Direct and Rescattered Electrons under Ultrafast Laser Pulses

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Introduction

Simulating direct scattering and elastic rescattering of electrons under ultrashort strong laser pulses

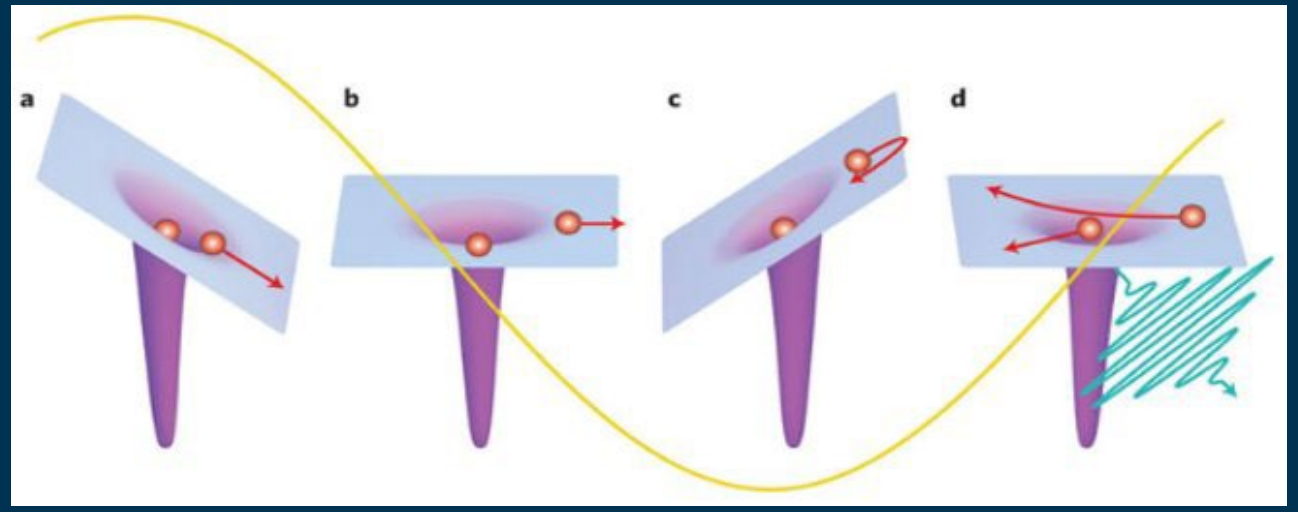
Calculating values such as ionization probability, energy of ionized electron, etc.

Goal is to explain the electron energy spectra for rescattered electrons

What are Direct and Rescattered Electrons?

3-Step Process:

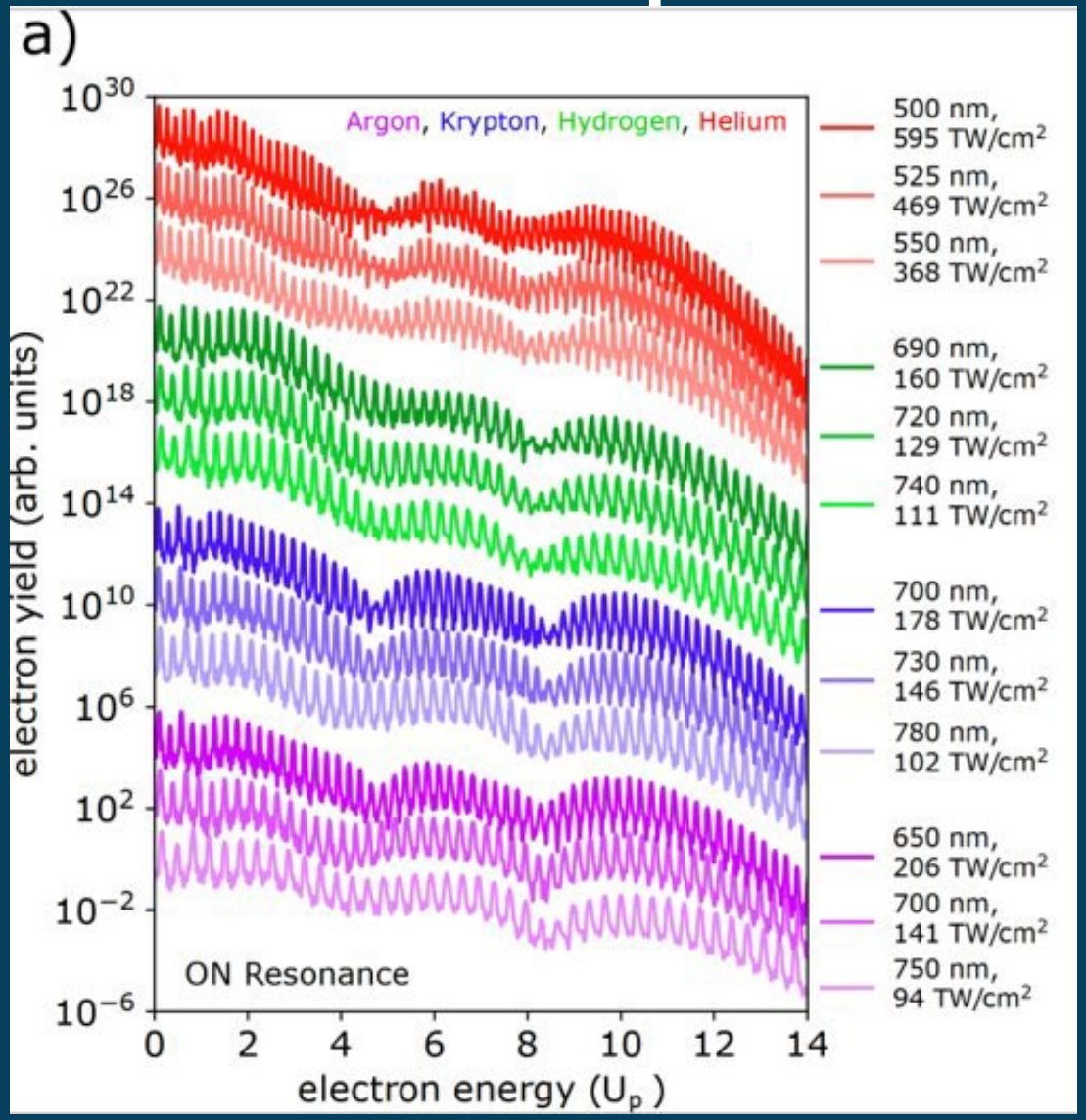
1. Initial Ionization of Electron (Direct process ends here)
2. Change of e-field direction leads to electron acceleration
3. Electron is “rescattered” again after passing through atom

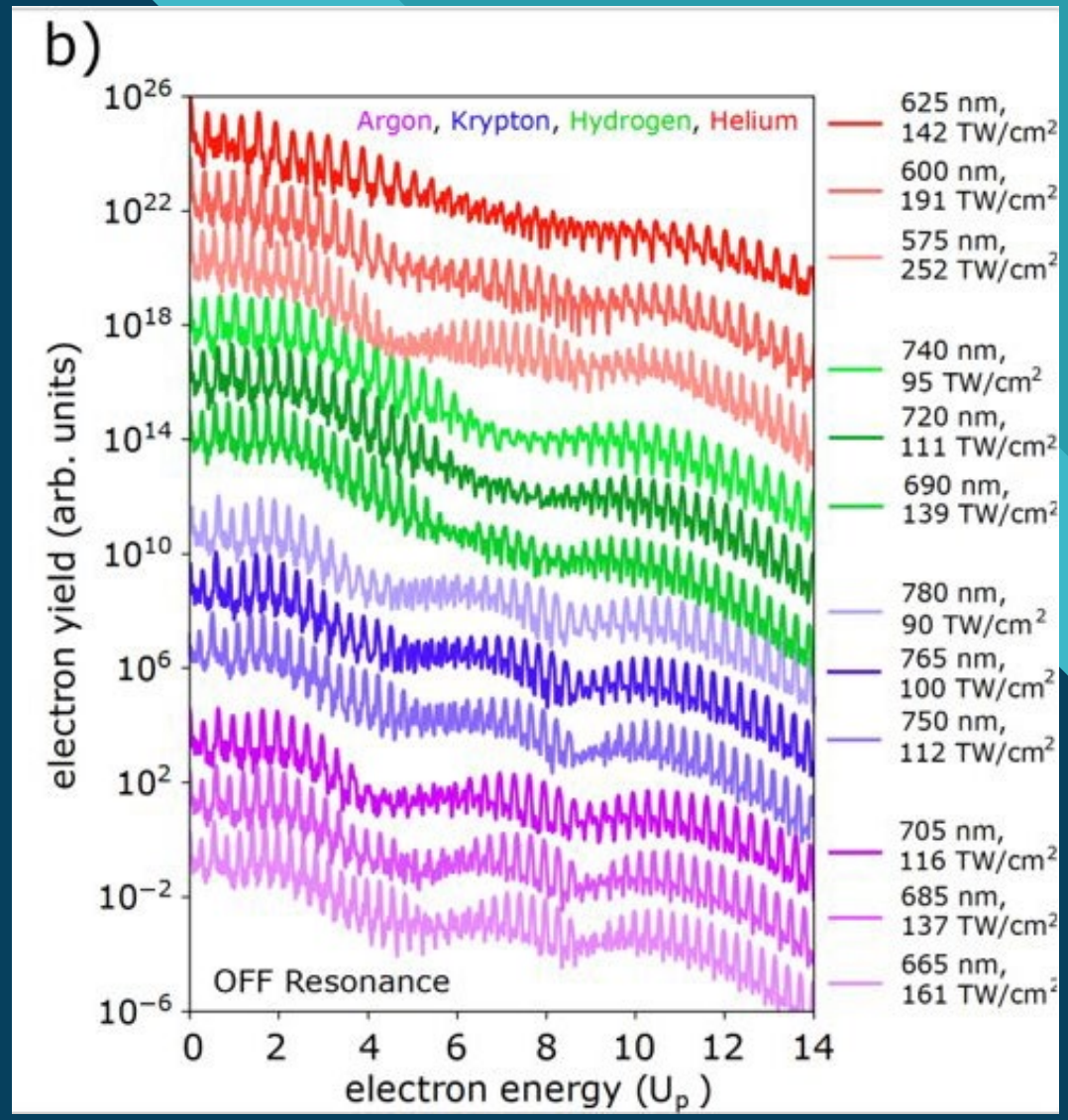


Midorikawa, *Nat. Phot.* **5**, 640 (2011)

Photoelectron Spectra

$$E_k = N\hbar\omega - U_p - IP$$





Modelling of Electron Wavefunction

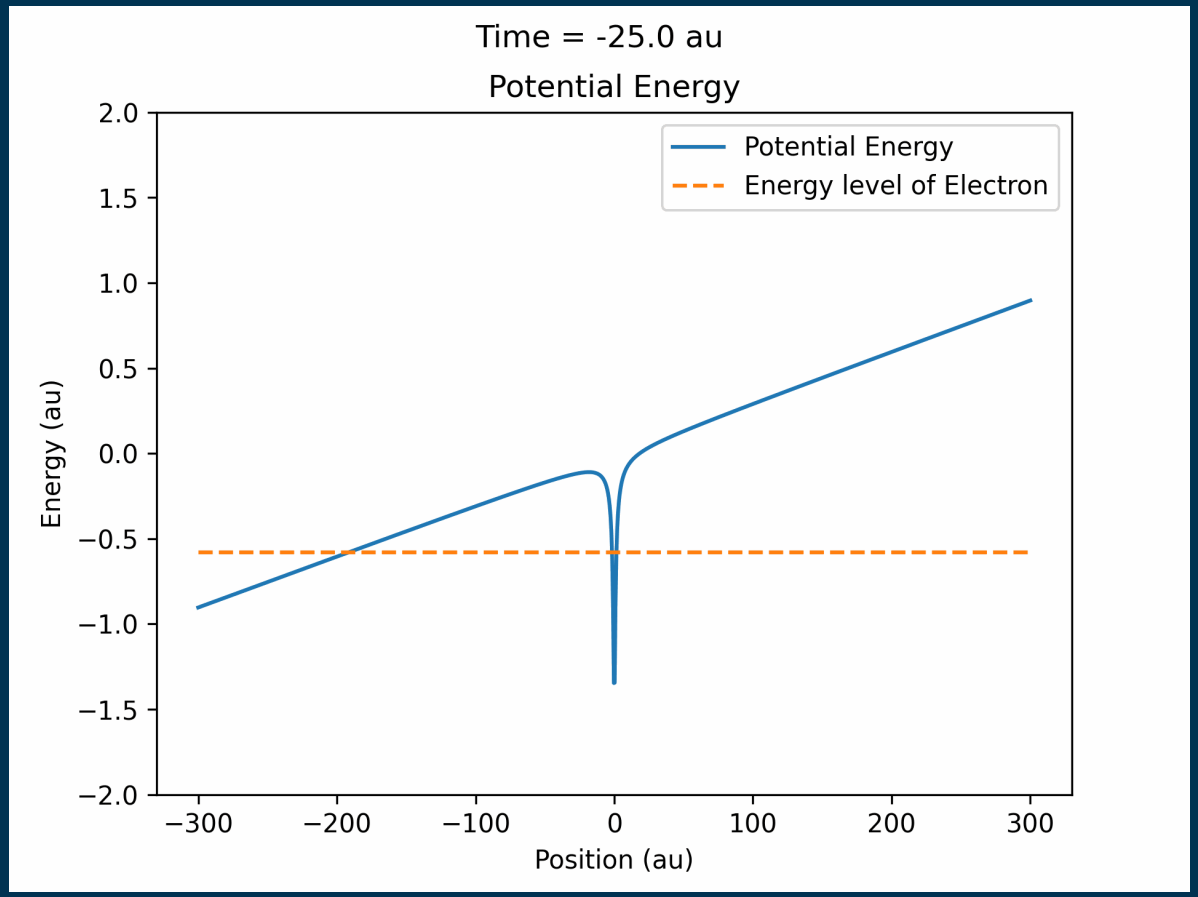
- Numerov Method to calculate stationary states under atomic soft-core potential
  - $V(x) = \frac{-1}{\sqrt{x^2+a^2}}$
- Crank-Nicolson Method to propagate wavefunction over time with TDSE:
  - $-i\hbar\frac{\partial\psi}{\partial t} = \hat{H}\psi$

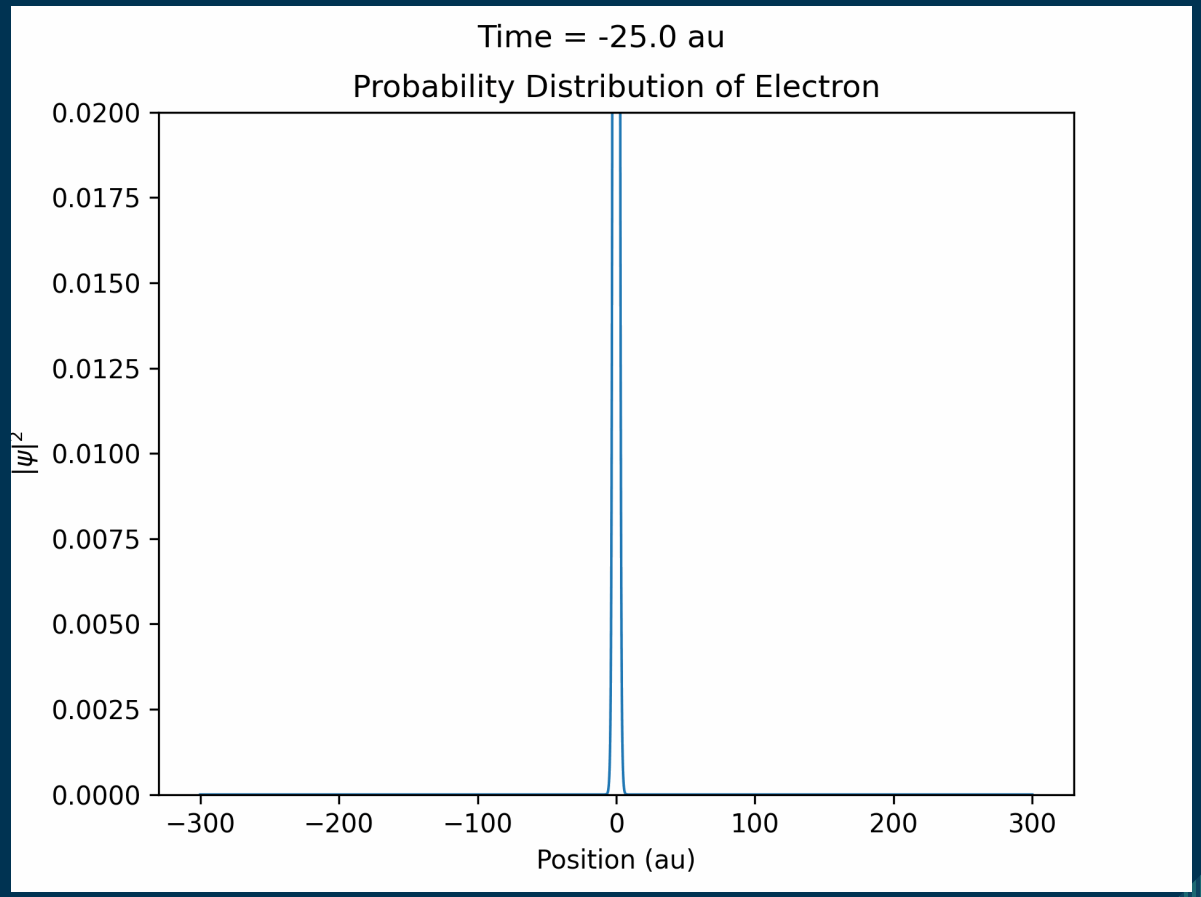
$$\left(1+\frac{i\tau}{\hbar}\hat{H}_{i+1}\right)\psi_{i+1} = \left(1-\frac{i\tau}{\hbar}\hat{H}_i\right)\psi_i$$

B. R. Johnson; *J. Chem. Phys.* (1977).

https://github.com/aychun/Crank-Nicolson-Method-for-Time-Dependent-Schrodinger-Equation

Constant Field Ionization



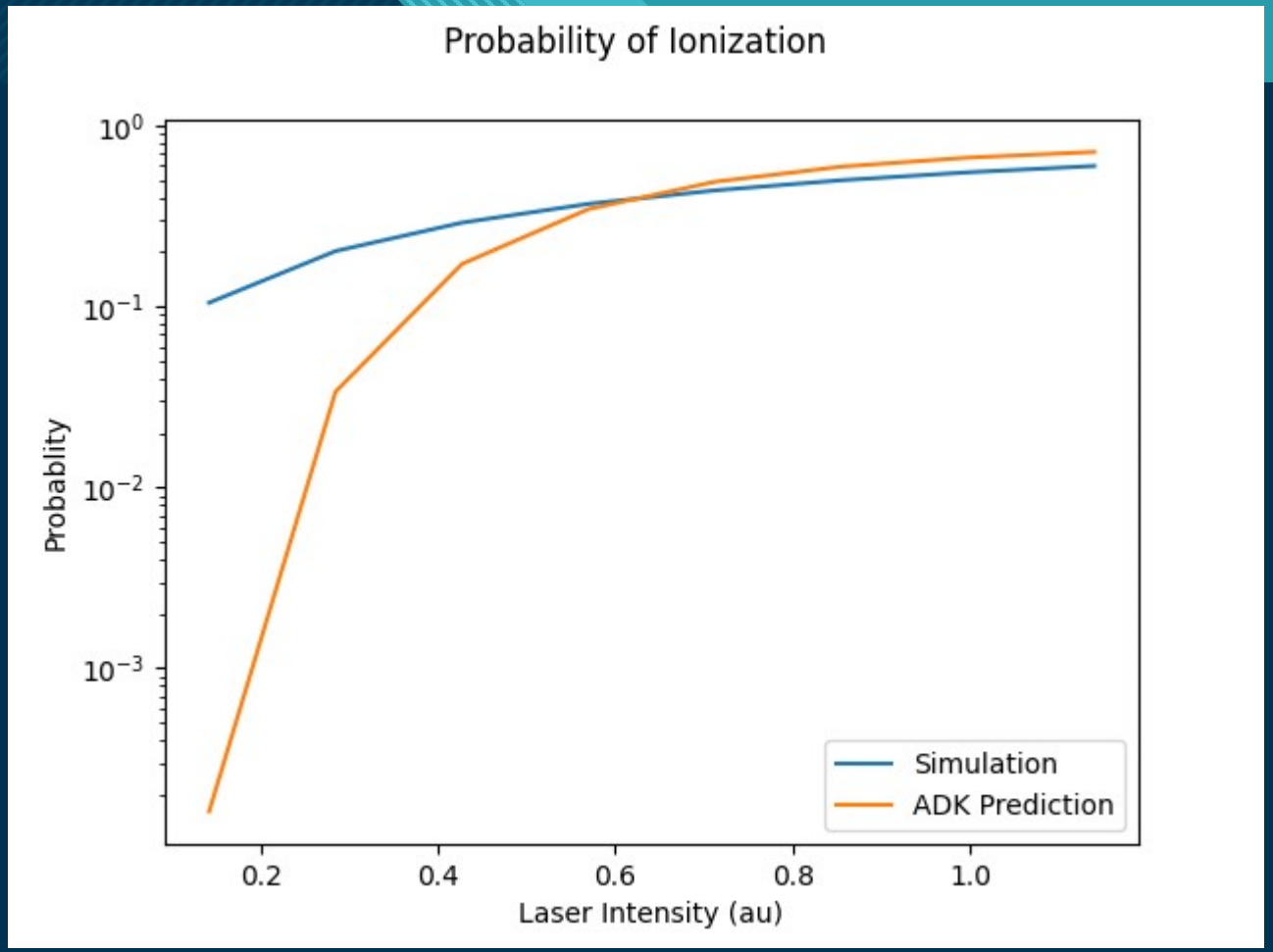


100 TW/cm^2 Constant Laser at Argon

Probability of Ionization

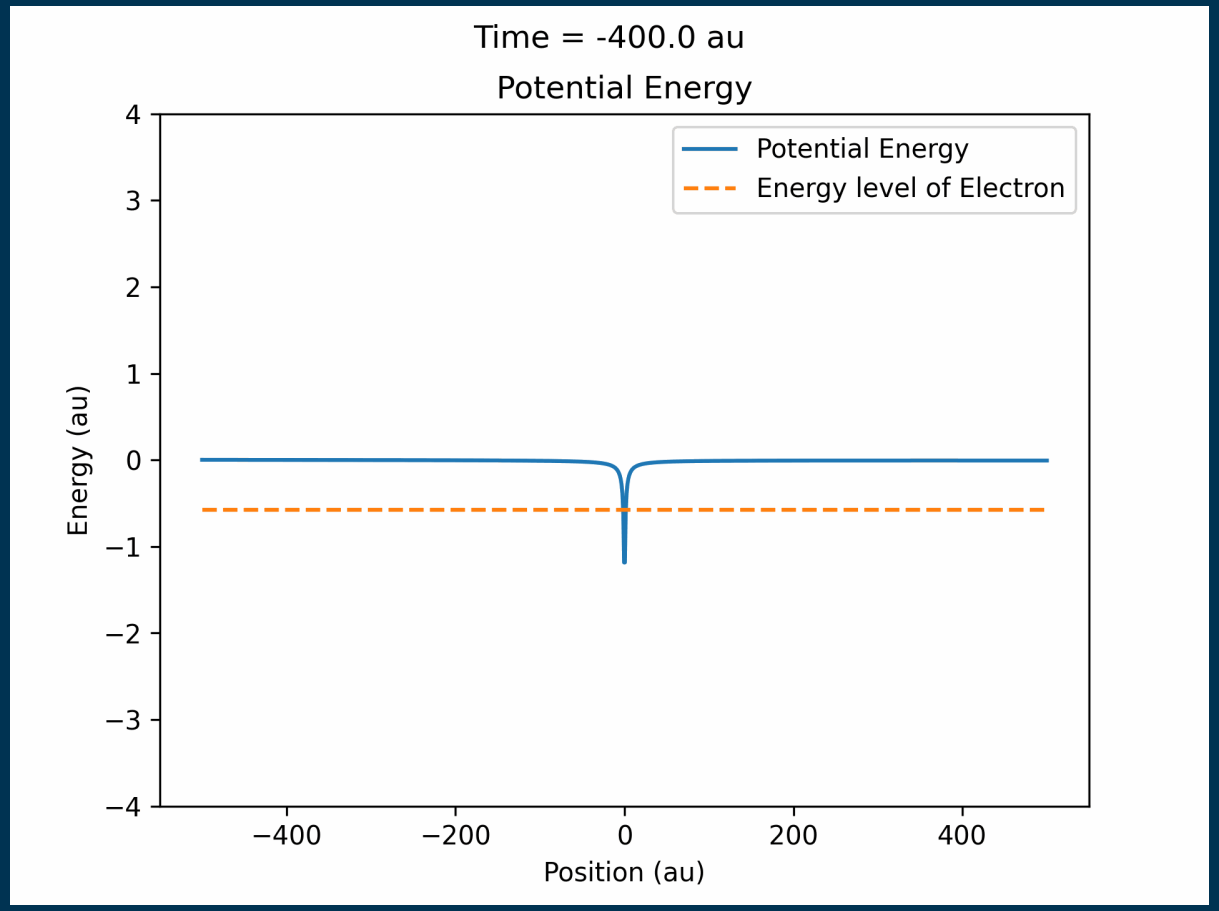
Can calculate probability through finding area of ionized wavepacket

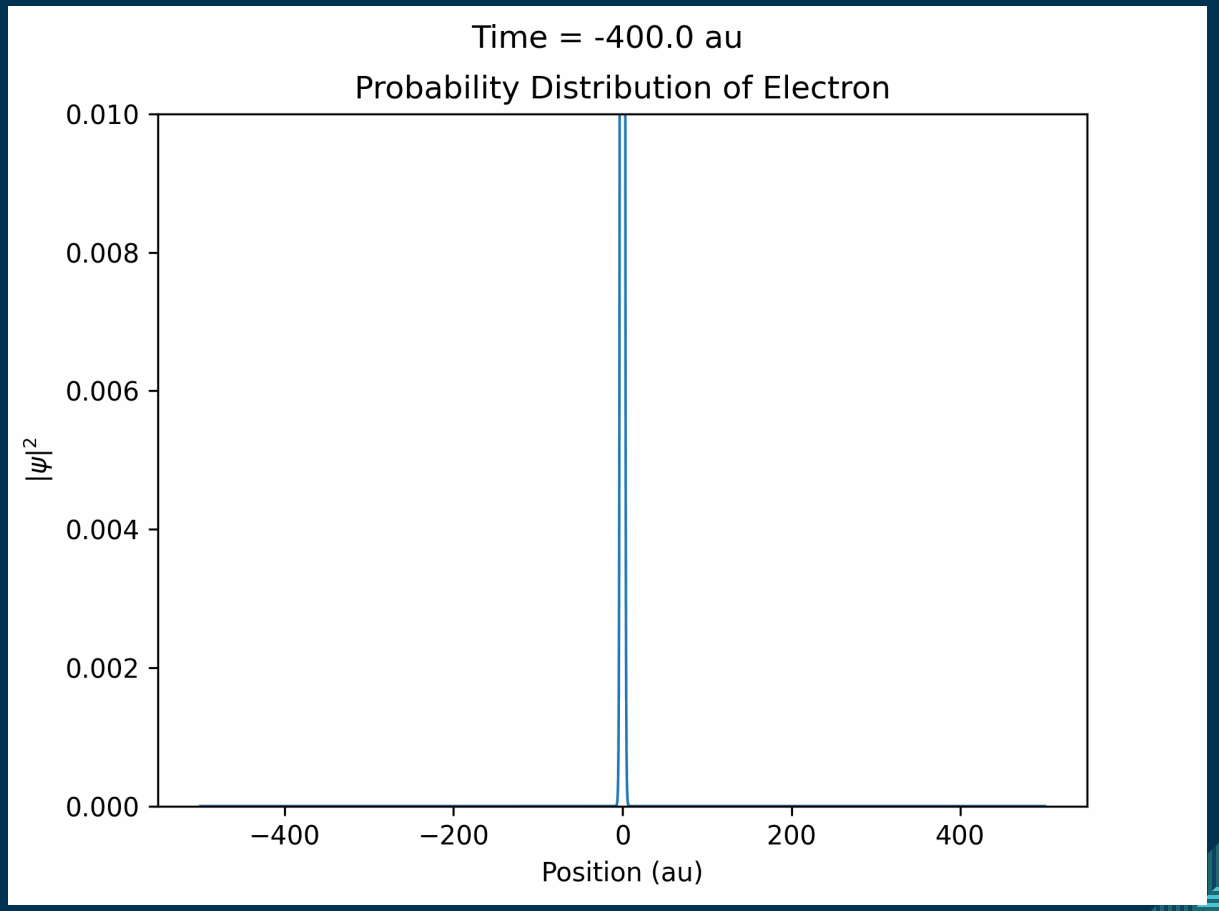
Compare to Ammosov-Delone-Krainov Theory



Laser at Ground State Electron in Helium Atom

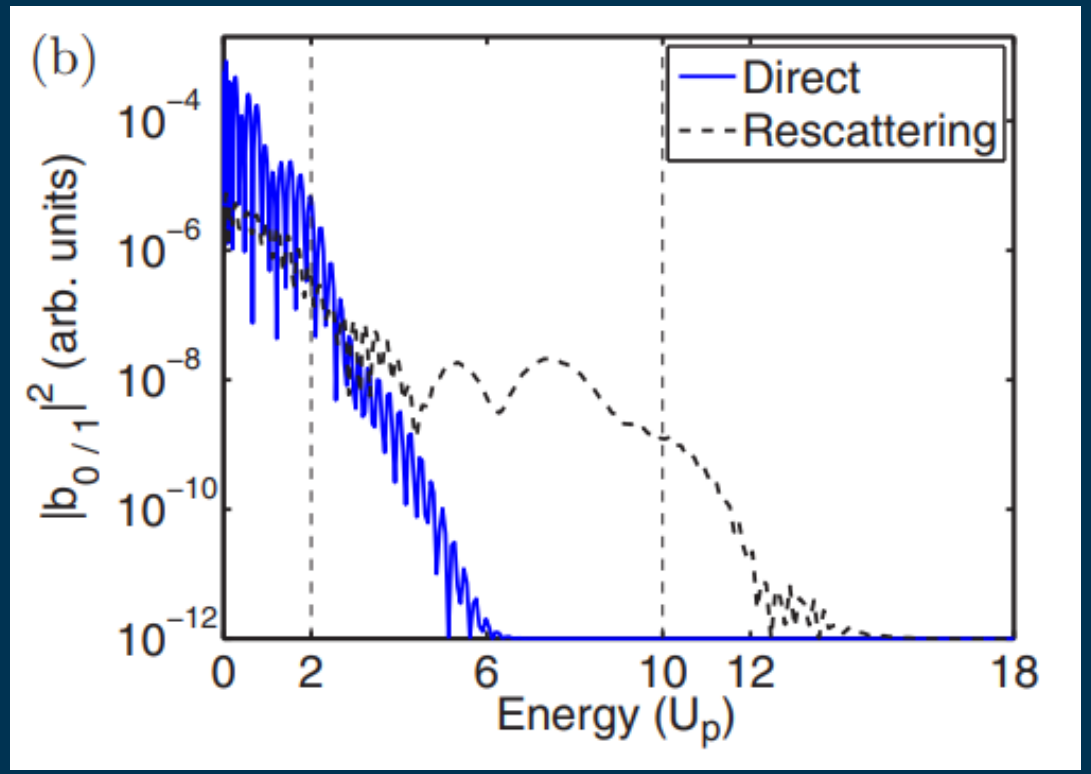
Ionization from Laser Pulse

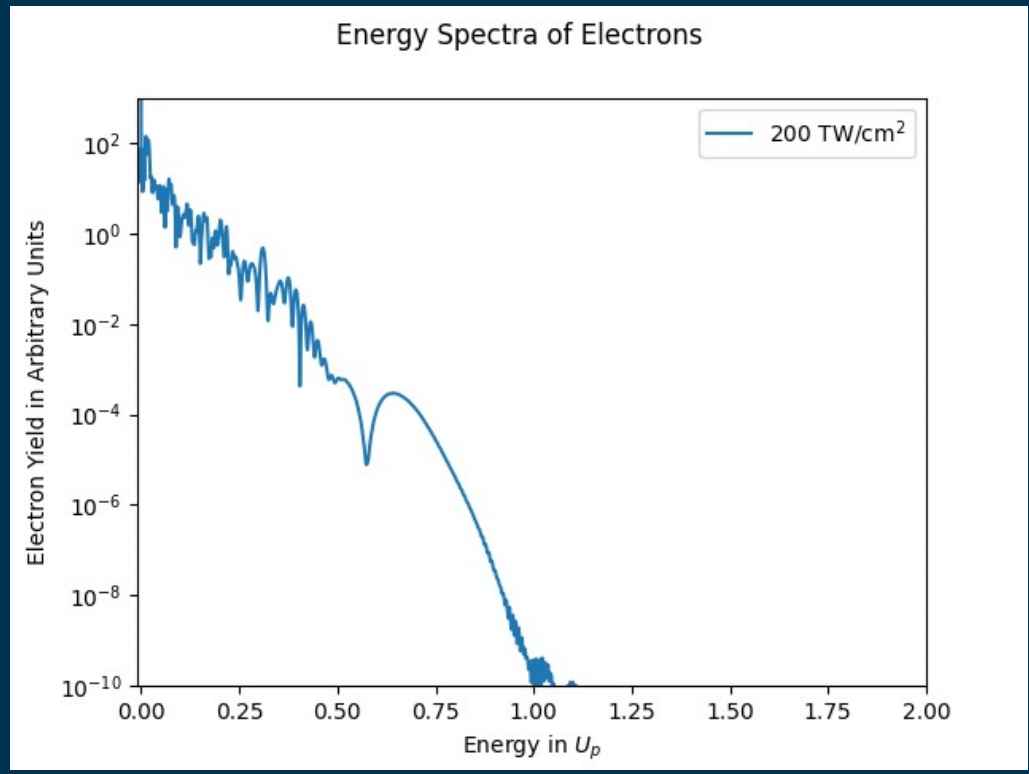




150 TW/cm^2 Laser @ 800 nm at Ground State Electron in Argon

Energy Spectra of Emitted Electron





Suarez, N., et al. *Phys. Rev. A. (2015)*

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Questions?

How do you determine Soft-Core Coloumb Potential constant?

Why does the simulation not start at t = 0?

What is the energy parameter U_p?