Photo-isomerization in dye-doped Liquid Crystal

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1 Introduction

Liquid crystals are a state of matter in which the molecules have a preferential orientation and can have (or not) a positional order; this organization is also known as soft matter [1].
Previous properties of liquid crystals can change radically when one considers a Dye-Doped Liquid Crystal (DDLC). Indeed, when nematics are doped with azo-dyes, their nonlinear response to opto-electrical perturbations is increased by several orders of magnitude [2]. Indeed, azo-dyes mediate the origin of the coupling of the electromagnetic waves with the liquid crystal; when these molecules are irradiated, they present an isomeric transition. This phenomenon is known as the Jánossy effect [3]. This transition is characterized by the fact that the molecule changes from an elongated structure (trans-state) to one with a boomerang shape (cis-state).

2 Experimental setup

To study the phenomena when the light is induced in a DDLC, we observe the spectrum of our dye-dopant **(methyl red methyl ester)** in Fig.1, in this way we notice that the response near to a $420\ nm$ wavelength is higher than the absorbance over $500\ nm$, for this reason in the setup, we use two beams, a *pump* ($445\ nm$) and a probe ($532\ nm$).

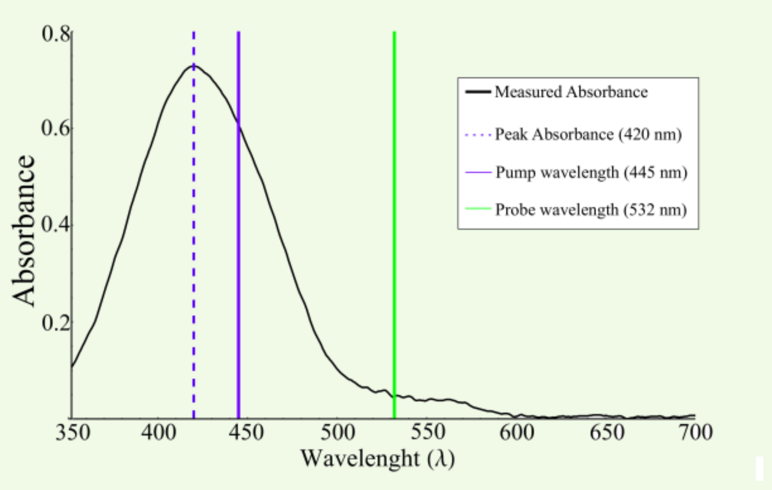

Figure 1: Absorption Spectrum of methyl red methyl ester

The setup consist in this two beams, the pump induce the photo-isomerization effect, in the other hand the probe allows observing the dynamics of the system. In addition two cross polarizers are placed at the beginning and end of the green beam path (pump).

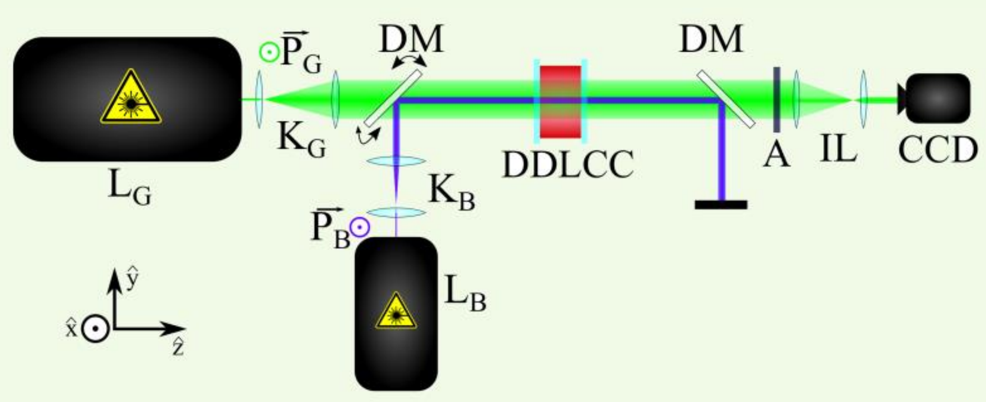

Figure 2: Experimental setup

3 Ring Pattern Formation

When we do the experiment, we use the prove beam at fixed intensity ($0.1\ mW$), varying the pump beam intensity from $0\ mW$ to $90\ mW$ the phenomena studied can be observed in Fig.3

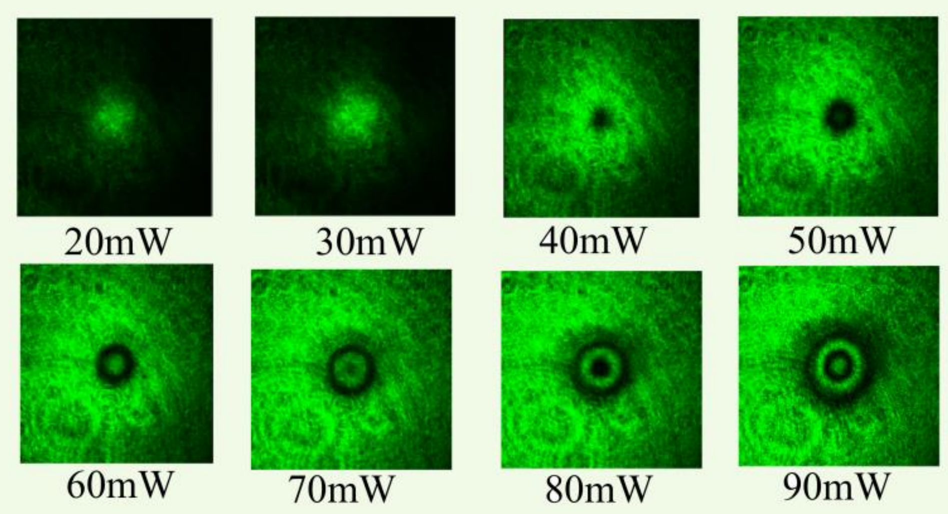

Figure 3: DDLC state in $t = 570s$ for different pump intensities

4 Theoretical Model

From the coupled model proposed in [4], we deduce a reduced model for the order parameter S, by assuming that the temporal evolution of the cis-state concentration is rapid compared to the dynamics of the order parameter, we can consider the adiabatic elimination of the cis-state concentration.

$$\partial_t S = -AS + BS^2 - S^3 - \nu\nabla^2 S - \nabla^4 S + bS\nabla^2 S + D\nabla^2 C_0(I),$$

Studying the solutions of this equation, we can find a good parameters region that allows observe a behavior similar to experiments, in particular the results are observed in Fig. 4.

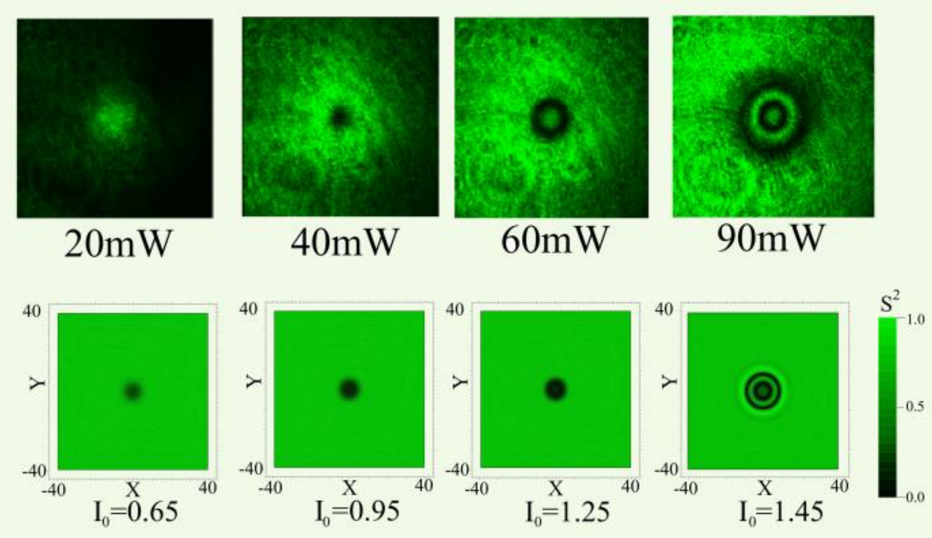

Figure 4: Experimental and Simulated phenomena

The phenomena is well described by the proposed adiabatic model, the evolution and emergence of this ring patterns is similar to experimental observations.

5 Acquired knowledge

This research elucidates the interaction between the light and a DDLC, we observe that the dye-dopant can change the optical properties of the Liquid Crystals when is illuminated; the emergence of a pattern formation is characterized.

6 References

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3. Jánossy, I.; Szabados, L. Photoisomerization of azo-dyes in nematic liquid crystals. J. Nonlinear Opt. Phys. 1998, 7, 539–551.
4. Andrade-Silva, I.; Bortolozzo, U.; et al. Dissipative structures induced by photoisomerization in a dye-doped nematic liquid crystal layer. Phil. Trans. R. Soc. A 2018, 376, 20170382.