Observation of Optical Polarization Möbius Strips

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Möbius strips are three-dimensional (3D) geometrical structures that hold great fascination because of their peculiar property of being surfaces with only one "side" – or, more technically, are "non-orientable" surfaces. Despite being easily realized artificially, for example with a strip of paper or of other flexible material, the spontaneous emergence of these structures in nature and science is exceedingly rare. Examples have occasionally been reported in chemistry and biology, particle physics, and materials science. A theoretical prediction that even the vectorial field of an electromagnetic wave, under suitable conditions, can assume a Möbius structure was advanced some years ago, but hitherto has remained unverified. Here, we generate Möbius strips of optical polarization by tightly focusing the light beam emerging from a q-plate, a liquid crystal device that modifies the polarization state of light in a space-variant manner, introducing an optical singularity of given integer topological charge $2q$. Using a recently developed method for 3D nano-tomography of the optical vector field we fully reconstruct the light polarization structure in the focal region, confirming the appearance of Möbius polarization structures with $2|q|+2$ half twists. Besides its fundamental interest, this result is important for complex light beam engineering and optical micro and nano fabrication.