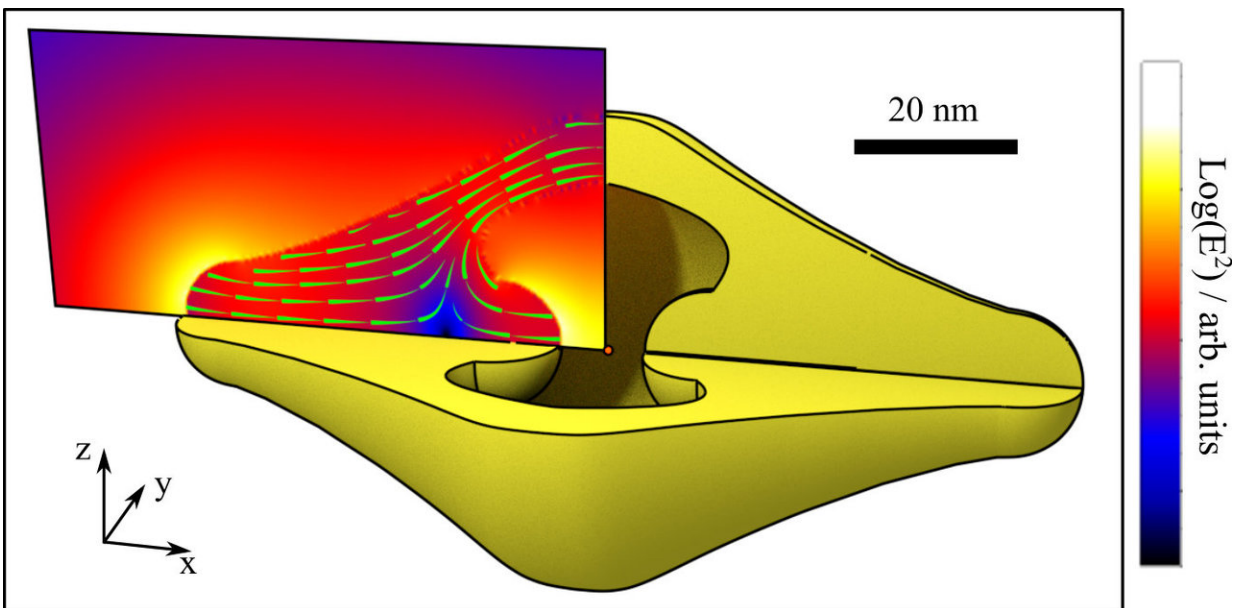


Targeted creation and control of photons: thanks to a new design for optical antennas

December 12 2017



Sketch of an optimized optical antenna: A cavity is located inside; the electrical fields during operation are coded by the colour scale. Current patterns are represented by green arrows. Credit: Thorsten Feichtner

Atoms and molecules can be made to emit photons. However, without external intervention, this process is inefficient and undirected. If it was possible to influence the process of photon creation in terms of efficiency and emission direction, new technical possibilities would be possible, including tiny, multifunctional light pixels that could be used to build three-dimensional displays or reliable single-photon sources for

quantum computers or optical microscopes to map individual molecules.

Nanometre-sized "[optical antennas](#)" are a well-known approach. They are capable of sending photons in a specific direction with high efficiency. The idea goes back to Nobel Laureate Richard P. Feynman who envisioned nanoscale antennas during a speech at the California Institute of Technology in 1959.

Feynman was way ahead of his time, but he inspired rapid development in nanotechnology, which enables building antennas for visible light today. The dimensions and structural details of such antennas can be controlled precisely at a size of around 250 nanometres.

The deficits of existing light antennas

The form of these optical antennas has previously been inspired by established models from radio communication and radio technology, which are usually made of specially shaped metal wires and metal rod arrays for wavelengths in the centimetre range. It is possible to construct antennas for light waves using metal nanorods to influence the creation and propagation of photons, but the analogy between radio waves and light waves is limited.

While macroscopic radio antennas have a high-frequency generator connected to the antenna via cable, the link at the nanometre scale of a light wave length has to be contactless. But atoms and molecules that act as photon sources do not feature connecting cables to hook them up to an optical antenna.

It is this major difference, combined with a number of other challenges caused by the high frequency of light, that has made it difficult thus far to produce and subsequently control photons with optical antennas in a satisfactory manner.

Physicists from Julius-Maximilians-Universität (JMU) Würzburg in Bavaria, Germany, have now solved this problem and established a set of rules for optimized optical antennas, which were published in *Physical Review Letters*.

The new rules could result in antennas for light enabling precise control of photon emission and subsequent propagation, at least theoretically, according to Thorsten Feichtner, a researcher at JMU's Institute of Physics in Professor Bert Hecht's team.

The principle behind the new antennas

"The idea behind this is based on the principle of similarity," the Würzburg physicist explains. "What's new in our research is that the currents of the free electrons in the antenna have to fulfil two similarity conditions at the same time. Firstly, the current pattern in the antenna must be similar to the field lines in the direct vicinity of a light-emitting atom or molecule. Secondly, the current pattern must also match the homogeneous electrical field of a plane wave as best as possible so that each [photon](#) can reach a distant receiver."

The novel antennas for [light](#) built with the help of these new rules extract far more photons from an emitter than previous [antenna](#) types derived from radio technology.

More information: Thorsten Feichtner et al, Mode Matching for Optical Antennas, *Physical Review Letters* (2017). [DOI: 10.1103/PhysRevLett.119.217401](#)

Provided by University of Würzburg

Citation: Targeted creation and control of photons: thanks to a new design for optical antennas (2017, December 12) retrieved 18 April 2024 from <https://phys.org/news/2017-12-creation-photons-optical-antennas.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.