

# Quantum Light Reveals How Solvents Affect Molecules

Pairs of photons provide a gentle way to measure the impact of a molecule's environment on its ultrafast dynamics.

By **Ryan Wilkinson**

Understanding how a molecule's neighbors shape its behavior is essential for explaining chemical reactions and designing molecular systems. Conventional ultrafast spectroscopy can uncover these dependencies. Unfortunately, the technique requires intense laser pulses, which can perturb or damage delicate samples and complicate measurements. Now Tanvir Rajib of Texas A&M University and his colleagues have demonstrated an approach that avoids those problems by using pairs of photons instead of intense laser pulses [1]. Researchers could apply the method to a wide range of chemical, biological, and nanoscale molecular systems.

In the technique, a nonlinear optical crystal transforms laser light into pairs of entangled, identical-frequency photons through a process called spontaneous parametric down-conversion. One photon in each pair interacts with a molecular sample, whose ultrafast molecular dynamics alter that photon's quantum state and, in turn, its indistinguishability

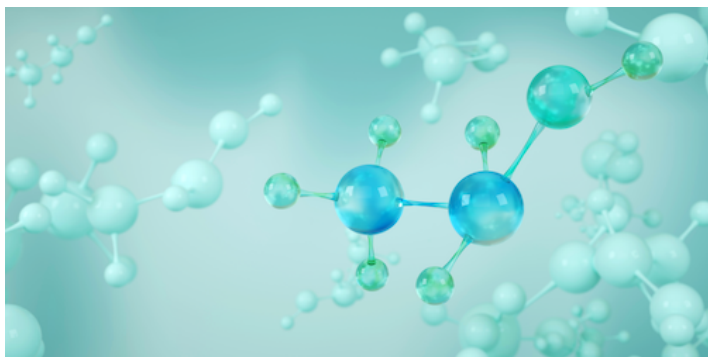
with respect to the other, noninteracting photon. The photons then enter opposite input ports of a four-port beam splitter. How likely they are to emerge from the same output port depends on their indistinguishability through an effect called Hong-Ou-Mandel interference, providing a way to infer the molecular dynamics.

In work published earlier this year, Rajib and his colleagues used the approach to measure a molecule's coherence time—its ability to maintain a definite phase relationship between its different energy states [2]. Now the researchers have studied how that time varies with the molecule's neighbors. They investigated a molecular dye known as IR-797 in five solvents—which provided differing dielectric environments—and found that the coherence time ranged from 25 to 60 femtoseconds. In future work, the researchers plan to optimize the method, boosting its speed, efficiency, and sensitivity.

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## REFERENCES

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2. T. I. Rajib *et al.*, “Quantum-light probe for molecular femtosecond dephasing in dyes,” *Phys. Rev. A* **113**, 033725 (2026).



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