Orientation-selective molecular tunneling ionization by four-color Fourier-synthesized laser fields

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Synopsis We have investigated the quantum control of molecular tunneling ionization by using four-color Fourier-synthesized laser fields.

The manipulation of atoms and molecules by laser fields has progressed rapidly due to the recent advent of techniques to generate intense ultrafast laser pulses. Tunneling ionization (TI) by laser fields is one of the most fundamental phenomena induced by intense laser fields. TI occurs when the laser field suppresses the binding potential of the electron so strongly that the wavefunction of the outermost electron penetrates and escapes the tunneling barrier [1]. Recent studies have revealed that TI occurs mainly in the attosecond (1 attosecond [as] = 10^{-18} s) time region, when the electric field of the laser reaches its maximum values owing to a highly nonlinear optical response [2]. Such highly nonlinear processes depending on the amplitude of the electric fields are strongly affected by the laser's phase. Therefore, so-called coherent or quantum control, which is the direct manipulation of the wavefunction and its quantum dynamics through the coherent nature of a laser field, is expected to be a powerful tool to control the coherent motion of electrons. Recently, we have investigated intense phase-controlled two-color laser fields consisting of a fundamental light and a second harmonic light to achieve quantum control of molecular TI in the space domain and the resultant orientation-selective molecular TI (OSMTI) in simple molecules (Fig.1) [3-10].

Here, we have extended the quantum control of molecular tunneling ionization by using four-color Fourier-synthesized laser fields[11]. The directionally asymmetric molecular TI induced by intense (～10^{13} W/cm^2) Fourier-synthesized laser fields consisting of fundamental, second-, third-, and fourth-harmonic light achieves the OSMTI. We show that the OSMTI is very effective for measurement of the relative phase differences between the fundamental and each harmonic light. Our results promise not only lightwave engineering but also the control of matter, triggering the creation and establishment of usage of Fourier-synthesized laser fields.

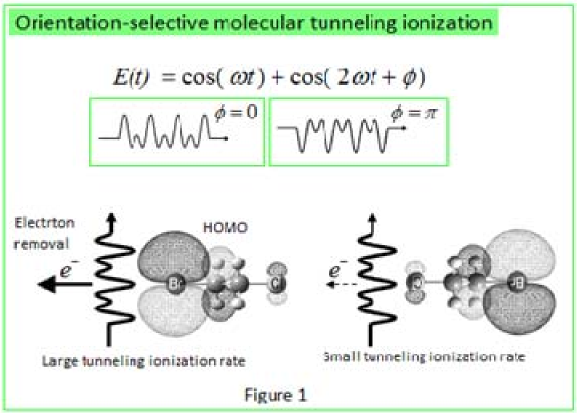

Figure 1. Princeple of orientation-selective molecular tunneling ionization.

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