Light-induced spiral mass transport in azo-polymer films under vortex-beam illumination

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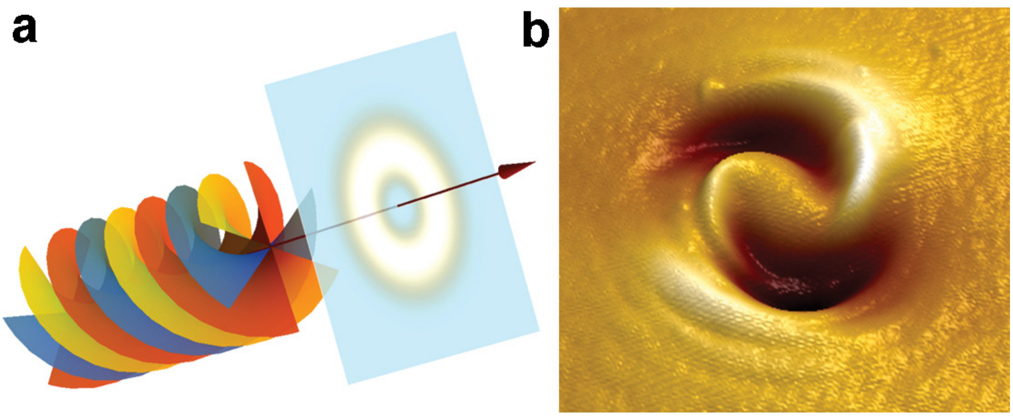
Nature Communications 3, 989, 2012

We report about a new feature in patterning azo-polymers deriving by light-matter interaction where the film is sensitive to the phase information carried out by optical vortexes of different topological charges.
In fact, we have found the unexpected experimental observation of spiral-shaped relief patterns on the surface of an azopolymer that has been illuminated with a vortex laser beam, that is a beam having a helical wavefront. The spiral handedness of the polymer pattern is determined by the vortex one. This result is quite surprising because the common understanding hitherto was that these surface patterns respond to the light intensity distribution and its gradients. The intensity pattern of a vortex beam is shaped as a "doughnut" and carries no information whatsoever about the vortex handedness. We found an explanation for our observations that links them to a peculiar interference effect occurring between longitudinal and transverse field components of the vortex beam. Furthermore, we have found out that the main features of the observed phenomenon can be predicted by a phenomenological theory that does not rely on a specific microscopic model and therefore, in this sense, is a model-independent interpretation.
Our finding will benefit the development of new lithography schemes as well as the interpretation of the phenomenon driving the material-displacement and the imaging of phase-related information.



a) Wavefront helical structures for vortex topological charges q = 3 (the wavefront is composed of three intertwined helical surfaces) and the associated doughnut-shaped transverse intensity distribution.

b) Three-dimensional AFM image of the topographical structure obtained at the sample surface when the polymer is illuminated by a focused q = 10 vortex beam.