Physicists turn to Maxwell's equations for self-bending light

April 21 2012, by Nancy Owano

(Phys.org) -- Can light self-bend into an arc? Can shape-preserving optical beams truly bend along a circular path? A confident answer emerged in this week's *Physical Review Letters*. Researchers at Israel's Technion reported their findings, saying that solutions to Maxwell's equations suggest it is possible. They have found solutions to Maxwell's equations— the equations governing electromagnetism--that precisely describe initial phases required for truly self-bending light.

Light travels in a straight line; light beams tend to propagate along a straight path. Under forced circumstances—with use of mirrors, lenses, and light guides--light can take a more circuitous path, What has interested some scientists is whether or not light beams can bend themselves along a curved path with no external cause.

What is more, the new report involves wave solutions to Maxwell's equations that are nondiffracting and capable of following a tighter circular trajectory than was previously thought possible.

The authors said in the report that "We have found nonparaxial accelerating beams and nonparaxial periodically oscillating accelerating beams. These beams are the full vector solutions of Maxwell's equation for shape-preserving accelerating beams. Moreover, in their scalar form, these beams are the exact solutions for nondispersive accelerating wave packets of the simple and most common wave equation describing time-harmonic waves."

The study, titled "Nondiffracting Accelerating Wave Packets of Maxwell's Equations," by Ido Kaminer, Rivka Bekenstein, Jonathan Nemirovsky, and Mordechai Segev, joins a body of related light-bending research.

Reaching into the research background, *ScienceNOW* described some study markers, going back to the late 1970s, when physicists at the University of Bristol in the United Kingdom and State University of New York said that an Airy waveform, a wave describing how quantum particles move, can sometimes bend by a small amount. In 2007, physicists at the University of Central Florid generated optical versions of Airy waves by manipulating laser light, and found that the resultant beam curved slightly as it crossed a detector.

The Technion examination is unique in that the scientists claim they figured out how to make light self-bend through any angle, even through a complete circle. (The problem with the Airy function, said study coauthor Mordechai Segev, is that the shape of its oscillations specify the right phases only at small angles.)

Commenting on this week's findings, Zhigang Chen, a physics professor at San Francisco State University, said in *Physics* that implications of their work are profound for other linear wave systems in nature, from sound and surface waves in fluids to many kinds of classical waves."One would expect that the nonparaxial Bessel-like accelerating beams proposed in this study could be readily realized in experiment. Apart from many exciting opportunities for these beams in various applications, such as beams that self-bend around an obstacle one might expect one day light could really travel around a circle by itself, bringing the search for an 'optical boomerang' into reality."

The study authors say that future work should examine the possibility of 3-D accelerating beams, including those with trajectories that do not lie

in a single plane. “In practical terms, this work brings accelerating beam optics into the subwavelength regime, through the less-than-wavelength features of our solutions, facilitating higher resolution for particle manipulation.”

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