FUNDING PROGRAM FOR NEXT GENERATION WORLD-LEADING RESEARCHERS

Project Title: Dynamical cross effect in chiral liquid crystals: Mechanism and applications to energy-transfer devices	
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1. Background of research

Liquid crystals (LCs), with liquid-like fluidity and solid-like optical anisotropy, have been widely used for TV, PC and cell phone displays. Because of the intermediate properties, LCs play an important role not only in the industrial field but also in biological systems such that biomembranes control the ion transfer into and out of the cell. The natural LC devices usually function in the non-equilibrium state exchanging heat, mass or electric charges with the external world, whereas the artificial LC devices make use of only their static structures. By utilizing the dynamical properties of the LCs in non-equilibrium state, a new field of LC devices can be opened.

2. Research objectives

Our goal is to develop a LC motor device which is driven by waste heat or diffusion current. We also try to use the inverse energy transfer and make the a micro- or nano-size LC device to transport heat and mass, which are controlled by weak light or low electric field.

3. Research characteristics (incl. originality and creativity)

Currently, all LC devices are driven by electric field. In contrast, the driving force of our LC motor is mass diffusion or heat current, which have never been used as the energy source to drive LCs. It is also our original idea to use LCs for a device transferring materials and heat in various circumstances including liquid.

4. Anticipated effects and future applications of research

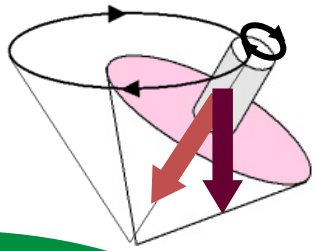
The LC motor proposed in this project is driven by such discarded energy as waste heat and diffusion current. If we can make nano- or micro-machines with the turbine composed of chiral LCs, they will offer a new tool for recycling the waste energy. Besides, when the LC motors are made of all natural elements, they can be used for medical applications such as an active capsule of drug delivery system.

Chiral LC motor driven by waste energy

Explorer mechanism of unidirectional rotation of chiral LCs

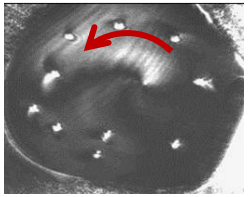
Reveal the roles of chiral propeller and macroscopic helix

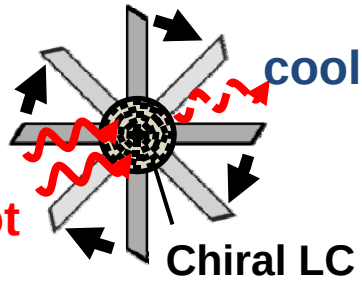
・MD Simulation
・Depolarization of fluorescence
・Electron microscopy
・IR spectroscopy



Recycling diffusion currents into energy

•Retarder driven by mass current
•Rotor driven by heat current

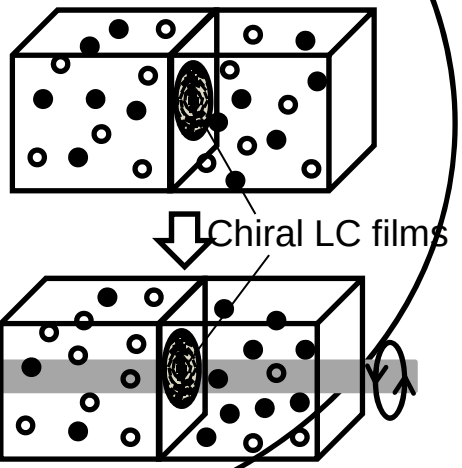




Control boundary condition, elasticity, viscosity of LCs ->
increase the energy transfer efficiency

Device with utilizing inverse rotation

・molecular separation



・Light-driven functional vesicle with LC motor