The possibility for calibrating laser intensity in strong-field-ionization experiments[§]

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Synopsis It is known that the strong-field phenomena depend extremely nonlinearly on the laser intensity. Yet experimentally there is still no simple reliable methods for determining the peak laser intensity within the focused volume. Here we present a simple method, based on an improved Perelomov-Popov-Terent'ev (PPT) model, for calibrating laser intensities from the measured ionization probabilities (or signals) of atoms or molecules. The PPT model is first examined by comparing ionization probabilities (or signals) of atoms and several simple diatomic molecules with those from solving the time-dependent Schrödinger equation. We then show the possibility of using this model to calibrate laser intensities for atoms, diatomic molecules as well as large polyatomic molecules, for laser intensities from the multiphoton ionization to tunneling ionization regimes.

When an atom or molecule is exposed to an intense laser field, a valence electron can be removed by absorbing several photons (so-called multiphoton ionization) or by tunneling through the potential barrier formed by the Coulomb force and the laser field (i.e., tunneling ionization). According to the Keldysh theory [1], these two ionization mechanisms can be distinguished by the Keldysh parameter $\gamma=\sqrt{I_p/2U_p}$, where I_p is the ionization potential and U_p is the ponderomotive energy. The multiphoton ionization dominates if $\gamma > 1$, while tunneling ionization prevails when $\gamma < 1$.

These days, ionization probabilities of atoms and small molecules for a fixed laser intensity have been obtained by solving the time-dependent schrödinger equation mostly based on the single-active-electron approximation (SAE-TDSE). Calculations including all electrons in the atoms or molecules have been performed by using the time-dependent density functional theory (TDDFT), the time-dependent Hartree-Fock (TDHF) theory or the multiconfiguration time-dependent Hartree-Fock (MCTDHF) theory. However, such calculations are quite time-consuming and not practical for calibrating peak laser intensity in a strong-field-ionization experiment especially for large nonlinear molecules. It found that the Ammosov-Delone-Krainov (ADK) [2-4] model works very well in the tunneling ionization regime, while it is invalid in the multiphoton ionization regime. Here we present the improved Perelomov-Popov-Terent'ev (PPT) [5] model for calibrating peak laser intensity.

In this work [5], we first examined carefully the PPT model by comparing with the SAE-TDSE method and the experimental data. We confirmed that The PPT model fits very well all the SAE-TDSE calculations and the experimental data in a wide range covering from the multiphoton and tunneling ionization regimes, while the ADK model fails to work in the multiphoton ionization region. In Fig.1 we show an example for calibrating peak laser intensity by fitting the measured ionization probabilities (or signals) to those from the PPT model.

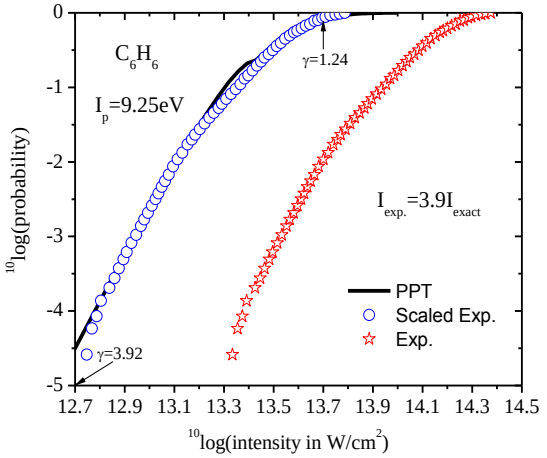

Figure 1. Ionization probabilities of C_6H_6 as a function of laser intensity. The laser is a Gaussian pulse with wavelength of 804 nm and FWHM of 50 fs. Experiment from Ref. [6].

References

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