DYNAMIC DIFFRACTION GRATINGS IN DYE-DOPED CHIRAL NEMATICS

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Liquid crystals (LC) have been proved to be among the most efficient media for the realisation of laser beam control in different areas of scientific as well as application-related activities. Introduction of a small amount of a dye into the LC matrix allows for achievement of an extra strong nonlinear optical response overcoming by many orders of magnitude that of the conventional optically active materials [1].

Dynamic diffraction gratings realised in dye-doped chiral nematic liquid crystals (CLC) reveal specific peculiarities in the frequency range near the selective reflection band of CLC. The chiral nematic mixture (E7 with CB15 chiral dopant) containing a small amount of Methyl-Red (MR) dye appeared to be an efficient nonlinear optical medium with extremely large dynamic range (over three orders of magnitude in light intensity) for the both self-diffraction regime and probe beam diffraction. Unlike the experiments with the MR-doped nematic LC, in which surface effects and the light-induced anchoring played the principal role [2], in the dye-doped CLC systems the only dynamic gratings have been recorded with no permanent gratings appearing. The helical LC structure has been also found responsible for a manifold increase of the LC texture stability towards the action of intense laser beam radiation.

An essential non-monotonic dynamics of the diffracting light intensity has been observed. The times characteristic of the grating recording appeared to be inversely dependent on the pumping light intensity with times of the grating relaxation being also intensity dependent. These effects are explained due to the excitation of the gratings of higher harmonics resulted from the saturation of the concentration of light-transformed MR molecules.

Light-induced trans-cis isomerisation of MR molecules and the subsequent distortion of the LC ordering in the vicinity of a dye molecule (light-induced order modulation [3]) determine a relatively fast response time and spatial resolution of down to 1 μm. Optical properties characteristic of the photonic band gap allows for a maximum gain for circularly polarized interacting beams [4]. The gain is insensitive to changes in linear polarization, while it varies with the grating period and with the pump-to-signal intensity ratio. Further investigations are in development in order to reveal the interplay between the chiral structure and the light action on the MR molecules.

References: