# Pulse-shape Effects on the Autler-Townes Doublet in Strong-field Ionization of Atomic Hydrogen

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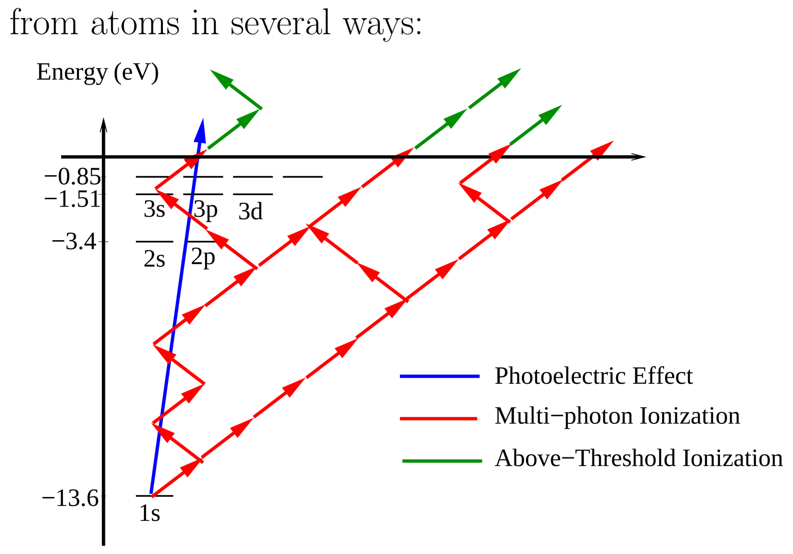
## Abstract

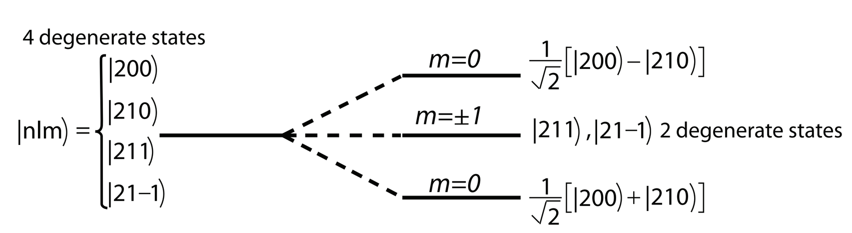
**We have applied a newly developed parallelized computer code to treat the ionization of atomic hydrogen by a strong laser pulse. In particular, we studied the effect of the pulse shape, as well as the peak intensity and the central wavelength, on the theoretical results for the so-called Autler-Townes doublet. While the splitting is well known for the quasi-static case, the *dynamic (time-dependent)* Stark effect studied here is much less understood. The strong dependence on the laser pulse found in this work is not only surprising, but may also be a limiting factor for calibrating absolute laser intensities.**

## Introduction and Motivation

- Very short and intense laser pulses can be used to study the details of (valence) electron interactions in atoms and molecules.
- Typical laser intensities in this field range from $10^{12}$ to $10^{15}$ W/cm$^2$.
- **$10^{14}$ W/cm$^2$ is a million billion times stronger than the radiation that the Earth receives from the Sun directly above us on a clear day.**
- Such intensities can rip electrons away from atoms in several ways:
  - **Multi-photon ionization**
  - **Above-threshold ionization**
  - **Field (tunnel) ionization**




## The Stark Effect




- The Stark effect splits up the energetically degenerate (for fixed $n$) energy levels in atomic hydrogen by the interaction with a strong external electric field.
- The energy splitting is proportional to the electric field strength.
- For linearly polarized light, we can "see" only the two $m = 0$ levels.
- These levels form the "Autler-Townes" doublet in the energy spectrum of the ejected electron.
- We investigate this doublet in two-photon ionization, where the central frequency of the laser is tuned in such a way that it either hits (0.375 a.u. $= 10.2$ eV) or just misses (0.350 a.u.) the $1s \to 2s, 2p$ resonance transition as as stepping stone.
- Also, **we vary the splitting by ramping on/off the pulse**.

## Results

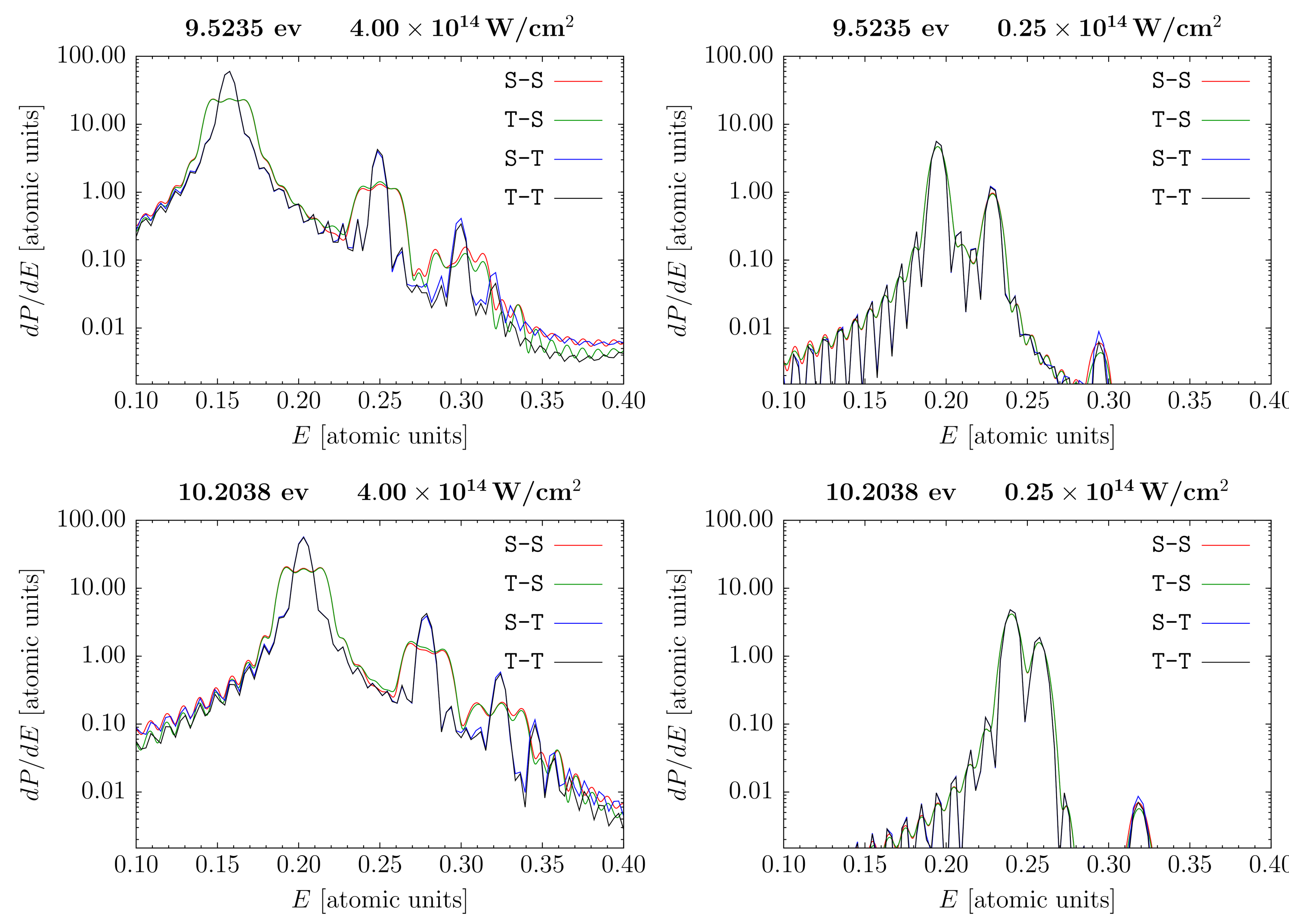



FIG. 1: These plots illustrate that triplet effect depends on the intensity, not on the energy of the laser pulse. Note, this effect is only present for pulses ending with the sin$^2$ envelope. This suggests the shape of the field at the end of the pulse is significant.

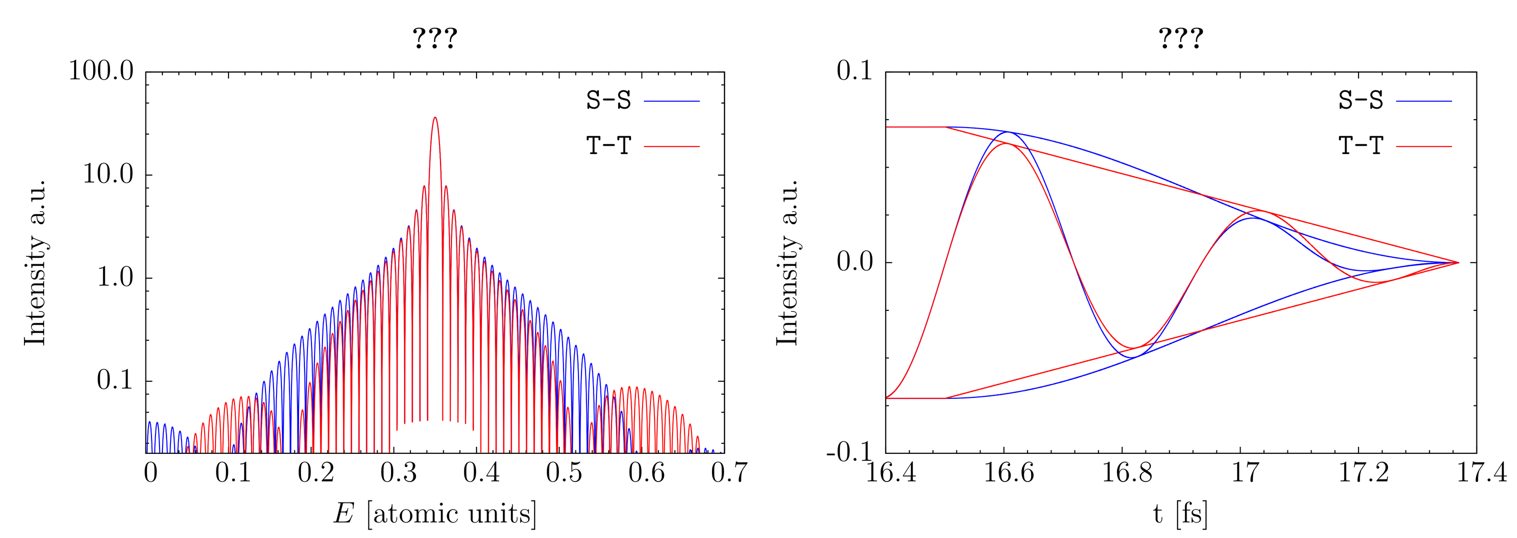



FIG. 2: LEFT:

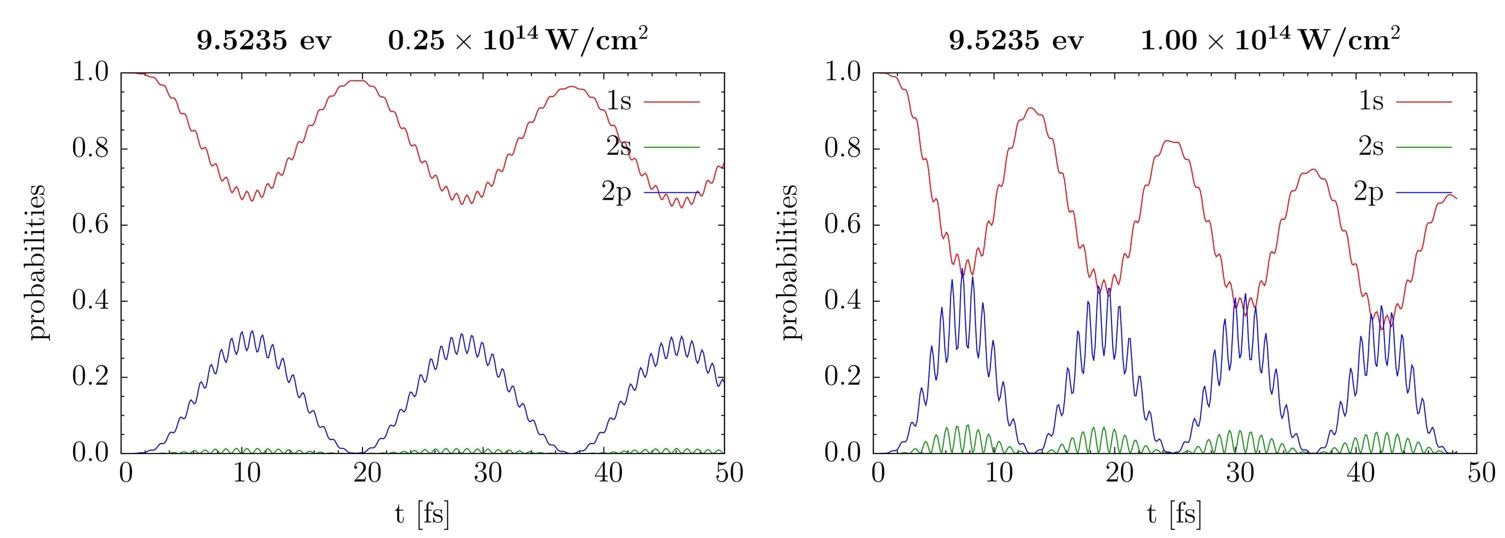



FIG. 3: LEFT:

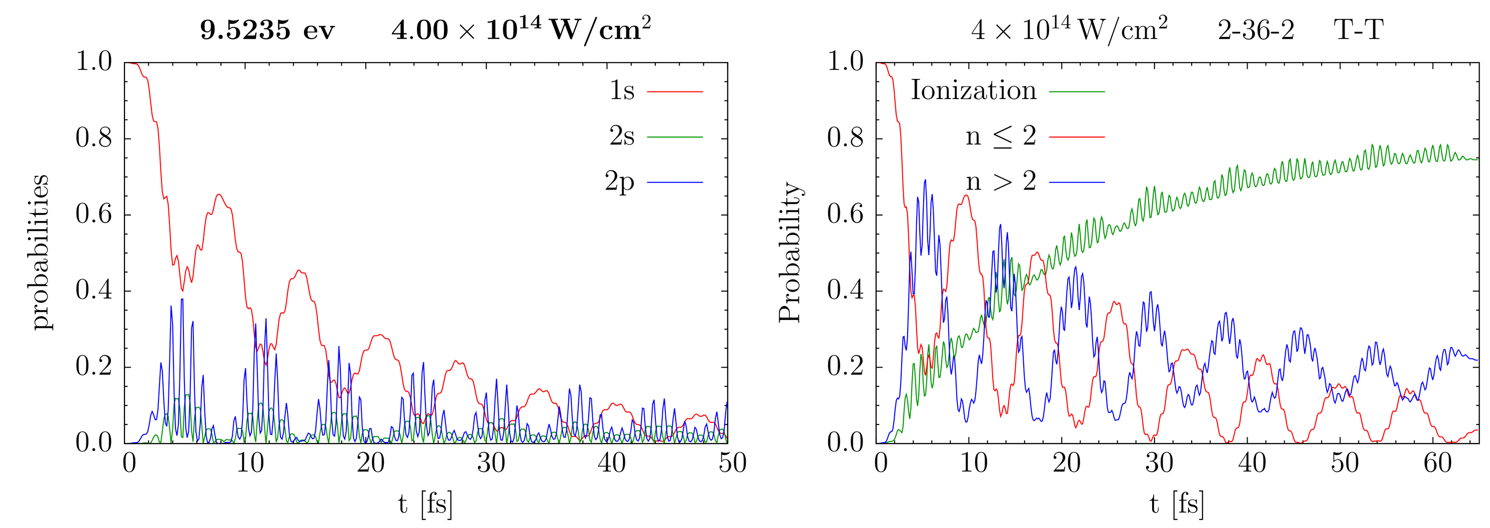



FIG. 4: LEFT:

## Conclusions