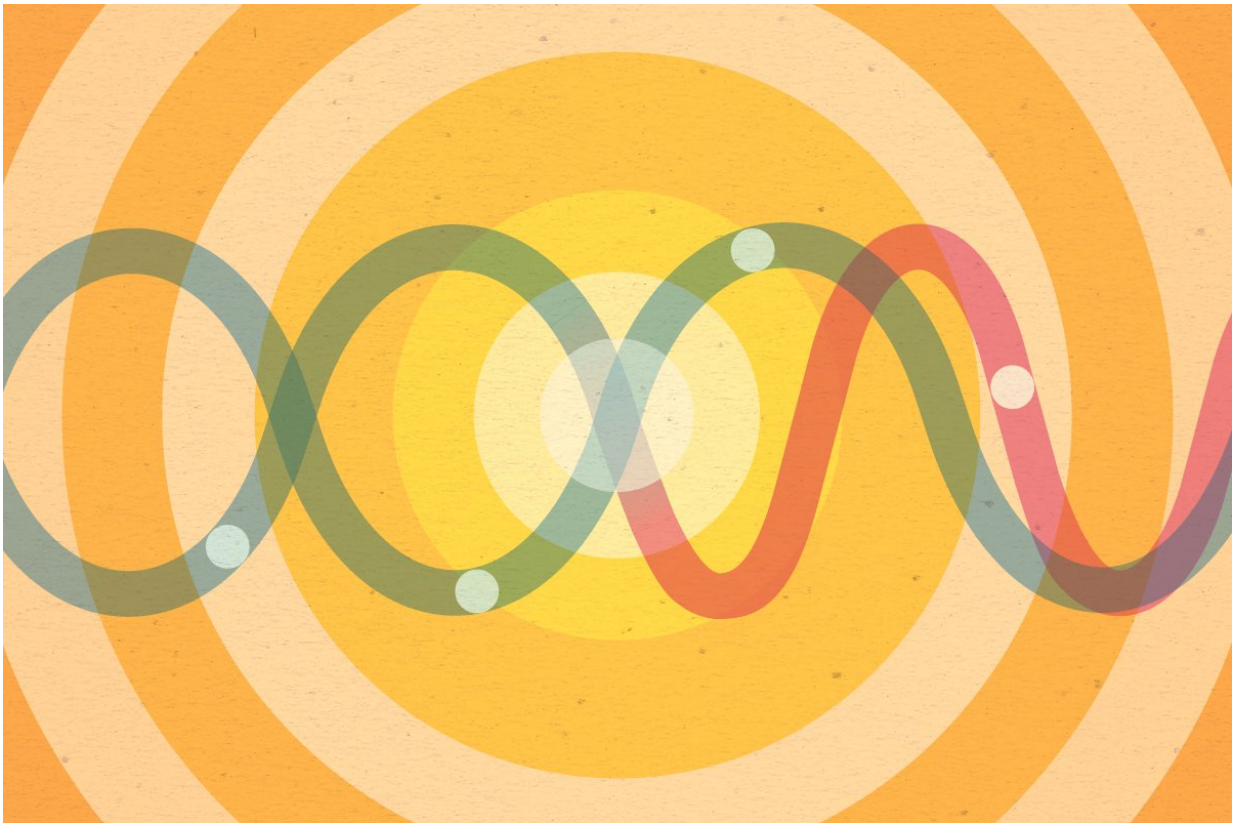


Physicists mix waves on superconducting qubits

November 14 2017



Credit: MIPT

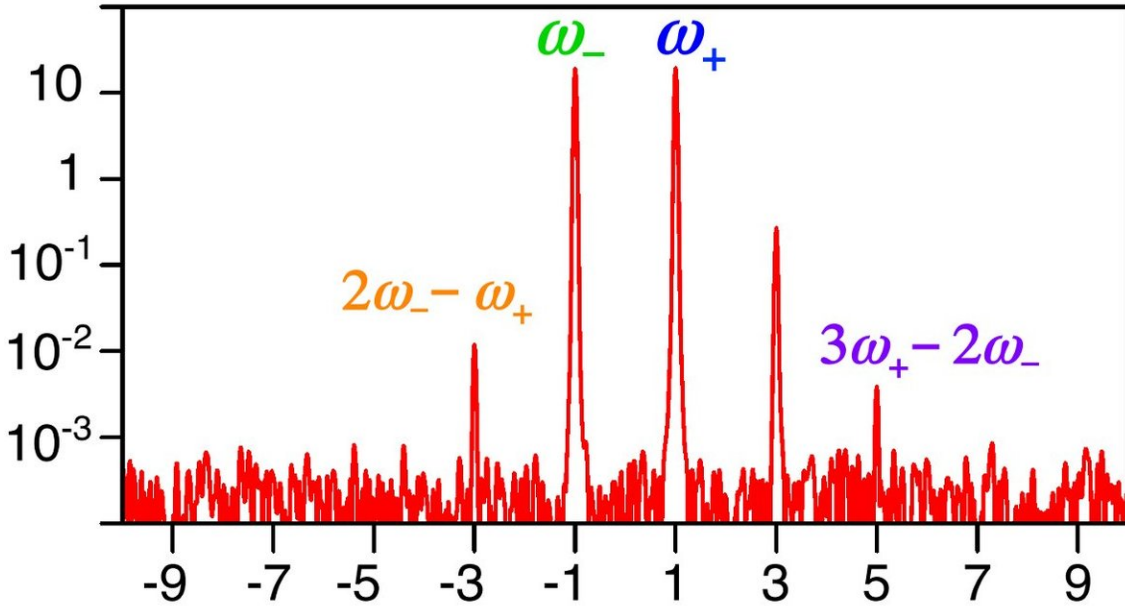
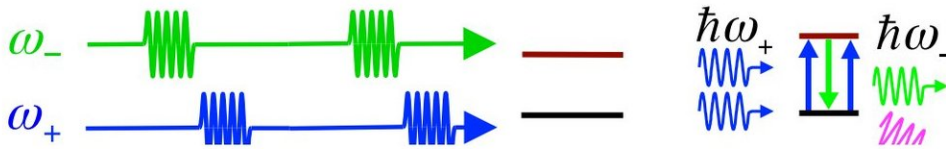
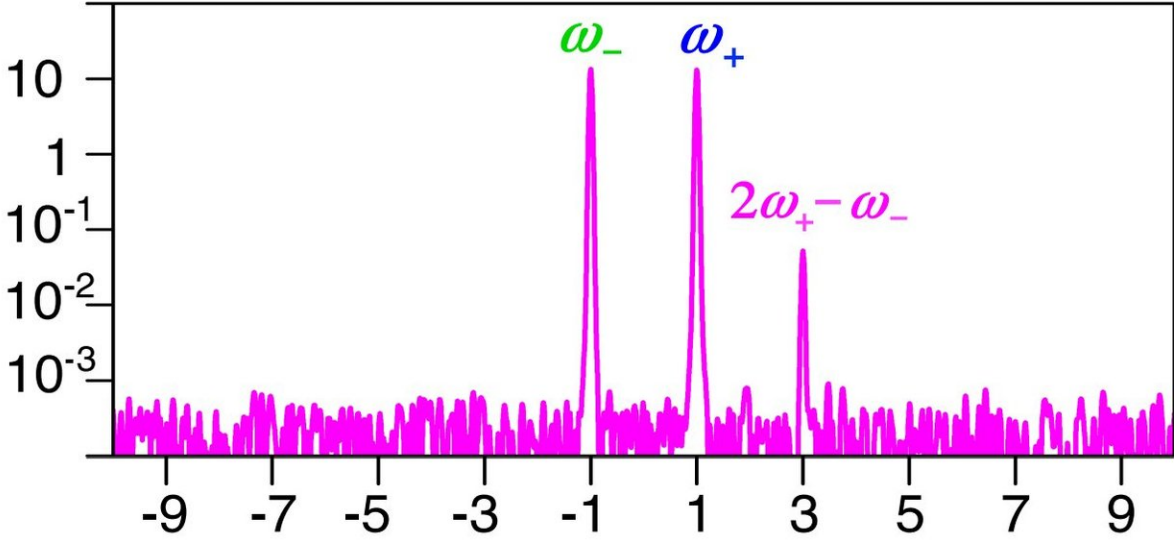
Physicists from the Moscow Institute of Physics and Technology (MIPT) and Royal Holloway, University of London, have demonstrated an effect known as quantum wave mixing on an artificial atom. Their results,

published in the journal *Nature Communications*, could help develop quantum electronics of an entirely new kind.

Researchers from MIT's Laboratory of Artificial Quantum Systems led by Professor Oleg Astafiev teamed up with their British colleagues to examine a superconducting quantum system, which is physically equivalent to a single atom. Cooled to ultra-low temperatures, this device emitted and absorbed a single quanta of microwave radiation—the same way that an atom interacts with photons of light.

Artificial [atoms](#), which are at the heart of this study, are a staple of quantum optics experiments. Physicists use these systems to investigate the processes that are otherwise hard to study, such as the emission and absorption of several photons. Whereas a real atom in a mirror cavity emits light in an arbitrary direction, a superconducting system radiates in a controlled way. This enabled the authors to detect the scattering of several light quanta on an [artificial atom](#), or wave mixing.

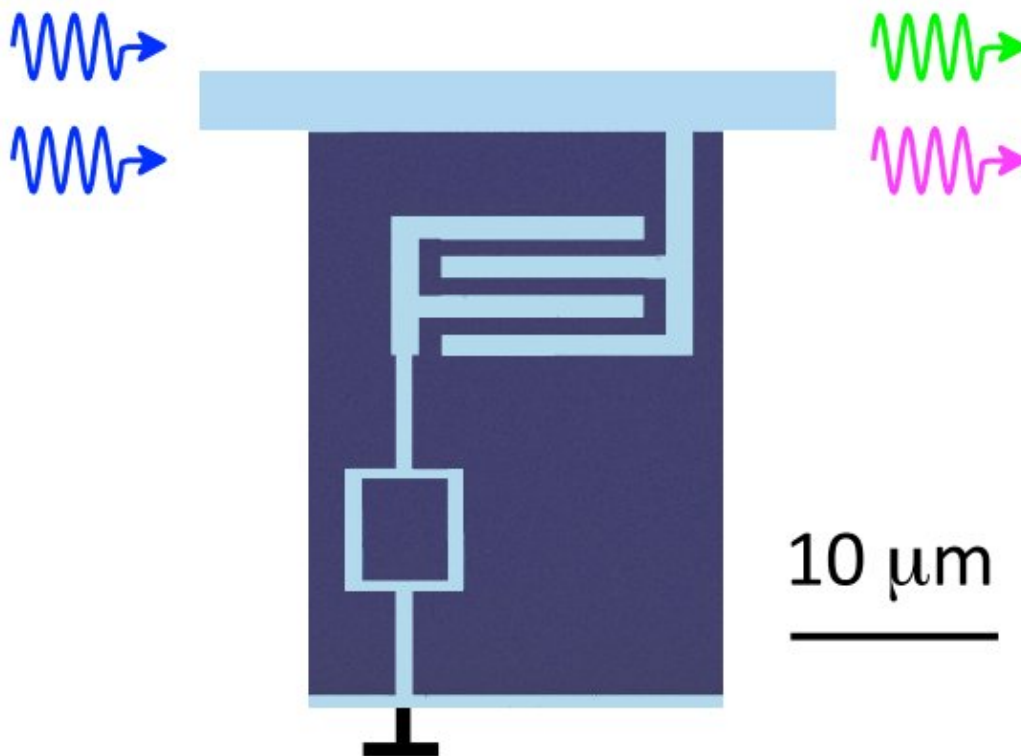
In the output of the system described above, the researchers observed both source radiation and electromagnetic waves resulting from its interaction with the artificial atom. The frequencies of these waves were determined by the nature of the excitation involved. This pointed to the effect of [quantum wave](#) mixing, which had not been observed in systems of this kind before.



The graph above shows the results of the experiment: Wave frequencies are plotted on the horizontal axis against radiation intensity on the vertical axis. The two highest peaks correspond to source radiation frequencies. The peaks labeled in pink, orange, and purple are attributed to the phenomenon of quantum wave mixing on a single atom. The top graph illustrates the experiment using an artificial atom with two energy levels, while the bottom graph corresponds to the case with three energy levels. Credit: MIPT

The appeal of superconducting systems goes beyond their capacity to reveal various quantum optical effects. According to the authors of the paper, the artificial atom doubles up as a qubit—the basic element of a quantum computer. Qubits enable computations using basic units of information different from conventional bits. Whereas a classical memory cell stores either a one or a zero, its quantum analog—the qubit—can be in both states at the same time due to a principle known as superposition.

"Our paper reports the findings of an experiment demonstrating unusual wave mixing effects on a single artificial atom in the gigahertz frequency range. We examined a qubit strongly coupled to the electromagnetic field in the transmission line and observed the mixing of the photonic quantum state prepared in the qubit with that of the coherent light in the transmission line," says MIPT doctoral student Aleksei Dmitriev, one of the authors of the study. The physicists point out that the observed effect offers a way of visualizing the quantum state statistics of source photons. This could find application in quantum computing, which has emerged as a hot research field in the recent years.



Signals incoming via an on-chip superconducting stripe are shown in blue. The artificial atom is depicted as a square in the lower left part of the chip. It is coupled to the superconducting stripe and to the ground contact. Credit: MIPT

Quantum computers are based on the notion that a quantum object is capable of being in multiple states simultaneously. This property allows quantum algorithms to be implemented, enabling researchers to tackle problems that are virtually impossible to solve within a reasonable time frame using classical methods. Additionally, [quantum](#) effects are already used in secure data transmission channels that make it impossible to intercept information without the sender and receiver knowing.

More information: A. Yu. Dmitriev et al, Quantum wave mixing and

visualisation of coherent and superposed photonic states in a waveguide,
Nature Communications (2017). [DOI: 10.1038/s41467-017-01471-x](https://doi.org/10.1038/s41467-017-01471-x)

Provided by Moscow Institute of Physics and Technology

Citation: Physicists mix waves on superconducting qubits (2017, November 14) retrieved 24
April 2024 from <https://phys.org/news/2017-11-physicists-superconducting-qubits.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.