Active microrheology of soft materials with acoustical tweezers

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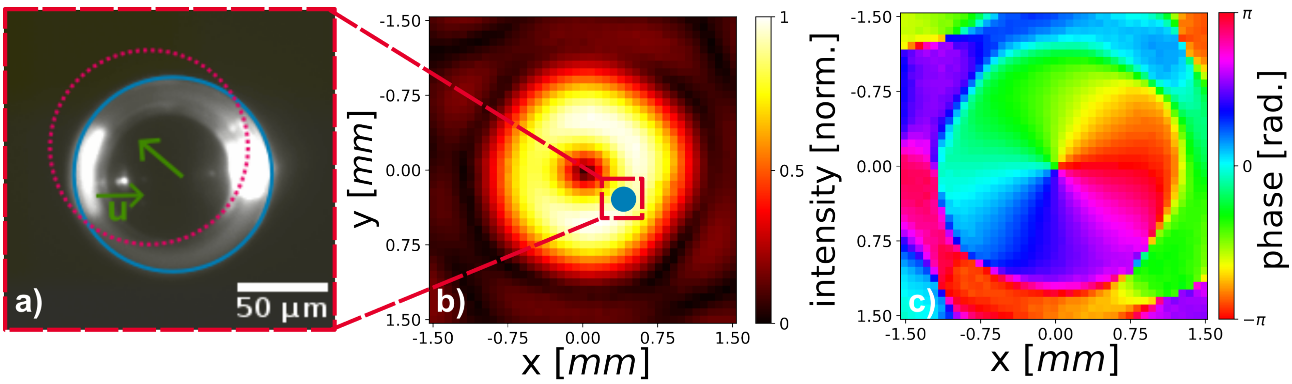
Probing the local and internal elastic properties of soft materials is important to characterise the mechanics of biological tissues. Therefore, this work focuses on the development of an active microrheological method based on the use of acoustical tweezers, a recently developed technique to exert contactless forces on microscopic objects. Here, a focused acoustic vortex beam pulls on a microbubble (100 μm in size) embedded in a soft hydrogel with the radiation force. This force can be modelled using precise pressure measurements of the incident beam, and the net displacement of the microbubble centre can be optically obtained. Combined with a simple elastic model for the medium, the local elastic properties of the hydrogel can finally be deduced. By using carbopol hydrogels with typical shear moduli ranging from a few tens to a few hundreds of pascals, microbubble displacements of 1 to 10 micrometers were observed, consistent with forces in the micronewton range. Overall, this novel approach presents real benefits compared to conventional rheology methods, as it can be considered minimally intrusive, local, and well-adapted to probe thick and opaque-to-light materials in bulk such as cellular tissues.



a) Displacement of a microbubble (100 μm in size) by a few micrometers in the vortex beam, **b)** Normalized intensity of the vortex beam, **c)** Phase of the vortex beam.