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Harnessing Quantum Light Science for Tabletop X-Ray Lasers, with Applications in Nanoscience and Nanotechnology

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Ever since the invention of the laser over 50 years ago, scientists have been striving to create an X-ray version of the laser. The X-ray sources we currently use in medicine, security screening, and science are in essence the same X-ray light bulb source that Rntgen used in 1895. In the same way that visible lasers can concentrate light energy far better than a light bulb, a directed beam of X-rays would have many useful applications in science and technology. The problem was that until recently, we needed ridiculously high power levels to make an x-ray laser. To make a practical, tabletop-scale, X-ray laser source required taking a very different approach that involves transforming a beam of light from a visible femtosecond laser into a beam of directed X-rays. The story behind how this happened is surprising and beautiful, highlighting how powerful our ability is to manipulate nature at a quantum level. Along the way, we also learned to generate the shortest strobe light in existence - fast enough to capture the fastest attosecond electron dynamics in materials. We also learned how to achieve sub-wavelength spatial resolution at soft X-ray wavelengths for the first time. These new capabilities are already impacting nano and materials science, as well as showing promise for next-generation electronics, data and energy storage devices.

Reference: J. Miao, T. Ishikawa, I. K. Robinson, and M. M. Murnane,“Beyond Crystallography: Diffractive Imaging with Coherent X-ray Sources,” *Science* **348**, 530 (2015).

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