understanding of the macroscopic theory of optical momentum.

While the internal force distributions may differ with details of the material microscopic lattice structure, the total force prediction for a material object depends only on the macroscopic optical parameters. This conclusion agrees with theoretical derivations of equivalence of total optical force under time-average considerations[9]. Because of this, experimental verification could be difficult, as has been demonstrated with many other predictions involving optical momentum[3]. Experimental observation of optical pressures on amorphous air–liquid boundaries have been reported for many years, including one of the more detailed reports in 2014 that reconciled macroscopic theory and experiment[10]. However, detailed experimental measurement of surface deformation at the surface of a negative-index metamaterial should be expected to be much more difficult. Such metamaterials generally exist as solids with lattice dimensions that are sometimes only slightly smaller than a wavelength.

There seems to be no single, simple, or clear answer for the question 'what is the momentum of light?' Recent research on negative-index metamaterials illustrates once again how illusive the answer can be, as it has been for more than a century. Science awaits a fundamental understanding of how a material microstructure contributes to the propagation of optical momentum and experimental verification of the effect on stress at the boundary. ❐

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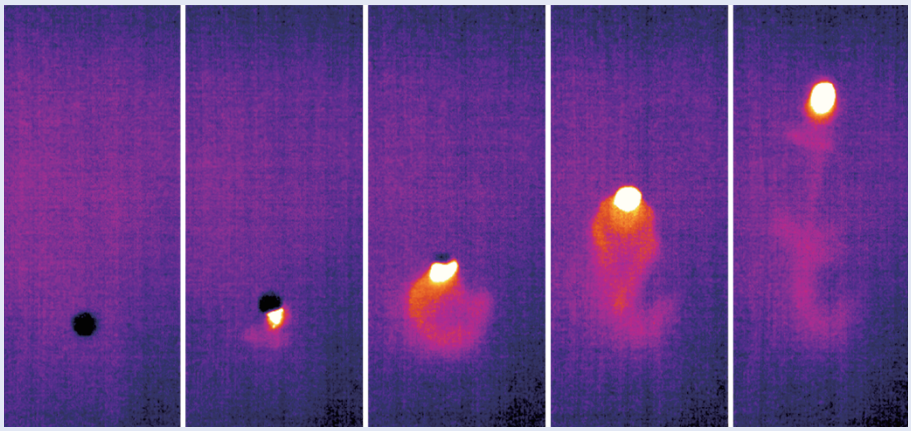
Correction

In the version of the News & Views article 'Imaging: Making sensing of incoherence' originally published (*Nature Photon.* **10,** 211–213; 2016), ref. 11, 'Waller, L., Situ, G. & Fleischer, J. W. *Nature Photon.* **6,** 474–479 (2012)', was missing. Corrected in the online versions 13 April 2016.

OPTICAL MANIPULATION

Light-driven delivery

Optical techniques to remotely transport miniature packages to a desired location and then control the release of active substances on demand would be invaluable for a variety of applications such as light-controlled microfluidics and drug delivery systems. Maxime Paven and co-workers in Germany and Japan have now demonstrated exactly that functionality using powder-encapsulated liquids, referred to as liquid marbles (LMs). The team showed how a near-infrared laser beam could be used to move the LMs over the surface of water and cause them to release their contents at a specific place and time (*Adv. Funct. Mater.* http://doi.org/f3mb22; 2016).



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To introduce the light-driven delivery ability, the German and Japanese scientists used two different powders, polypyrrole (PPy) and carbon black (CB), as LM stabilizers (encapsulating layers). Individual LMs were prepared by rolling a 10 μL (=2.7 mm diameter) aqueous drop over the powder of PPy or CB. The PPy or CB powders immediately coated the water drops and rendered them hydrophobic and non-wetting. Once transferred onto the surface of water the LMs remained intact for more than 10 h.

To move the floating LM, its contact point on the air/water interface was irradiated by a near-infrared laser beam at an angle of 45°. The laser illumination leads to the creation of a temperature difference between the bulk water (18 °C) and the water near the LM (30 °C), which then causes a surface tension difference (2 mN m^{-1}). This surface tension difference drives the locomotion of the LM away from the illuminated region (pictured). The maximum velocity, acceleration and generated force were experimentally determined as 2.7×10^{-2} m s^{-1}, 0.17 m s^{-2} and 1.8 μN, respectively.

Once the LM is in the desired location, illuminating it from above (90°) with near-infrared laser light for several tens of seconds causes the surface of the LM to be ablated and the inner materials to be released. The location of the release can also be fixed by exploiting a small solid object such as a polytetrafluoroethylene (PTFE) pin in the water film. The PPy-coated LM is laser-driven towards the PTFE pin, and once it is sufficiently close (1–1.5 cm), it is attracted by a lateral capillary force without any further irradiation. The trapped LM can then be irradiated until it breaks up (within 20 s).

Furthermore, the LMs can also be used as light-driven engines for pulling cargo structures (miniature plastic boats loaded with multiple LMs).

The international team believes that light-driven delivery and release of materials on demand could prove to be particularly useful in microfluidics for the delivery of analytes.

NORIAKI HORIUCHI