

Nonlinear Atomic Tunnelling Boosted by Bright Squeezed Vacuum

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Nonlinear optical processes, mediated by multiphoton interactions rather than single-photon response, are routinely exploited to enable a range of light-based functionalities in devices and applications. Nonlinear effects are enhanced through higher intensity fields, which is a limiting strategy owing to potential radiation damage. An alternative strategy relies on the fluctuation redistribution typical of quantum light, but experimental demonstrations at the most fundamental level have been limited. Here we report experimental nonlinear tunnelling ionization of isolated atoms, a pivotal nonlinear process that drives high-harmonic generation and forms the basis of attosecond science, boosted by quantum light — bright squeezed vacuum (BSV). A BSV light with an average pulse energy of 300 nJ achieves an effective intensity equivalent to that of a coherent light with 7.1 μ J, demonstrating a more than 20-fold quantum boost in nonlinear effect from BSV light. This boost is revealed by matching the peaks of the photoelectron momentum spectra produced by the BSV and coherent light using angular streaking. Furthermore, we demonstrate control of the effective intensity of the BSV by tuning the correlation function at fixed average pulse energy, establishing a robust method to tailor nonlinear processes via quantum statistics rather than classical intensity scaling. These findings may facilitate the development of quantum-controlled strong-field dynamics using tailored quantum light sources [1].

References

- [1] Z Jiang, S Pan, J Chen, *et al.*, Nature **654**, 356 (2026)