Summary

Synthetic fields in optics have gained attention over the past several years. It helps to bring the dynamics of different optical systems, like different modes in coupled waveguides, forward and backward propagating beams in photonic crystal, signal and idler beam generation through nonlinear optical process in atomic system etc., under the umbrella of a single unified formalism in the form of synthetic fields. But the study of synthetic fields in third-order nonlinear susceptibility ($\chi^{(3)}$) led phenomena are inadequate till date. So, in this thesis, I have considered the filamentation process arising from self action effect of a beam (called pump) as a result of the medium's third-order nonlinearity. Two symmetric perturbations created in the filamentation are differentiated by their transverse beam profile. The differential wave equations of these generated beams are modelled in the form of quantum mechanical Schrödinger equation in a suitable transformed frame of reference. The analogous Hamiltonian mimics that of a charged particle in an electromagnetic field where the generated beams carry opposite pseudo-charge. Although in general, Hamiltonian is non-Hermitian, it shows $\mathcal{PT}$-symmetric behaviour and the eigenvalues of Hamiltonian are real only for a negative value of nonlinear refractive index (n_2). Hence, I chose *toluene* as the nonlinear medium which shows $n_2 < 0$ at high repetition rate of nanosecond pulsed laser at $532\ nm$ wavelength. The synthetic fields are solely dependent upon pump beam characteristics and it enables us to control them all-optically. A transversely symmetric (topologically trivial) Gaussian pump beam profile would generate only an electric field that leads to symmetric splitting of the beams, creating a Hollow Gaussian Beam. This splitting creates an all-optical analogous Stern-Gerlach effect in $\chi^{(3)}$ led process. Then, an Elliptic Gaussian beam (topologically non-trivial) is generated through incorporating asymmetry in the trans-

verse profile by employing a cylindrical lens. It resulted in shifting the two beams in two opposite directions which resembles an optical analogue of spin Hall Effect. The pseudo-spins acquire an exact amount of opposite Berry phase which has been verified through experimentally acquired interference fringe pattern.