

Quantum Light Leaves Its Fingerprint on Electrons

When intense quantum light knocks electrons out of atoms, the statistics of the light can be transferred to the electrons.

By **Ryan Wilkinson**

Strong-field ionization—a process in which intense laser light strips electrons from atoms or molecules—provides a way to track electron dynamics on ultrashort timescales. So far, most experiments have used laser light in a coherent state, whose photon number has only small fluctuations. Now Yunquan Liu and his colleagues at Peking University have studied strong-field ionization driven by bright squeezed vacuum—a quantum state of light that has large photon-number fluctuations [1]. The team’s findings show that these fluctuations can be imprinted on the number of emitted electrons, offering a tool for probing and controlling electron motion.

Liu and his colleagues generated pulses of bright squeezed vacuum using a pair of nonlinear optical crystals and focused the light onto a jet of xenon atoms. They measured each pulse’s intensity as well as the energies and momenta of electrons emitted by the atoms. Next, they determined how the probability of electron emission depended on the photon number. This step enabled them to obtain the distribution in

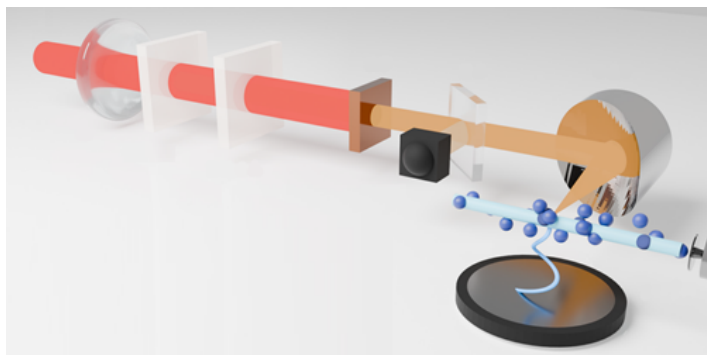
electron yield for each pulse and to quantify how strongly that yield fluctuates.

The electron energy spectra exhibited an upper-energy cutoff that increased roughly linearly with the light’s intensity, as expected for strong-field ionization. More strikingly, fluctuations in the photon number were passed to the electron yield, with the largest photon numbers preferentially leading to the electrons with the highest energies and momenta. “Our results point toward a general paradigm in which bright squeezed vacuum can be harnessed as a resource for ultrafast imaging and spectroscopy,” Liu says.

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REFERENCES

1. H. Liu *et al.*, “Energy- and momentum-resolved single-shot yield fluctuations in bright-squeezed-vacuum-driven atomic strong-field ionization,” *Phys. Rev. Lett.* **137**, 153201 (2026).



Credit: H. Liu *et al.* [1]