Connecting field ionization to photoionization via 17 GHz microwave fields

Josh Gurian
H. Maeda
T.F. Gallagher

May 20, 2009
Rydberg atoms

- $W = \frac{-1}{2n^2}$
- $r \propto n^2$
- $\text{Lifetime} \propto n^3$
- $\omega_{\text{kepler}} \propto \frac{1}{n^3}$
- $V_{\text{coulomb}} = \frac{-1}{|Z|}$
Microwave Ionization

What happens as we approach the photoionization limit?

Field Ionization Process

$$ F = \frac{1}{9n^4} $$

$$ \omega < \frac{1}{n^3} = \omega_k $$
Experimental Setup

Connecting field and photoionization via 17 GHz microwave fields
Connecting field and photoionization via 17 GHz microwave fields
J. Gurian  
Connecting field and photoionization via 17 GHz microwave fields
Experimental Setup

J. Gurian

Connecting field and photoionization via 17 GHz microwave fields
Expected Results

Number of MW photons to the ionization limit

Normalized bound state electron signal (arb)

Binding Energy (GHz)

No MW
MW

Connecting field and photoionization via 17 GHz microwave fields
Microwave Ionization Steps

Number of MW photons to the ionization limit

Normalized bound state electron signal (arb) vs. Binding Energy (GHz)

-400 -350 -300 -250 -200 -150 -100 -50 0

0 5 10 15 20

Binding Energy (GHz)

0 V/cm
3.62 V/cm
5.11 V/cm
10.2 V/cm
20.3 V/cm
81 V/cm

Connecting field and photoionization via 17 GHz microwave fields
50% Ionization

Rabi width = \( \frac{0.4108}{\omega^{5/3}n^3} \cdot F \geq \frac{1}{n^3} \rightarrow F = 2.4\omega^{5/3} \)


J. Gurian
Connecting field and photoionization via 17 GHz microwave fields
50% Ionization

Rabi width = \( \frac{0.4108}{\omega^{5/3}n^3} \cdot F \geq \frac{1}{n^3} \rightarrow F = 2.4\omega^{5/3} \)


J. Gurian Connecting field and photoionization via 17 GHz microwave fields
Ground State Ionization Comparison

Connecting field and photoionization via 17 GHz microwave fields
Above-Threshold Bound States

MW pulse can drive states both up and down in energy

J. Gurian
Connecting field and photoionization via 17 GHz microwave fields
Connecting field and photoionization via 17 GHz microwave fields
Ionization Rates - Experiment

Connecting field and photoionization via 17 GHz microwave fields
Summary

- First measurement of 50% microwave ionization from the field ionization limit to the photoionization limit
- Results in agreement with recent theoretical predictions of Schelle et al. and Jensen et al.
- Multiphoton ionization microwave field intensity similar to single-photon ionization field intensity
- Microwave ionization is $n$ independent when $\omega_{MW} > \omega_{kepler}$
- Single-photon ionization rates lower than perturbation theory prediction