Scientists show that quantum infrared spectroscopy can achieve ultra-broadband spectroscopic measurements

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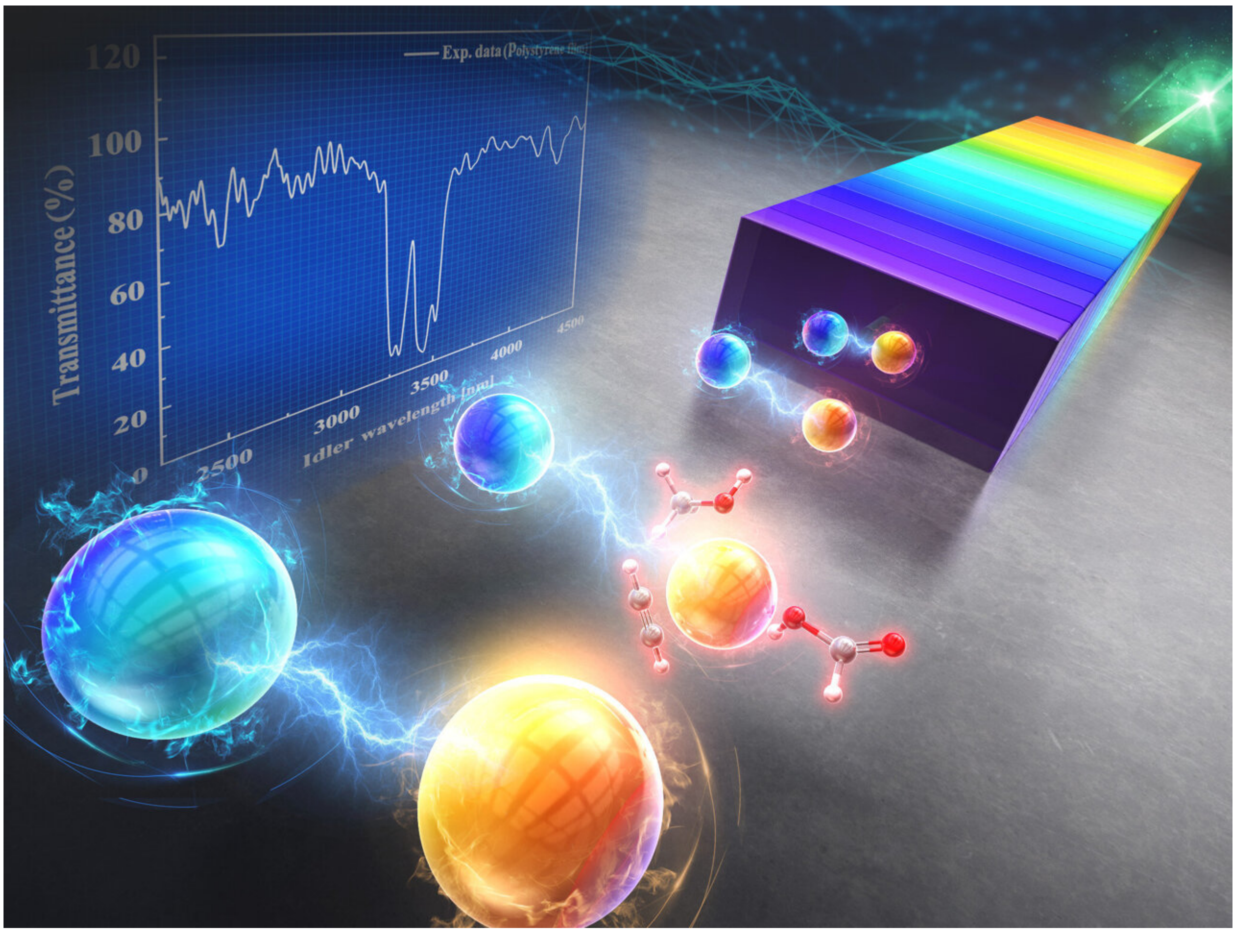

Quantum infrared spectroscopy using ultra-broadband entangled photons. Credit: KyotoU/Shigeki Takeuchi

Our understanding of the world relies greatly on our knowledge of its constituent materials and their interactions. Recent advances in materials science technologies have ratcheted up our ability to identify chemical substances and expanded possible applications.

One such technology is infrared spectroscopy, used for molecular identification in various fields, such as in medicine, environmental monitoring, and industrial production. However, even the best existing tool—the Fourier transform infrared spectrometer (FTIR)—utilizes a heating element as its light source. Resulting detector noise in the infrared region limits the devices' sensitivity, while physical properties hinder miniaturization.

Now, a research team led by Kyoto University has addressed this problem by incorporating a quantum light source. Their innovative ultra-broadband, quantum-entangled source generates a relatively wider range of infrared photons with wavelengths between 2 µm and 5 µm. The research is published in the journal *Optica*.

"This achievement sets the stage for dramatically downsizing the system and upgrading infrared spectrometer sensitivity," says Shigeki Takeuchi of the Department of Electronic Science and Engineering.

Another elephant in the room with FTIRs is the burden of transporting mammoth-sized, power-hungry equipment to various locations for testing materials on-site. Takeuchi eyes a future where his team's compact, high-performance, battery-operated scanners will lead to easy-to-use applications in various fields such as environmental monitoring, medicine, and security.

"We can obtain spectra for various target samples, including hard solids, plastics, and organic solutions. Shimadzu Corporation—our partner that developed the quantum light device—has concurred that the broadband measurement spectra were very convincing for distinguishing substances for a wide range of samples," adds Takeuchi.

Although quantum entangled light is not new, bandwidth has thus far been limited to a narrow range of 1 μm or less in the infrared region. This new technique, meanwhile, uses the unique properties of quantum mechanics—such as superposition and entanglement—to overcome the limitations of conventional techniques.

The team's independently developed chirped quasi-phase-matching device generates quantum-entangled light by harnessing chirping—gradually changing an element's polarization reversal period—to generate quantum photon pairs over a wide bandwidth.

"Improving the sensitivity of quantum infrared spectroscopy and developing quantum imaging in the infrared region are part of our quest to develop real-world quantum technologies," says Takeuchi.

More information: Toshiyuki Tashima et al, Ultra-broadband quantum infrared spectroscopy, *Optica* (2023). DOI: 10.1364/OPTICA.504450

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