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# Ionization of atoms and molecules in a strong two-color field

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**Synopsis** We experimentally investigated the asymmetry of photo-ion and photoelectron momentum spectra of argon and nitrogen by ionizing an argon-nitrogen gas mixture in a strong two-color (400 nm + 800 nm) laser field. By changing the time delay between the 400 nm laser pulse and the 800 nm pulse, the fan-like stripes in low-energy electron momentum shift from negative momentum to positive for both argon and nitrogen. A clear difference of asymmetric electron emission between Ar and $N_2$ is observed.

Two-color laser fields, which are synthesized by an 800 nm laser pulse and its second harmonic, have been demonstrated as an ideal tool to control the electronic wavepackets on attosecond time scales [1]. In order to understand the difference of tunnel ionization between different atoms and molecules, we perform an experiment by focusing the two-color laser field into an argon-nitrogen gas mixture in a Reaction Microscope [2].

The second harmonic laser pulse is generated by passing a 25 fs laser pulse at the central wavelength of 800 nm through a BBO crystal. Two color pulses with parallel polarization, overlapped temporally and spatially by using a two-color interferometer, are focused into the Reaction Microscope for ionizing the supersonic gas mixture.

With the above-mentioned experiment setup, we obtain the 3D photo-electron momentum from $N_2$ and Ar. The fan-like stripes in the low momentum region and the Freeman resonances [3] can be clearly observed for both nitrogen and argon electrons. By changing the time delay between the 400 nm laser pulse and the 800 nm laser pulse, the fan-like stripes shift from negative momentum to positive momentum for the two species. Figure 1 shows the asymmetric electron momenta when the relative phase delay between the two color pulses changes from 0.25 $\pi$ to 1.25 $\pi$. The electron momentum from Ar is almost identical to the one from $N_2$, only a minor difference is obtained. As the directional electron emission is strongly modulated with the time-delay between the two-color pulses, we also investigate the asymmetry in the number of counts between electrons emitted with positive and negative longitudinal momentum for nitrogen and argon. A phase difference of asymmetric electron emission at a certain longitudinal momentum (the case of 0.5 a.u. and 0.2 a.u. is shown in Figure 2 (a) and (b), respectively), corresponding to tens of attosecond time delay, is observed between argon and nitrogen. The phase difference between atoms and molecules may help us to investigate the tunnel ionization process and its dependence on small details of the system potential or resonance structure.

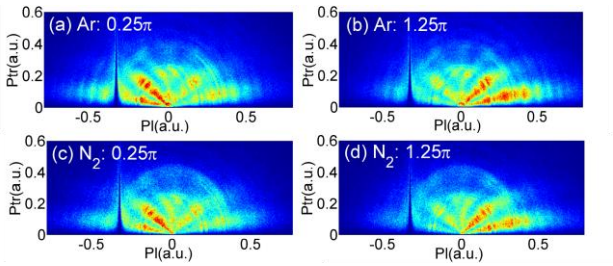



**Figure 1.** Asymmetric electron momentum distribution from $N_2$ and Ar for different relative phase between two-color fields

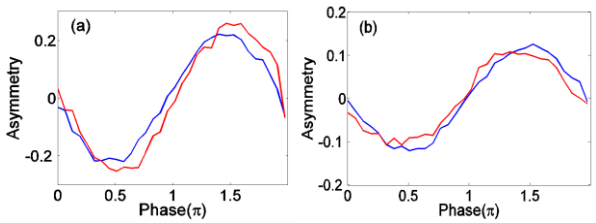



**Figure 2.** Asymmetry of electron emission between Ar (blue) and $N_2$ (red) at a certain longitudinal momentum ( (a) 0.5 a.u. and (b) 0.2 a.u.) as a function of relative phase between 800 nm pulse and 400 nm pulse

## References

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