Angular optomechanics of micro-spinners at fluid interfaces

H. Magallanes[1], G. Seniutinas[2], D. Hakobyan[1,2], S. Juodkazis[2] and E. Brasselet[1]

1 Université de Bordeaux, CNRS, LOMA,UMR 5798, F-33400 Talence, France
2 Center for Micro-Photonics, Faculty of Engineering and Industrial Sciences,Swinburne University of Technology, Hawthorn, VIC 3122, Australia

Unconventional manifestations of mechanical effects of light refer to an intriguing topic that attracts a lot of interest. In particular, since a few years, several studies have been devoted to the concept of so-called negative optical forces, which refers to optical forces that push objects upstream of an incident photon flux, see review paper [1], and whose first experimental demonstrations have been reported recently [2,3]. The extension of such counter-intuitive effects to optical torques, namely the angular analog of negative optical forces [4], is the context of present report. This corresponds to a light field exerting a radiation torque on matter, where the direction of the torque is opposite to that of the incident angular momentum. Such an optomechanical effect is described as being ‘left-handed’ rather than ‘negative’. This agrees with the fact that physicists usually refer to a phenomenon as being ‘left handed’ to emphasize its counter-intuitive nature. In addition, this terminology avoids potential confusion with the sign of the incident angular momentum, which can be positive or negative, irrespective of whether it induces expected or counter-intuitive mechanical effects.

In previous studies [4,5] the indirect experimental observation of left-handed optical torque has been reported by exploiting the interaction between the spin and orbital angular momentum of light. Indeed, if the optical radiation torque is dominated by the orbital contribution rather than that of the spin, reversing the angular momentum balance becomes possible. In practice this was achieved by using transparent inhomogeneous anisotropic media. However, to date, the use *macroscopic* nanostructured optical elements prevented direct observation of the effect. To address this issue, we consider the fabrication of *microscopic* nanostructured optical elements. The experimental challenge consists to put into rotation the fabricated micro-optical elements by light. This requires the development of a release strategy, which is done by depositing the fabricated elements onto a degradable layer. Then, angular optomechanics as such can be assessed, in a similar way as previously done in the case of optically driven rotation of microstructured form birefringent half-waveplate [6]. Practically, we place our micro-spinners at the interface between two distinct fluids that hold the object by capillarity. Optically induced spinning is eventually monitored by direct video imaging. The encountered fabrication and optical manipulation challenges and optimization strategies will be discussed in the presentation.

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2. O. Brzobohatý *et al.*, “Experimental demonstration of optical transport, sorting and self-arrangement using a tractor beam”, Nature Photon. **7**, 123-127 (2013).
3. V. Kajorndejnukul *et al.*, “Linear momentum increase and negative optical forces at dielectric interface”, Nature Photon. **7**, 787-790 (2013).
4. D. Hakobyan and E. Brasselet, “Left-handed optical radiation torque”, Nature Photon. **8**, 610-614 (2014).