Physicists hope to tie light beams in knots

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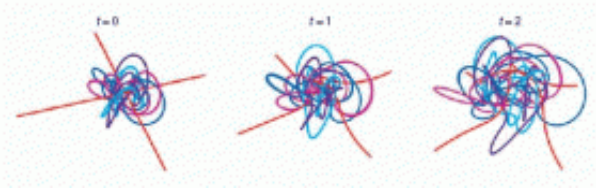

Physicists have investigated little-known solutions to Maxwell's equations, in which light beams can be linked and knotted in various configurations. Credit: Irvine and Bouwmeester. ©2008 Nature.

Usually, light beams shine in a straight line, with the possible exception of light being bent by gravity. But scientists are now investigating how to make light beams into looped and knotted configurations. The possibility for these structured light beams arises from some curious solutions to Maxwell's equations, which describe the fundamentals of electricity and magnetism.

Physicists William Irvine of New York University and Dirk Bouwmeester of the University of California, Santa Barbara, and Leiden University in The Netherlands have published a study in *Nature Physics* on their analysis of knotted light. The scientists looked at the physical properties of knotted light and discovered that it can be experimentally generated using circularly polarized laser beams.

In some little-known solutions to Maxwell's equations, all the electric and magnetic field lines form circles that are all linked to each other. These loops of field lines can be used to construct the donut shape of a torus. In such a scenario, each circle wraps around the torus once, and no two circles cross each other. Smaller tori could then be nested within larger ones, filling three-dimensional space with circles of light beams.

These solutions differ from any known existing form of light because of the intricate knotted structure, the physicists told *PhysOrg.com*. As they explained, this structure is based on the Hopf fibration, which was introduced in 1931 to mathematically investigate the structure of spheres in four and higher dimensions, a topic that seemingly has nothing to do with light.

After investigating knotted light's properties, the physicists determined that they could use laser fields to create the structures. Starting with a single-pulsed beam of circularly polarized light, and tightly focusing the beam, it should be possible to create various shapes of looped light beams. By using holographic techniques and a spatial light modulator, the shape and profile of the looped light could also be controlled. These same techniques have recently been used to produce Airy beams, which are light beams that don't spread out as they propagate.

Currently the physicists are preparing for an experimental realization of the new solutions either using electromagnetic radiation in the optical regime, i.e. light, or in the microwave regime. The main challenge will be to deal with ultra-short pulses of radiation in order to create a broad spectrum of frequencies as needed for the construction of the light knots.

Because knotted light beams have both beamlike properties and unique unexplored properties, the physicists predict that creating the beams could have applications in several areas. These could include applications in plasma confinement, atomic particle trapping, manipulating cold atomic ensembles, and generating soliton-like solutions in nonlinear media.

More information: Irvine, William T. M. and Bouwmeester, Dirk. "Linked and knotted beams of light." *Nature Physics,* Vol. 4, September 2008, pp. 716-720.

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