Chiral ferronematIcs for Responsive Circularly polarised LasErs (CIRCLE)

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Lasers, although they may sound like something out of science fiction movies, are now an inseparable part of everyday life.

They are associated with exceptional precision, which finds applications in microsurgery, material processing, and targeting devices. At the same time, the interior of a laser conceals carefully designed structures, tailored to create extreme conditions in which the emitted light is coherent. That is, composed of many identical photons.

The heart of a classical laser is a system of two mirrors placed parallel to each other, with an emitter located between them. The distance between the mirrors is usually about 50 times smaller than the diameter of a human hair. Light emitted inside reflects between the mirrors, intensifying with each reflection. This process stimulates the emitter to generate additional portions of light, leading to the formation of an intense beam.

A challenge associated with the use of such lasers in certain applications (e.g., flexible displays) is their complex and rigid construction. They cannot be made flexible due to the necessity of incorporating mirrors. However, it turns out that the two-mirror setup is not the only way to create the conditions needed for lasing. It has been discovered that light can be amplified within a spatially periodic structure. In this case, the laser is not a homogeneous solid but contains very small, periodically repeating structural elements. These interact with the emitted light in such a way that it is amplified similarly to how it would be between mirrors.

Among the materials used in laser construction, organic compounds represent an important group. They are soft, lightweight, and inexpensive to produce on a large scale. This makes them excellent candidates for building flexible lasers.

The goal of the project is to develop a new class of organic materials that could be used in the future to create a flexible laser. By combining organic dyes serving as the emitter with light-reflecting liquid crystal compounds, we plan to produce thin films capable of lasing without being placed between mirrors. Moreover, the developed materials will be controllable by applying a small voltage.

The liquid crystal compounds used can not only form structures that enhance light within them, but they also interact differently with two specific states of light: right-handed and left-handed circular polarization. In this project, we will use this property to create a lasing material that predominantly emits one circular polarization over the other. Such materials are in demand for a variety of applications, including quantum computing and fiber-optic communication.

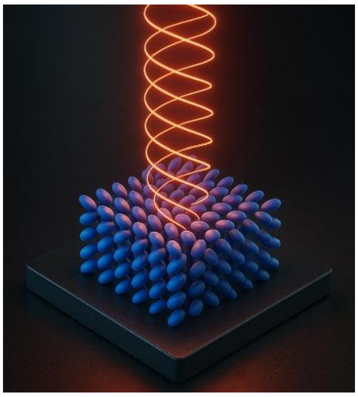

Figure 1. The idea behind the CIRCLE project is to use organic materials to create thin films that emit circularly polarized laser light.