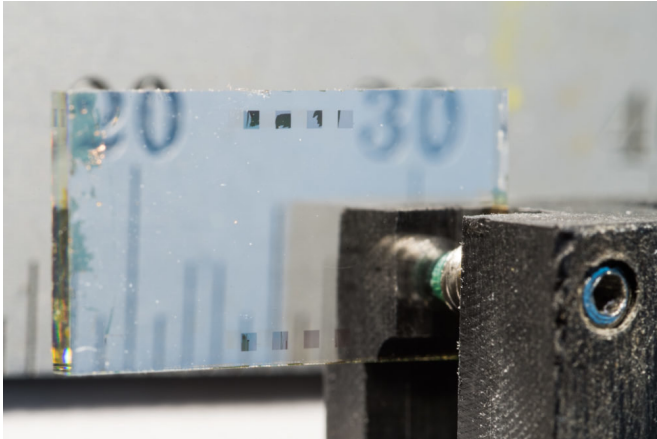


Researchers develop small device that bends light to generate new radiation

25 October 2018, by Morgan Sherburne



A research team led by University of Michigan physicists have developed a way to generate synchrotron using a device the size of a match head. Typically, synchrotron radiation is generated at facilities the size of several football fields. Credit: Austin Thomason/Michigan Photography

University of Michigan physicists have led the development of a device the size of a match head that can bend light inside a crystal to generate synchrotron radiation in a lab.

When physicists bend very intense beams of charged particles in circular orbits near the speed of [light](#), this bending throws off bits of light, or X-rays, called [synchrotron radiation](#). The U-M-led researchers used their device to bend visible light to produce light with a wavelength in the [terahertz](#) range. This range of wavelength is considerably larger than that of [visible light](#), but much smaller than the waves your microwave produces—and can penetrate clothing.

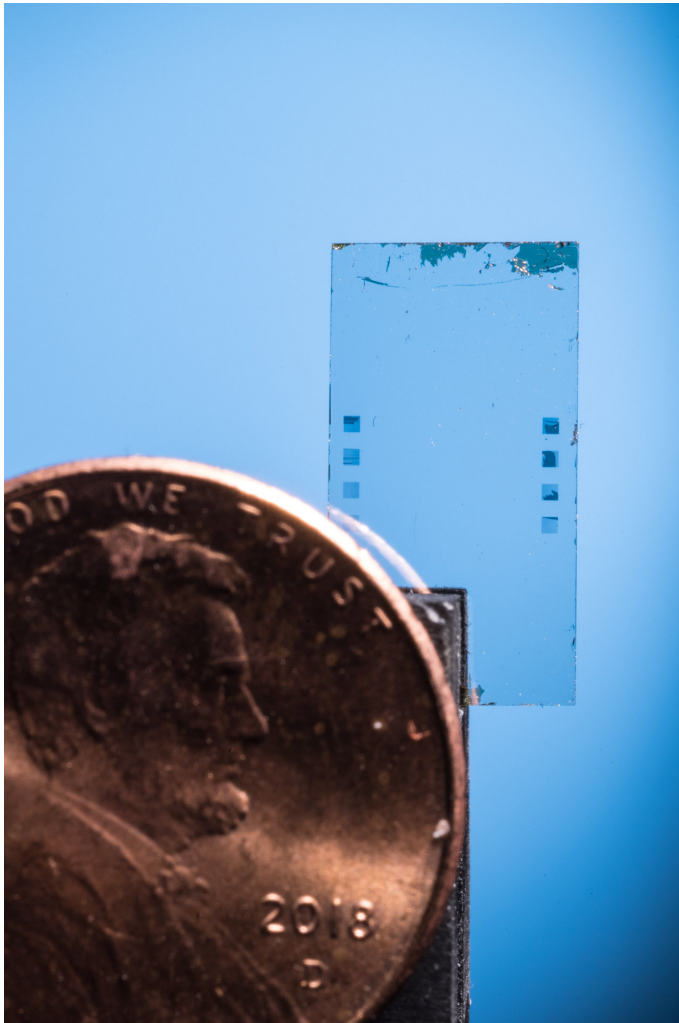
Synchrotron radiation is usually generated at large-scale facilities, which are typically the size of several football stadiums. Instead, U-M researchers Roberto Merlin and Meredith

Henstridge's team developed a way to produce synchrotron radiation by printing a pattern of microscopic gold antennae on the polished face of a lithium tantalate crystal, called a metasurface. The U-M team, which also included researchers from Purdue University, used a laser to pulse light through the pattern of antennae, which bent the light and produced synchrotron radiation.

"Instead of using lenses and spatial light modulators to perform this kind of experiment, we figured out by simply patterning a surface with a metasurface, you can achieve a similar end," said Merlin, professor of physics and electrical engineering and computer science. "In order to get light to curve, you have to sculpt every piece of the light beam to a particular intensity and phase, and now we can do this in an extremely surgical way."

Anthony Grbic, U-M professor of electrical engineering and computer science, led the team that designed the metasurface with former doctoral student Carl Pfeiffer developing the metasurface.

The metasurface is composed of roughly 10 million tiny boomerang-shaped antennae. Each antenna is considerably smaller than the wavelength of the impinging light, said Henstridge, lead author of the study. The researchers use a laser that produces "ultrashort" bursts or pulses of light which last for one trillionth of a second. The array of antennae causes the light pulse to accelerate along a curved trajectory inside the crystal.



circular path, producing synchrotron radiation at a single terahertz frequency.

The scientific community uses single-frequency terahertz sources to study the behavior of atoms or molecules within a given solid, liquid or gas. Commercially, terahertz sources are used to scan items hidden in clothing and packaging crates. Drugs, explosive and toxic gases all have unique "fingerprints" in the [terahertz range](#) that could be identified using [terahertz spectroscopy](#).

The device's uses aren't limited to the security industry.

"Terahertz radiation is useful for imaging in the biomedical sciences," Henstridge said. "For instance, it has been used to distinguish between cancerous and healthy tissue. An on-chip, single-frequency terahertz source, such as a tiny light-driven [synchrotron](#) such as our device, can allow for new advancements in all of these applications."

Provided by University of Michigan

Microscopic device that bends light. Credit: Austin Thomason/Michigan Photography

The light pulse creates a collection of electric dipoles—or, a group of positive and negative charge pairs. This dipole collection accelerates along the curved trajectory of the light pulse, resulting in the emission of synchrotron radiation, according to Henstridge, who earned her doctoral degree at U-M and is now a postdoctoral scientist at the Max Planck Institute for the Structure and Dynamics of Matter in Hamburg, Germany.

The researchers' device produces synchrotron radiation that contains many [terahertz frequencies](#) because the light pulses travel just a fraction of a circle. But they hope to refine their device so that the [light pulse](#) revolves continuously along a

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