Laser Induced Tunneling in Less Than 12 Attoseconds: Instantaneous or Invalid Concept?

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It is typically assumed that electrons can escape from atoms through tunneling when exposed to strong laser fields, but the timing of the process has been controversial, and far too rapid to probe in detail. We have used attosecond angular streaking to place an upper limit of 34 attoseconds and an intensity-averaged upper limit of 12 attoseconds on the tunneling delay time in strong field ionization of a helium atom in the non-adiabatic tunneling regime. This is the fastest process that has ever been measured. To achieve this we exploit the exact timing of a close to circular polarized intense laser field in the two-cycle regime. Our experimental results give a strong indication that there is no real tunneling delay time, which is also confirmed with numerical simulations using the time-dependent Schrödiger equation. We hope that our results will shed some light on the ongoing theoretical discussion and stimulate additional discussions on strong field ionization and tunneling time. Tunneling theories are the standard approach to intense-field ionization and have successfully described high harmonic generation (HHG), quantum path interference in QPI and laser-induced electron tunneling and diffraction. On the other hand, as suggested by Reiss, tunneling may not be the appropriate picture to describe strong field ionization. In a velocity gauge treatment, no tunneling would be involved in the ionization process.