due to the THz emission is from nonlinear crystals, the spectrum of generated THz

vector beams is larger than reported results of other methods based on photoconductive antennas, or narrow bandwidth elements.

To evaluate the generated THz vector beams, three experimental setups were employed. At first, intensity distributions of the THz vector beams were recorded by a THz camera. From the results, donut intensity distributions of radially and azimuthally polarized THz beams are observed, and with inserting and rotating a wire grid polarizer (WGP), two lobes related to the orientation of the WGP are confirmed. These features testify the THz vector modes are successfully generated. Then 2D photoconductive (PC) antenna and free space electro-optics (EO) THz time domain spectroscopy (TDS) systems were built to register full information of the THz vector field, including amplitude, phase and polarization features. The longitudinal electric or magnetic field in the focal volume of the THz vector beams were experimentally proved. Based on the observed results, clear and complete characteristics of THz vector beams are confirmed.

Furthermore, the THz radial beams were introduced to efficiently couple to bare metal wires to realize sufficient THz wave-guiding. In comparison with reported results, the spectrum of guided THz wave in our experiments is as large as 1.5 THz, this number is about 3 times broader; the dispersion and attenuation are proved to be quite low in this much larger spectrum. Moreover, the energy coupling efficiency is firstly evaluated, at 0.3 THz, the efficiency is as large as 66%, which is about two orders improved in comparison with the reported scattering in-couple method.

Based on these results, potential generation, characterization, and applications of THz vector beams were discussed.