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A B S T R A C T

PhD thesis, MSc Klaudia Dradrach

„*Photonic vortices – generation and properties*”

In this dissertation an author presents results of measurements related to photonic vortices that are laser-induced symmetric flows of streams of liquid. The main goal was to define photonic vortices in reference to physical aspects, which enable vortices generation process in controlled manner An additional goal was to describe vortices properties in various media, in different samples geometries and setup configurations. Obtained results and conclusions allows to think about brand new applications of photonic vortices in future.

The thesis begins with „Analysis of the state of knowledge”, in that part general background like light-matter interactions and a mathematical description of Newtonian liquids were given. Characteristics of transport phenomena in a molecular scale and a macroscale were also included in that part of the dissertation. Capillarity forces and phenomena connected with medium surface tension changes were also discussed. The experimental part includes characteristics of materials (for instance liquid crystals and organic dyes), characteristics of samples (sessile droplets or thin liquid films and liquid confined between two glass plates) and an experimental setup as well as different techniques that have been used (for example optical polarizing microscope coupled with laser setup, absorption spectroscopy and others). In this part generation of vortices in different materials and cells was also described. The most extensive part was “Results and discussion”. The thesis ends with potential applications of photonic vortices and a short summary with conclusions.

The description of the experimental part begins by describing the effect of photostability of the dye solution in which the vortices are generated. It has been shown that the chemical composition changes in such solutions during light illumination, and electron spectra of these solutions changes as well. Absorption in this multicomponent mixture is higher, therefore it affects the process of photonic vortices generation (laser-induced flows of liquid streams then occur when using a laser beam of wavelength that initially was not absorbed). Photonic vortices are the effect of an indirect conversion of energy carried by light into mechanical work and the light absorption itself plays a key role here.

Due to the doping of microparticles to solutions, it was possible to trace them and determine the direction in which liquid streams flow – they always rotate towards the gas-liquid interface. The speed distribution of suspended particles is also given. It was observed

that the higher the power of the light source, the higher the speed values of the rotating particles.

Photonic vortices have a tendency to bend the interfacial surface. Thanks to this observation, it was possible to measure the bending amplitude of the gas-liquid interface in the liquid layer confined between two glass plates. Influence of layer thickness and light intensity on the bending amplitude was indisputable. It was also observed that the greatest influence on the interface bending was a result of such parameters: viscosity, surface tension and solvent evaporation.

In the next part of the thesis an increase of "inner" drops was described as well as the physical background associated with competing capillary effects - thermocapillary and solutocapillary effect. The kinetics of droplet growth induced by laser light in various solvents were measured, a growth rate and an effect of laser power on inner droplet size were also discussed. These studies have allowed to state that the size of droplets and their growth rate can be controlled by choosing a solution with adequate volatility and viscosities.

Vortices characterization has contributed to determining possibilities of their use in absorbing liquids. Described applications are as follows: mixing and moving particles in a liquid crystalline material, forming gas bubbles in liquid and moving them, as well as partitioning of liquid areas and moving small amounts of liquid.

Those results were obtained during performing doctoral study programme and were published in 2 scientific papers and 2 patents, and also presented on the national and international scientific conferences.