A new idea for rapid generation of strong magnetic fields using laser pulses

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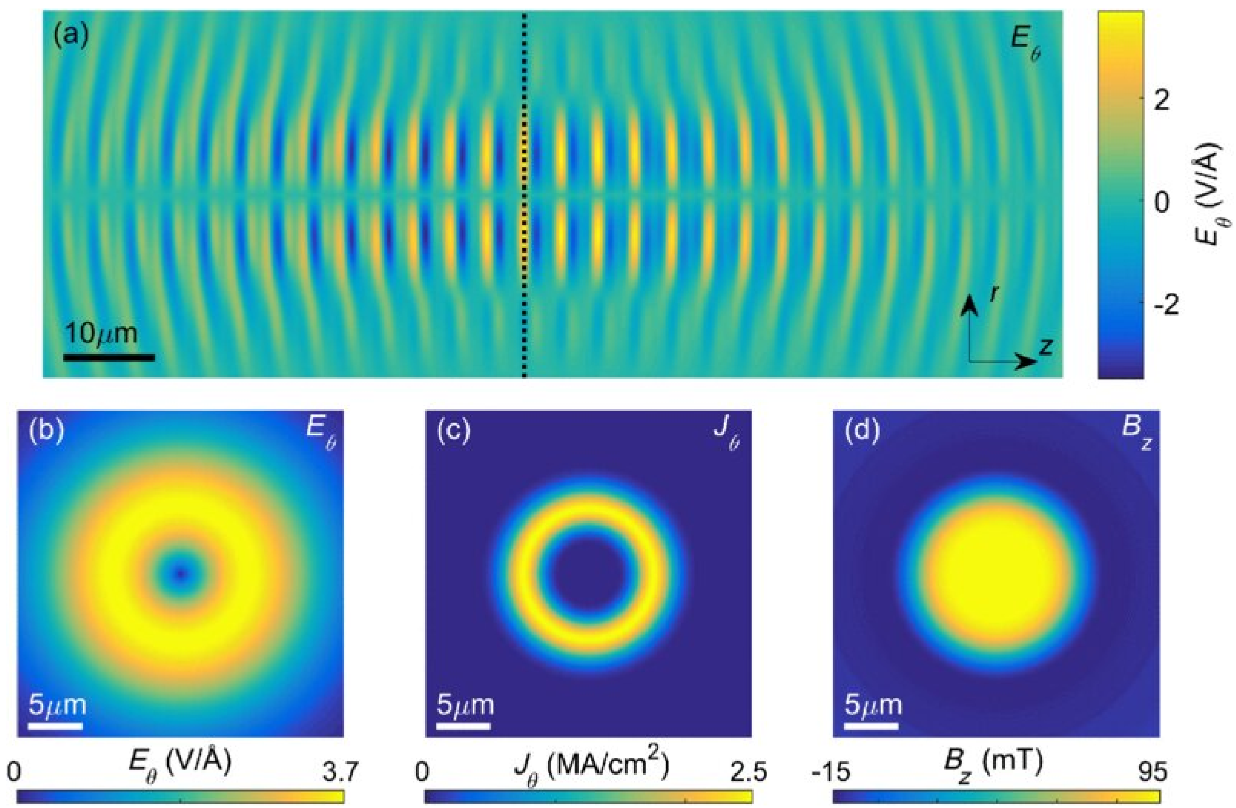

Numerical simulations of strong field coherent control in atomic hydrogen using azimuthal vector beams. Credit: *Physical Review X* (2020). DOI: 10.1103/PhysRevX.10.011063

A combined team of researchers from the University of Ottawa and National Research Council Canada has developed a new way to generate rapid strong magnetic fields using laser pulses. In their paper published in the journal *Physical Review Letters*, the researchers describe their new technique and the ways it might be used.

Over the past several years, magnetic fields have become more important in a variety of research areas, including medicine. But a means for generating strong magnetic fields rapidly has been lagging. In this new effort, the researchers have found a way to overcome problems associated with prior attempts to speed up magnetic field generation.

The new work builds on prior attempts to use lasers to speed up the process—these experiments have typically been used to push electrons in plasma around a loop, but such devices require very strong lasers that are only available at a few research sites. Also, in prior attempts to use lasers, researchers have aimed their lasers configured as an optical vortex in a gas. The researchers with this new effort instead propose an azimuthal-vector laser beam. In such a system, the electric field lines should take the shape of circles around a central beam axis. The system is most intense in the ring-shaped part of the region. That should allow for sending an electron around the ring, generating a magnetic field in the direction of the beam. The researchers' idea also introduces a second laser with a frequency tuned to twice that of the first beam. This changes the timing of the process, allowing electrons to move when the field is at its peak.

Simulations of their idea showed that if an 11.3-microjoule main laser pulse was used and a 1.9-microjoule frequency-doubled pulse was added as the second laser, the system would be able to turn on an 8-Tesla field in just 50 femtoseconds. Such a setup, the researchers note, could be used in typical lab settings, though they note it would likely destroy magnetic samples under study. They suggest these problems could be reduced by moving samples farther away from the magnetic field. They further suggest that devices built using their ideas could be used for optoelectronics requiring speedy switches.

More information: Shawn Sederberg et al. Tesla-Scale Terahertz Magnetic Impulses, *Physical Review X* (2020). DOI: 10.1103/PhysRevX.10.011063