Quantum-device-based novel coherent terahertz light source – Science Advances

Terahertz light sources are critical in advancing a wide range of scientific and technological fields due to their unique ability to probe and manipulate matter at the molecular and atomic levels. Unlike visible light, terahertz radiation can penetrate materials like plastics, textiles, and biological tissues without causing damage, making it invaluable for applications in imaging, spectroscopy, homeland security, and material characterization. Additionally, terahertz light sources are essential for the development of high-speed wireless communication systems and quantum computing technologies, where precise control of quantum states is necessary. The ability to generate and manipulate terahertz waves opens new frontiers in medical diagnostics, security screening, and fundamental research in condensed matter physics, further driving innovation in these areas.

However, the generation and control of THz radiation are technically challenging due to the "THz gap"—a region between the microwave and infrared parts of the electromagnetic spectrum where traditional techniques become less effective. This gap necessitates sophisticated and often costly equipment, such as high-power lasers and specialized nonlinear materials. As a result, THz light sources are rare and difficult to develop, making the pursuit of effective and accessible THz technology a critical area of ongoing research and development. This is especially true for so-called coherent THz sources, which behave similarly to lasers, emitting nearly monochromatic photons with similar properties. Due to their similarity to light-based LASERs (Light Amplification by Stimulated Emission of Radiation), such devices are called TASERs.

The authors of the paper described here sought a solution to this problem by investigating new materials. They demonstrated in the prestigious journal *Science Advances* that in nitrogen-doped diamond, a high magnetic field and external optical irradiation creates an energy structure that exhibits a population inversion similar to that found in lasers. They provided evidence for the emission of coherent terahertz radiation from this structure. The use of diamond as a system is particularly interesting as it is a very stable material, resistant to environmental effects, and has become widely used in recent years as a quantum information storage and transmission element. In addition to the experimental implementation, the authors supported the phenomenon with detailed theoretical calculations. The authors hope that the realized system will not only contribute to the development of new terahertz light sources but also serve as a building block for future quantum optical networks. The article was achieved through international collaboration, but all the authors are Hungarian.

Alongside the BME, the HUN-REN Wigner RCP, the University of Notre Dame (USA), and the École Polytechnique Fédérale de Lausanne (Switzerland) contributed to the work. Its first author, Sándor Kollarics, recently obtained his PhD degree in the *Doctoral School of Physical Sciences* of the *Faculty of Natural Sciences* at the BME.

Availability of the publication:

Terahertz emission from diamond nitrogen-vacancy centers

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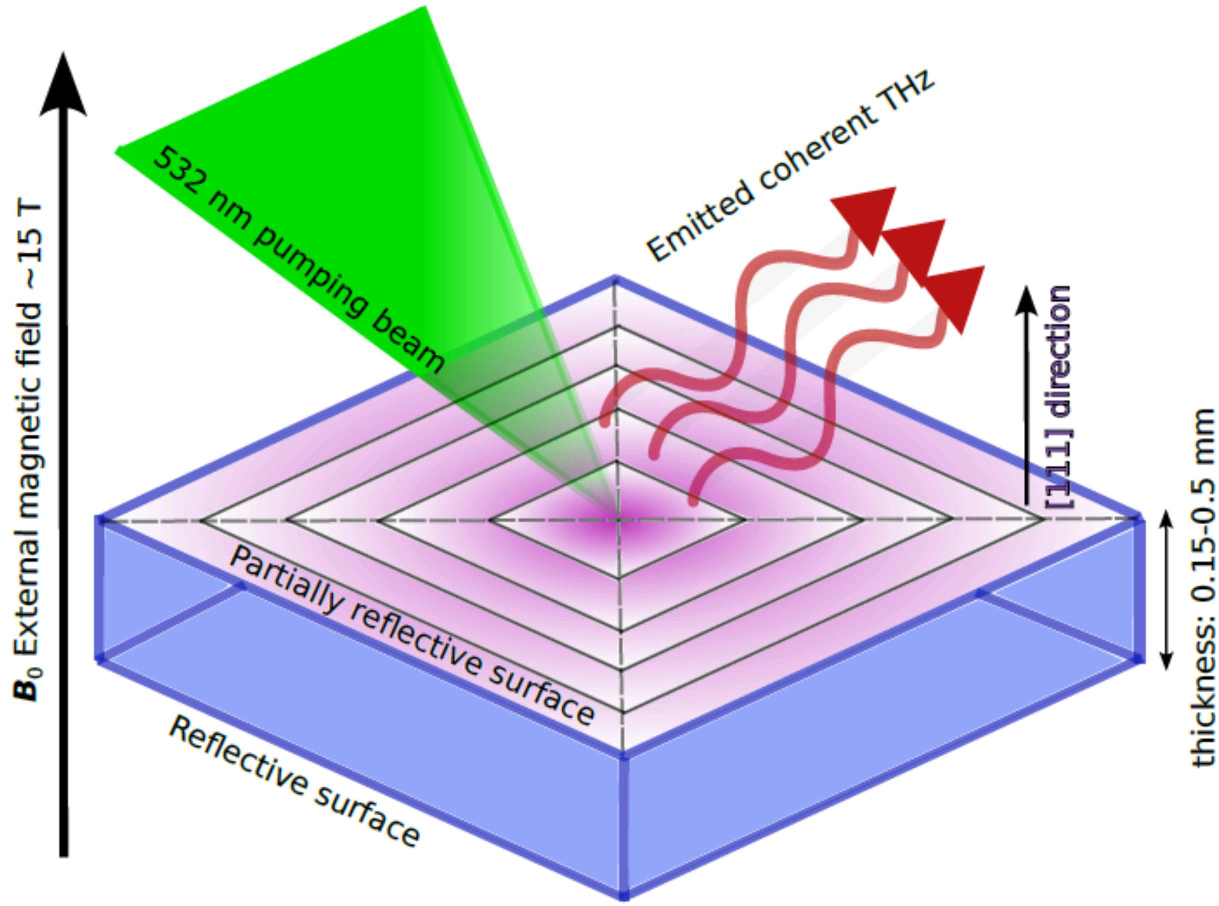

Proposed construction of a 0.4 THz TASER.