Research team exerts electrical control over polaritons, hybridized light-matter particles, at room temperature

April 9 2024

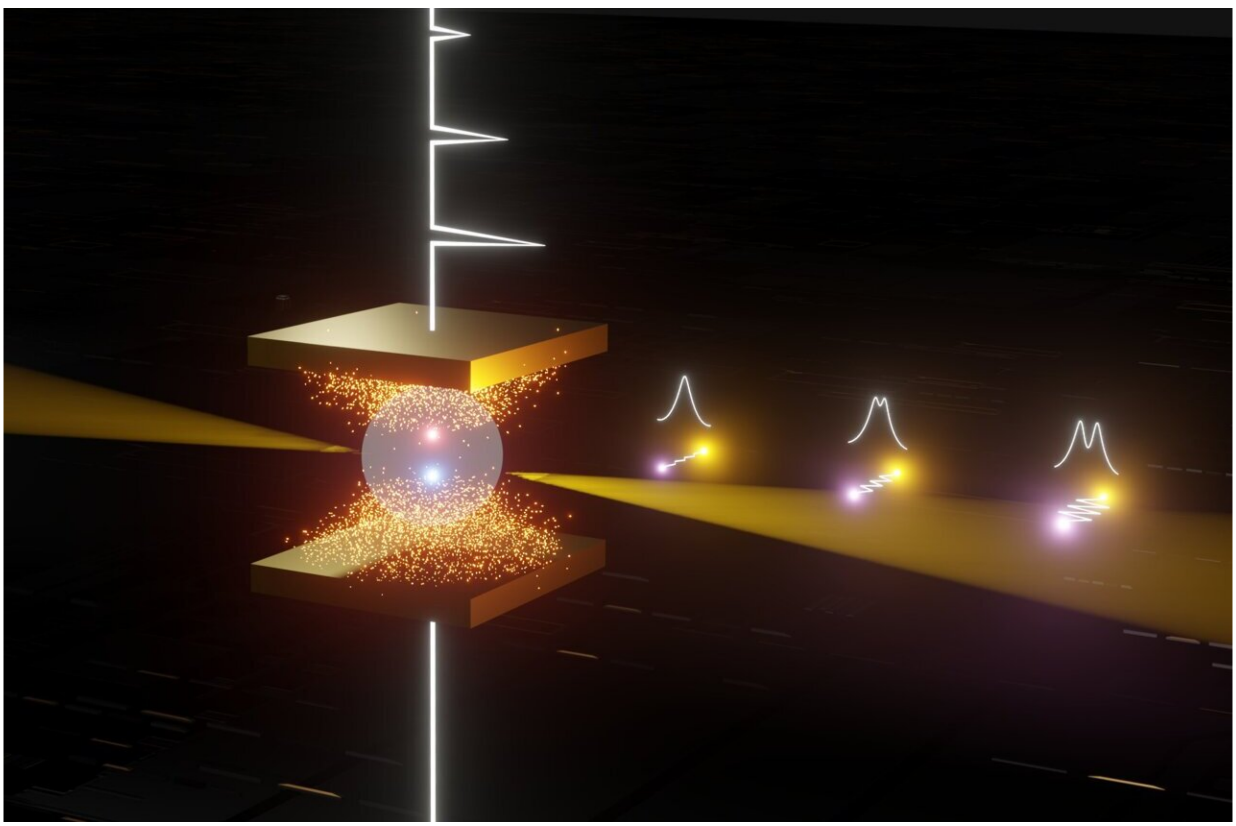

Image depicting the control of polariton particles using electric-field tip-enhanced strong coupling spectroscopy. Credit: POSTECH

A research team has pioneered an innovative technique in ultra-high-resolution spectroscopy. Their breakthrough marks the world's first instance of electrically controlling polaritons—hybridized light-matter particles—at room temperature. The research has been published in *Physical Review Letters*.

Polaritons are "half-light half-matter" hybrid particles, having both the characteristics of photons—particles of light—and those of solid matter. Their unique characteristics exhibit properties distinct from both traditional photons and solid matter, unlocking the potential for next-generation materials, particularly in surpassing performance limitations of optical displays.

Until now, the inability to electrically control polaritons at room temperature on a single particle level has hindered their commercial viability.

The research team has devised a novel method called "electric-field tip-enhanced strong coupling spectroscopy," enabling ultra-high-resolution electrically controlled spectroscopy. This new technique empowers the active manipulation of individual polariton particles at room temperature.

This technique introduces a novel approach to measurement, integrating super-resolution microscopy previously invented by Prof. Kyoung-Duck Park 's team with ultra-precise electrical control. The resulting instrument not only facilitates stable generation of polariton in a distinctive physical state called strong coupling at room temperature but also allows for the manipulation of the color and brightness of the light emitted by the polariton particles through the use of electric-field.

Using polariton particles instead of quantum dots, key materials of QLED televisions, offers a notable advantage. A single polariton particle can emit light in all colors with significantly enhanced brightness. This eliminates the need for three distinct types of quantum dots to produce red, green, and blue light separately.

Moreover, this property can be electrically controlled similar to conventional electronics. In terms of academic significance, the team has successfully established and experimentally validated the quantum confined stark effect in the strong coupling regime, shedding light on a longstanding mystery in polariton particle research.

The team's accomplishment holds profound significance as it marks a scientific breakthrough paving the path for the next generation of research aimed at creating diverse optoelectronic devices and optical components based on polariton technology. This breakthrough is poised to make a substantial contribution to industrial advancement, particularly in providing key source technology for the development of groundbreaking products within the optical display industry including ultra-bright and compact outdoor displays.

Hyeongwoo Lee, the lead author of the paper, emphasized the research's importance, stating that it represents "a significant discovery with the potential to drive advancements across numerous fields including next-generation optical sensors, optical communications, and quantum photonic devices."

The research utilized quantum dots fabricated by Professor Sohee Jeong's team and Professor Jaehoon Lim's team from Sungkyunkwan University. The theoretical model was crafted by Professor Alexander Efros of the Naval Research Laboratory while data analysis was conducted by Professor Markus Raschke's team from the University of Colorado and Professor Matthew Pelton's team from the University of

Maryland.

Yeonjeong Koo, Jinhyuk Bae, Mingu Kang, Taeyoung Moon, and Huitae Joo from POSTECH's Physics Department carried out the measurement work.

More information: Hyeongwoo Lee et al, Electrically Tunable Single Polaritonic Quantum Dot at Room Temperature, *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.133001

Provided by Pohang University of Science and Technology