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Quantum-enhanced measurements of molecular concentration and chirality using entangled photon pairs

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Abstract

Quantum light, such as entangled photon pairs, is a special state of light that cannot be described by classical electrodynamics. Owing to its nonclassical properties, the use of quantum light can open up new possibilities for optical spectroscopy that are not achievable by classical light sources. In this study, we report the realization of ultrasensitive absorption spectroscopy with quantum-enhanced sensitivity using entangled photon pairs as the light source [1]. This novel approach allows us to obtain absorption spectra with a noise level suppressed below the shot-noise limit, which is a fundamental and unavoidable limit in conventional absorption spectroscopy. We apply the developed method to the absorption measurements of dye solutions containing two different kinds of dye species and demonstrate that the concentration of each dye molecule can be determined with precision beyond the limit of conventional absorption spectroscopy [1]. Furthermore, by utilizing circularly polarized entangled photons instead of linearly polarized ones, we show that molecular chirality measurements based on circular dichroism spectroscopy can also be performed with quantum-enhanced sensitivity [2].

[1] K. Matsuzaki and T. Tahara, *Nat. Commun.* **13**, 953 (2022).
[2] K. Matsuzaki and T. Tahara, *ACS Photonics* **11**, 1376 (2024).