

## Investigation of the carrier envelope phase effect for molecular ionization

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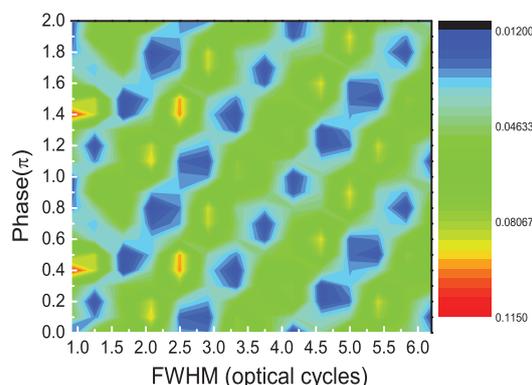
**Synopsis** In the interaction between the matter and the intense laser pulses of which only include a few optical cycles, the carrier envelope phase (CEP) of pulses will play an important role on strong field phenomena, such as the high-order harmonic generation and above threshold ionization *etc.* In this work, we investigated the influence of CEP on the molecular ionization.

As for the interaction between the intense laser pulses whose duration is short and matter, the carrier envelope phase (CEP) of pulses will have a direct effect on the phenomena occur, such as the high-order harmonic generation [1] and above threshold ionization [2] *etc.* The influence of CEP on the ionization of molecules was investigated in this paper. The ionization of molecular ion under the action of a laser pulse is investigated by numerically solving the time-dependent Schrödinger equation by means of the split-operator method [3]. In the calculation, the laser field  $E(t) = E_0 f(t) \sin(\omega(t - t_c) + \varphi)$  is adopted, where  $E_0$  and  $\omega$  are the peak amplitude and central frequency of the laser pulse, respectively.  $\varphi$  refers to the carrier envelope phase and  $f(t)$  is the envelope of the laser pulse. The soft core potential is adopted [4], molecular bond length is 4 atomic units (a.u.), and the energy difference between the ground state and first excited state is 0.079 a.u..

In Fig. 1 we present the ionization yield of molecule as a function of CEP and FWHM of the incident laser pulse. For the pulses with same FWHM, one can clearly distinguish the change of ionization yield with the carrier envelope phase. Especially, one can clearly observe distinct CEP effect for a long pulse. For the pulse with same CEP, there are many dips and peaks for the yield of molecular ionization with the variation of the laser pulse's FWHM. The distances between two peaks or two dips are the same for the different phases of carrier envelope. It should be noted that the CEP positions of yield peaks for molecular ionization increase linearly with the increase of FWHM of laser pulse.

The appearance of such phenomenon can be attributed to the energy levels structure in the molecular ion for the selected wavelength of laser. The ionization rate of the ground state electron is smaller than that of the excited state. The main

contribution to the ionization is the tunnelling from the first excited state. The population of the excited state is closely related to the CEP of the laser pulse [5]. Thus the ionization from the molecular ion is sensitive to the CEP. Using the variation of the molecular ionization, one can detect the phase of carrier envelope.



**Figure 1.** Variation of the ionization yield of molecule with the CEP and FWHM of the laser pulse for the case of  $E_0 = 0.08$  a.u. and  $\omega = 0.0226$  a.u..

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