Could megatesla magnetic fields be realized on Earth?

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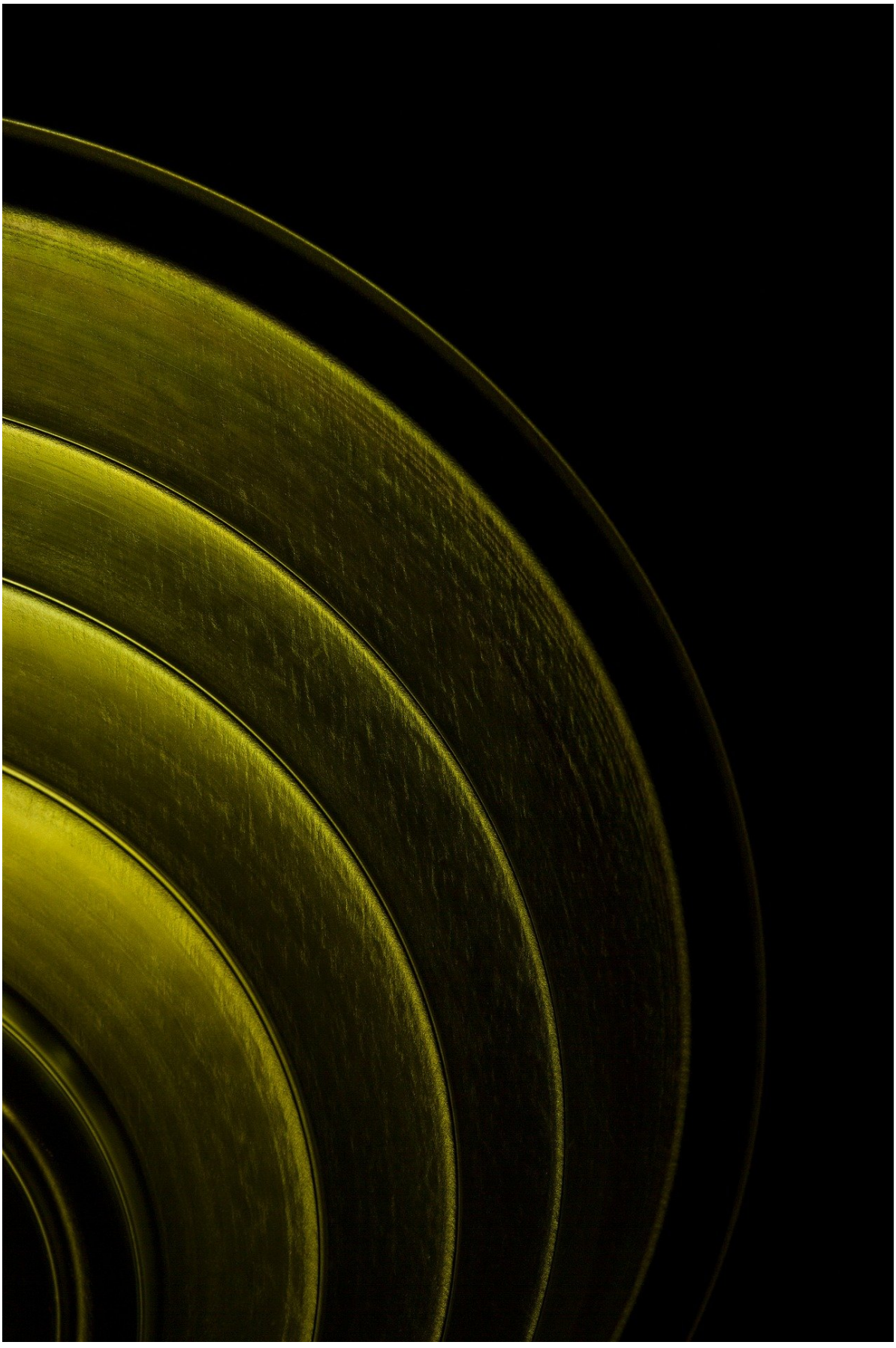

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Magnetic fields are used in various areas of modern physics and engineering, with practical applications ranging from doorbells to maglev trains. Since Nikola Tesla's discoveries in the 19th century, researchers have strived to realize strong magnetic fields in laboratories for fundamental studies and diverse applications, but the magnetic strength of familiar examples are relatively weak. Geomagnetism is 0.3–0.5 gauss (G) and magnetic tomography (MRI) used in hospitals is about 1 tesla (T = 10^4 G). By contrast, future magnetic fusion and maglev trains will require magnetic fields on the kilotesla (kT = 10^7 G) order. To date, the highest magnetic fields experimentally observed are on the kT order.

Recently, scientists at Osaka University discovered a novel mechanism called a "microtube implosion," and demonstrated the generation of megatesla (MT = 1010G) order magnetic fields via particle simulations using a supercomputer. Astonishingly, this is three orders of magnitude higher than what has ever been achieved in a laboratory. Such high magnetic fields are expected only in celestial bodies like neutron stars and black holes.

Irradiating a tiny plastic microtube one-10th the thickness of a human hair by ultraintense laser pulses produces hot electrons with temperatures of tens of billion of degrees. These hot electrons, along with cold ions, expand into the microtube cavity at velocities approaching the speed of light. Pre-seeding with a kT-order magnetic field causes the imploding charged particles infinitesimally twisted due to Lorenz force. Such a unique cylindrical flow collectively produces unprecedentedly high spin

currents of about 10^{15} ampere/cm^2 on the target axis and consequently, generates ultrahigh magnetic fields on the MT order.

The study conducted by Masakatsu Murakami and colleagues has confirmed that current laser technology can realize MT-order magnetic fields based on the concept. The present concept for generating MT-order magnetic fields will lead to pioneering fundamental research in numerous areas, including materials science, quantum electrodynamics (QED), and astrophysics, as well as other cutting-edge practical applications.

More information: M. Murakami et al. Generation of megatesla magnetic fields by intense-laser-driven microtube implosions, *Scientific Reports* (2020). DOI: 10.1038/s41598-020-73581-4

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