Abstract

PhD thesis titled: "Applications of holographic optical tweezers in measurements of certain properties of biological samples and coloids"

(Zastosowania holograficznej pęsety optycznej do pomiarów wybranych właściwości preparatów biologicznych i koloidów)

The optical tweezers are a new scientific tool, which is more and more widely used in biology, medical science, chemistry and material science. OT are based on the possibility of catching small (50nm-100μm) objects by strongly focused laser beam. With the optical tweezers one can measure the forces acting on the trapped objects with a resolution of single piconewtons. The trapped objects can be also moved within the sample volume.

The holographic optical tweezers (HOT) is the newest solution in developing the technology of optical manipulations. The main part of the HOT is spatial light modulator (SLM) – a device that serves as a platform for dynamic holograms generation. In the HOT setup these holograms form optical traps at the sample volume. By displaying the sequence of holograms one can move the trap in a controllable way. Moreover, tens of independent traps of various kind (light, dark and Bessel) can be generated at the same time. This flexibility is the big advantage of the HOT. Single HOT may replace various optical configurations of non-holographic optical tweezers. The disadvantages are: difficult holographic technology and low SLM's refreshing rate.

The aim of this work is to show that HOT system can be useful in the experiments with DNA and colloids. In the first part, the work on the HOT technique is described. The system of the HOT is adapted to the experiments with DNA and colloids. The second part is devoted to the applications, i.e. experiments with DNA molecule and colloids (ferrofluids). It is shown that with the HOT system the Young module of DNA molecule can be measured effectively. The experiments with ferrofluids revealed reach behaviour of the magnetic nanoparticles dispersed in organic solution under the strongly focused laser beam. When the energy density of laser beam is large, the organic solver evaporates forming the gas bubbles. A complicated system of whirlpools circulates around the gas bubble. When more evaporation centers are defined at the same time the number of gas bubble are created. These gas bubbles interact in a specific way and the magnetic material is exchange between them.

Different behaviour is obtained when working with lower power traps (under the threshold of evaporation) and applying a magnetic field. With the dark traps (which carry non-zero angular momentum) the polygonal whirlpools are generated. The question of polygonal whirlpool became popular after finding the big hexagonal storm at the north pole of Saturn (Cassini mission). Here we have reproduced the similar phenomenon in microscale but under similar conditions (vertical down-up heat transport, vertical magnetic field, angular momentum transfer to the medium). It is obvious that this kind of experiments were possible with HOT system. Any other way would be much more troubleshooting and is hard to expect that the experiments could be carried on.