Invited: AMOP-I-03

Interplay between light and magnetic field in inducing anisotropy in atomic systems

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Atoms are intrinsically isotropic, however interaction with light field and magnetic field can independently result in anisotropy. We understand and characterize this anisotropy by obtaining the complete nonlinear second rank susceptibility tensor ($\chi(E)$). The role of light field and the magnetic field is independently identified and their nonlinear interplay quantified for any arbitrary relative orientation. The principal coordinate system governing the nonlinear susceptibility tensor transforms counterintuitively from light based basis states to the magnetic field basis as the magnetic field strength is increased. The inherent symmetry in the atomic media largely results from the symmetric Clebsch-Gordan (CG) coefficients governing the atomic transitions. However, an external stimulus such as an elliptically polarized light may lead to optical pumping which breaks the symmetry of the response and can induce anisotropy. A range of such effects arising due to the optical field can be classified as Light Induced Anisotropy (LIA). The influence of LIA on the polarization of light has been studied and is known in the literature as Polarization Self-Rotation (PSR). Similarly, applying an external magnetic field breaks the atomic symmetry and induces anisotropy as it lifts the degeneracy of the energy eigenvalues. Magnetic field Induced Anisotropy (MIA) underlies a variety of magneto-optical effects such as the Faraday effect and the Voigt effect, which are associated with the direction of propagation of the light field, depending on whether the light propagates along or transverse to the direction of the magnetic field respectively. In all atomic systems, MIA is almost always accompanied with LIA. A systematic study of anisotropy involving the combined effects of light and the magnetic field with arbitrary orientation, especially in the vicinity of two-photon resonance has not been undertaken. Here, we address this lacuna and present the combined effect of light and magnetic field on the atomic system and discuss the induced anisotropy in detail, including obtaining the complete nonlinear susceptibility tensor.

References:

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