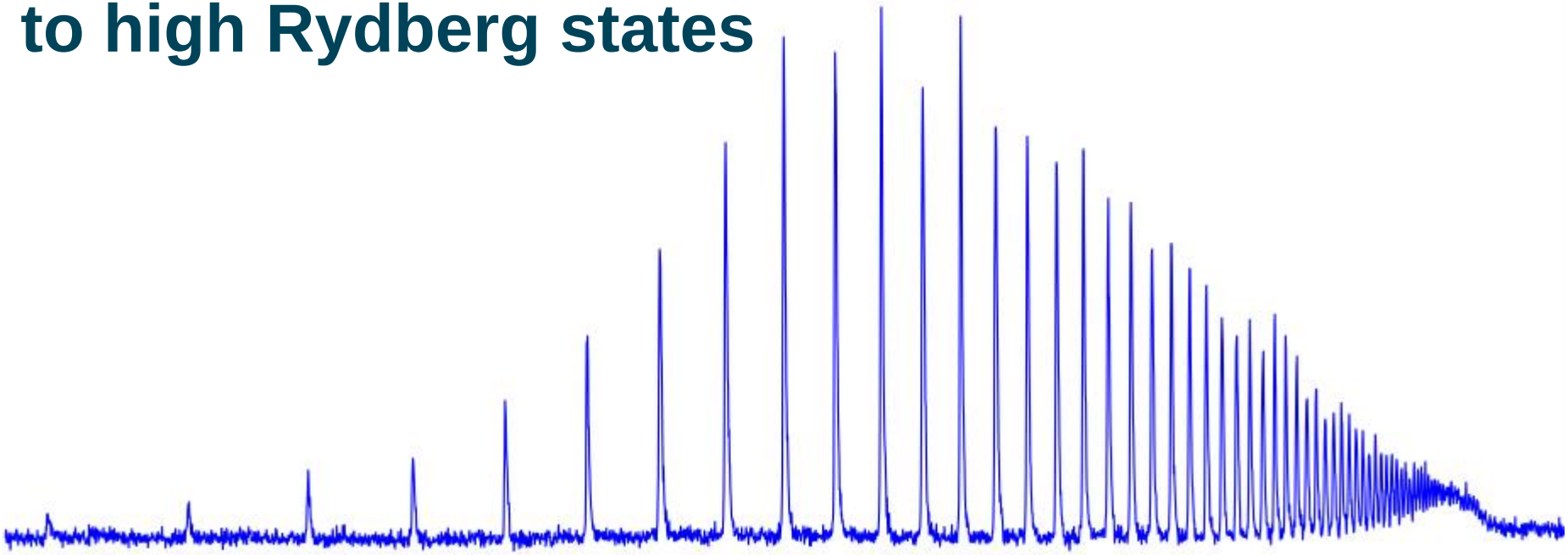
Non-resonant two-photon excitation to high Rydberg states



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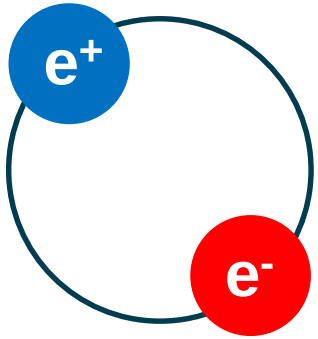
46th Conference of the European Group on Atomic Systems

Motivation



- Gravitational free-fall of Ps
- Triplet ground state short-lived
  (142 ns against annihilation)
- Rydberg states can live much longer
  (10 ms against fluorescence)

Rydberg Ps

PRL 108, 043401 (2012) PHYSICAL REVIEW LETTERS week ending 27 JANUARY 2012

Efficient Production of Rydberg Positronium

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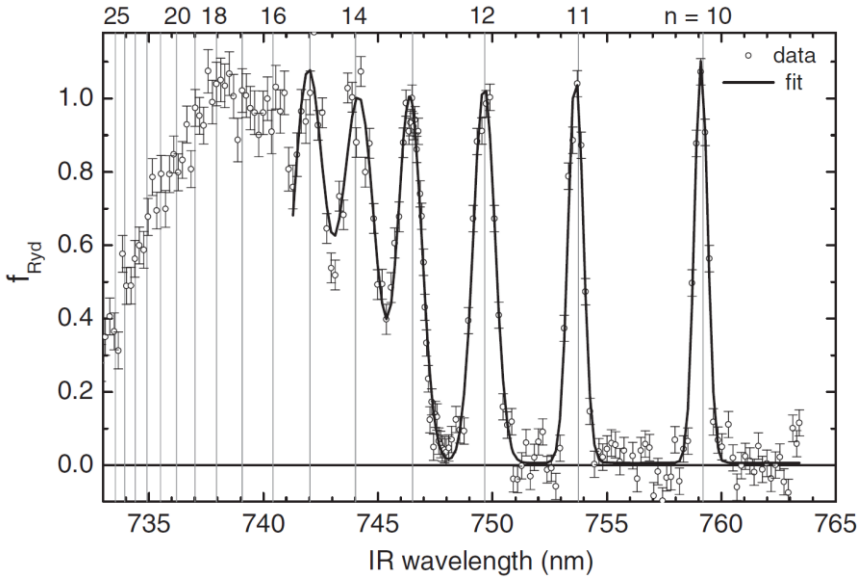
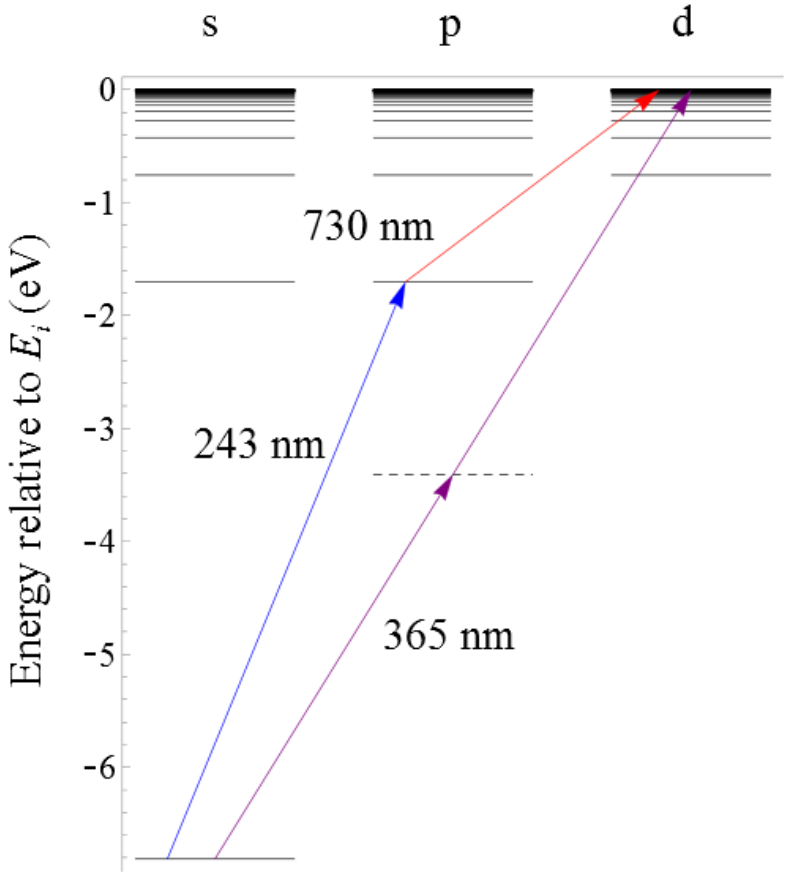
(Received 14 October 2011; published 26 January 2012)

We demonstrate experimentally the production of Rydberg positronium (Ps) atoms in a two-step process, comprising incoherent laser excitation, first to the $2\,^3P$ state and then to states with principal quantum numbers ranging from 10 to 25. We find that excitation of $2\,^3P$ atoms to Rydberg levels occurs very efficiently ($\sim 90\%$) and that the $\sim 25\%$ overall efficiency of the production of Rydberg atoms is

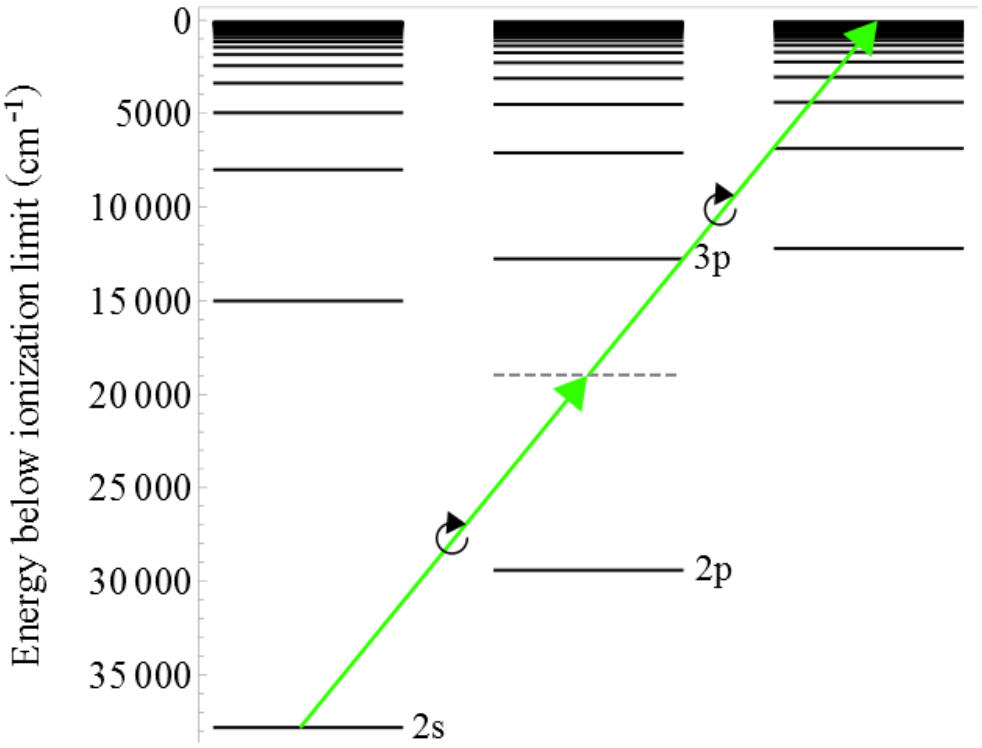




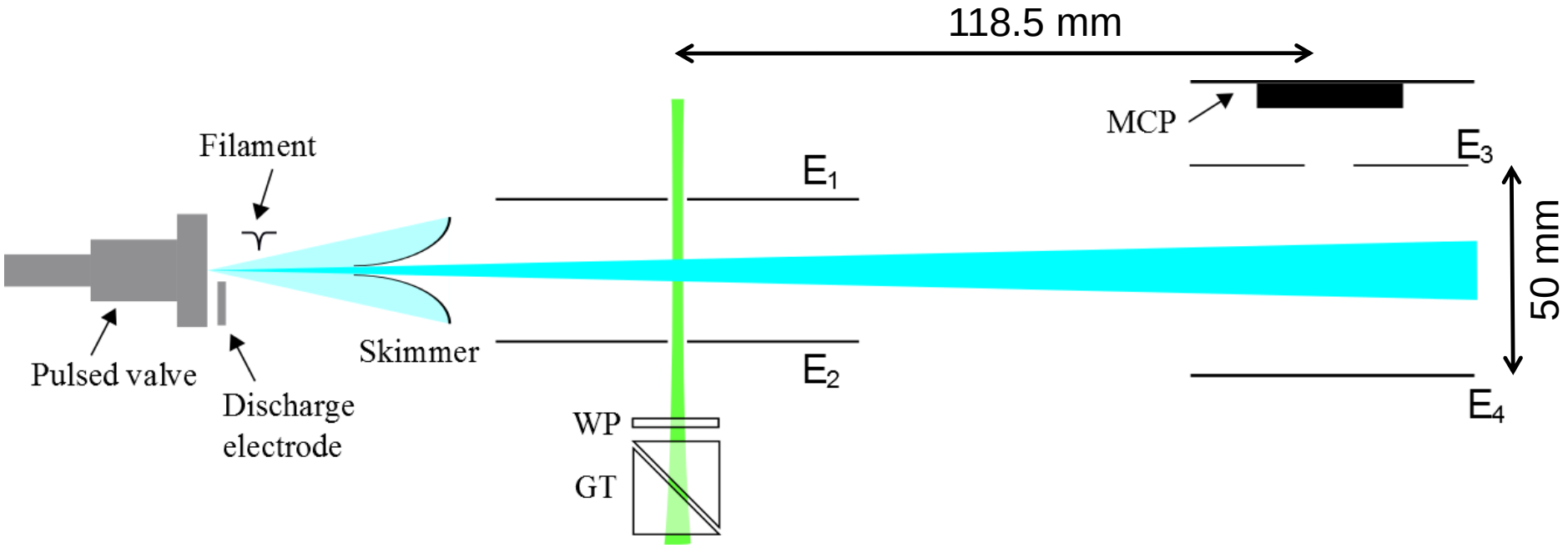
Doppler-free two-photon transition:

Better resolution and thus state selectivity at high *n*.

Helium


Energy below ionization limit (cm^{-1})
0
5000
10 000
15 000
20 000
25 000
30 000
35 000
2s
2p
3p

Experiment

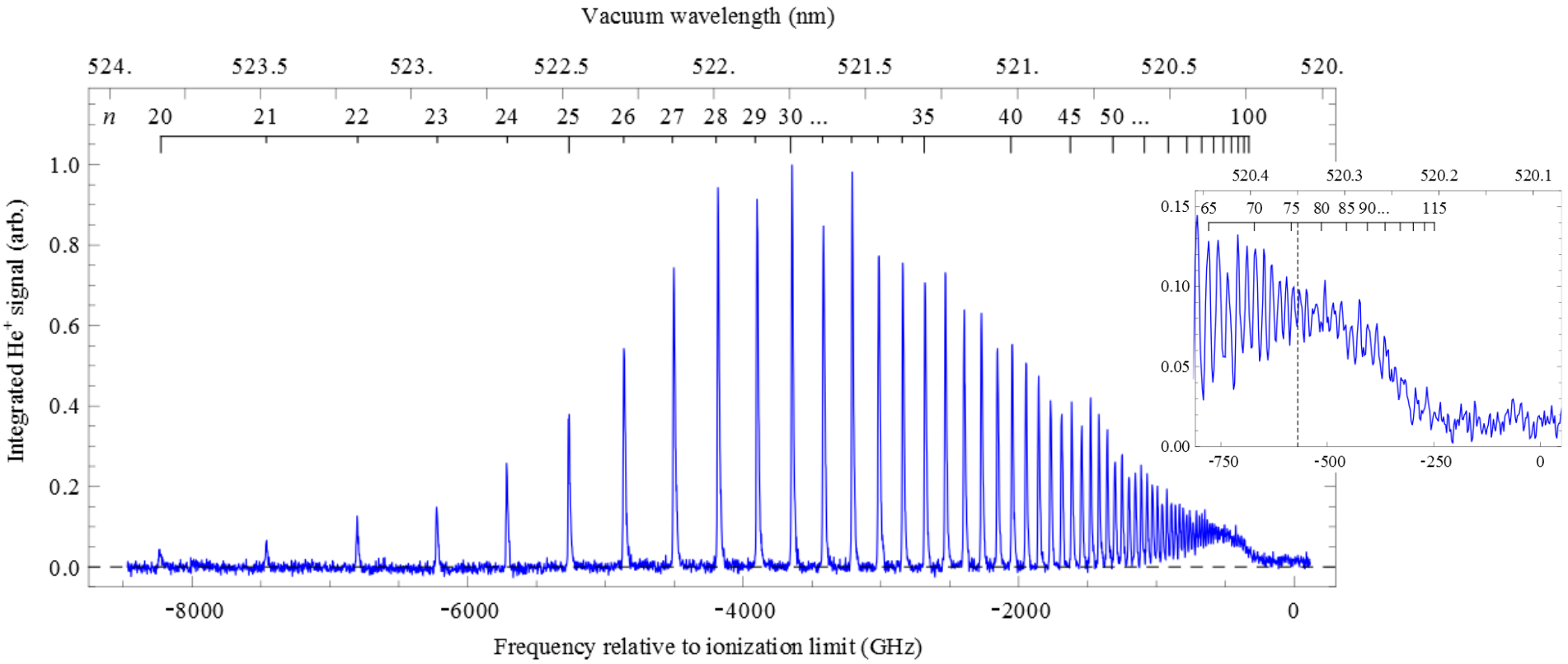


0 V < (V_1-V_2) < 280 V

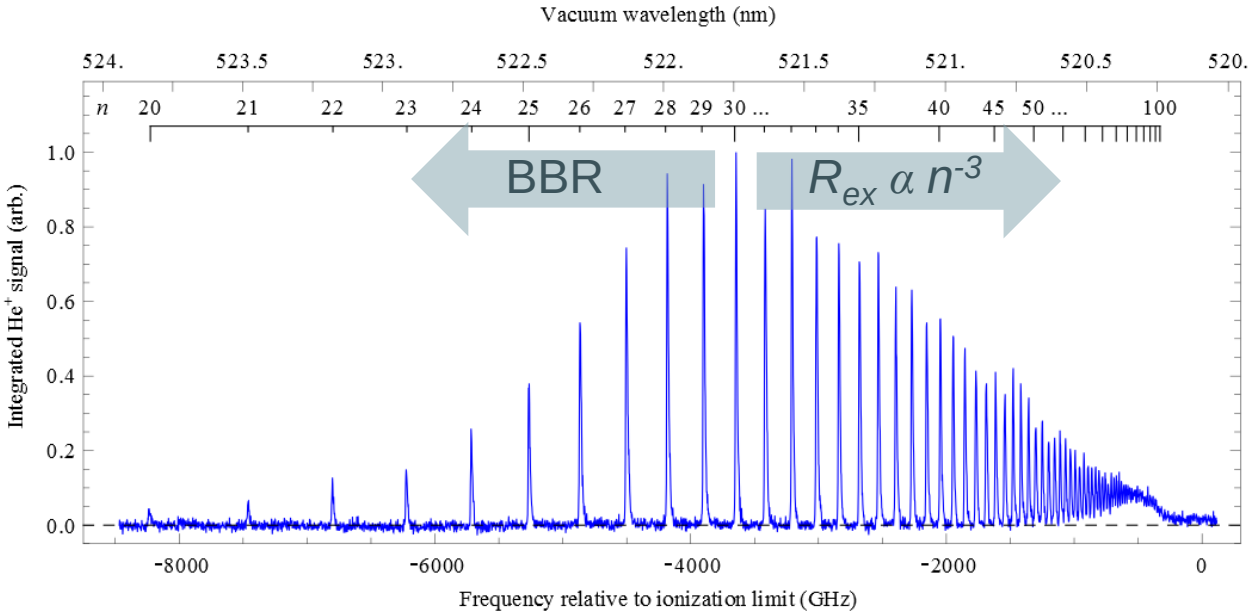
E_1/E_2 electrode separation = 18 mm

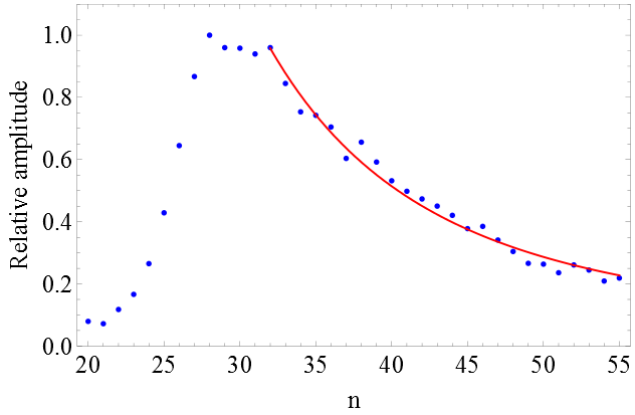
} Excitation fields up to 155 V/cm

Rydberg spectrum



Rydberg spectrum





Field required to start to ionize a given *n*-state:

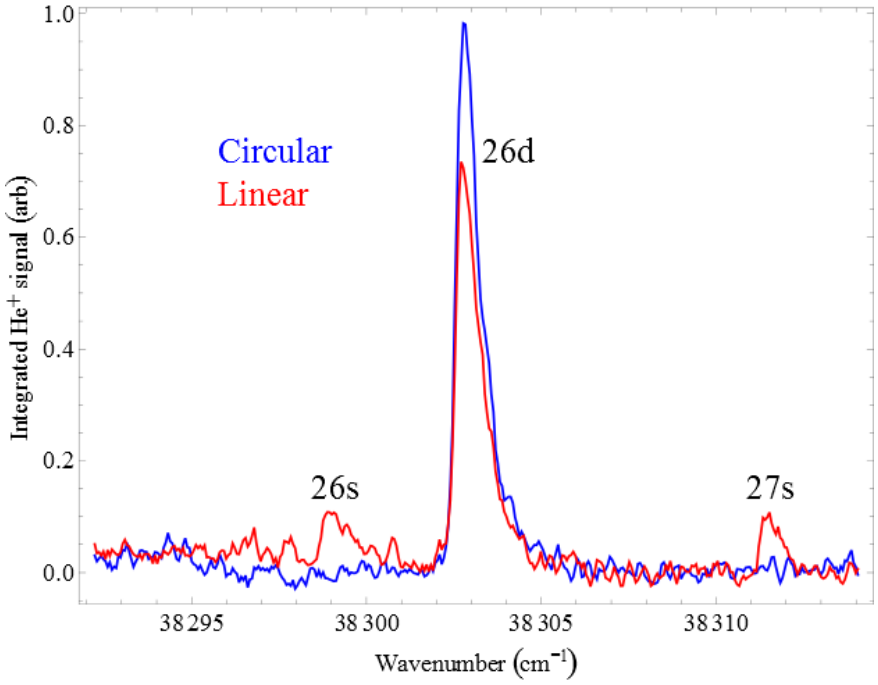
$$F_0 / (9\, n^4),$$

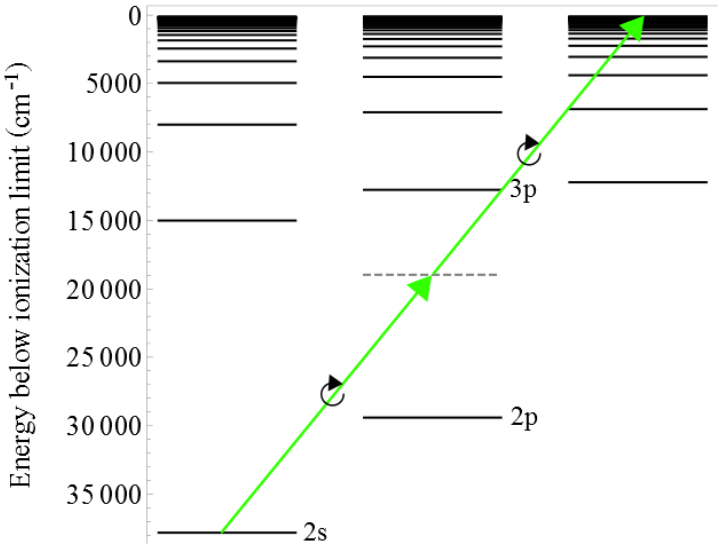
Where $F_0 = 5.14 \times 10^9$ V/cm

We use 800 V/cm for field ionization

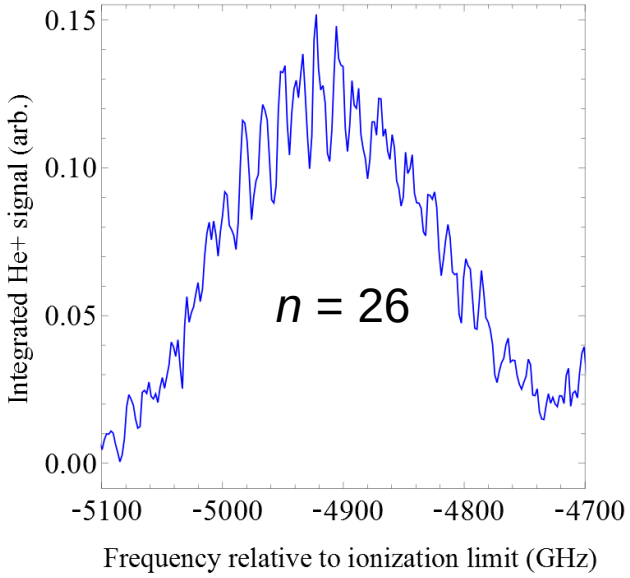
→ threshold is $n = 30$

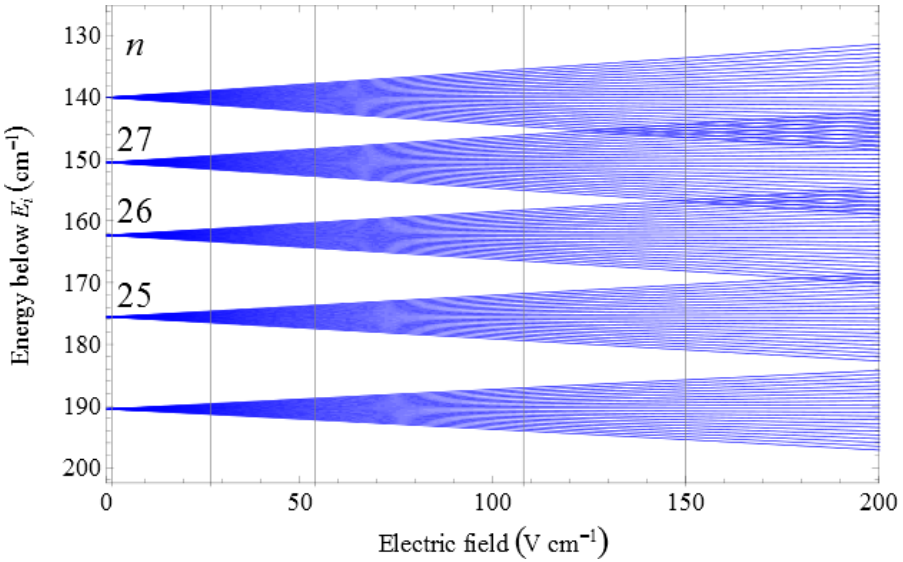
Polarization

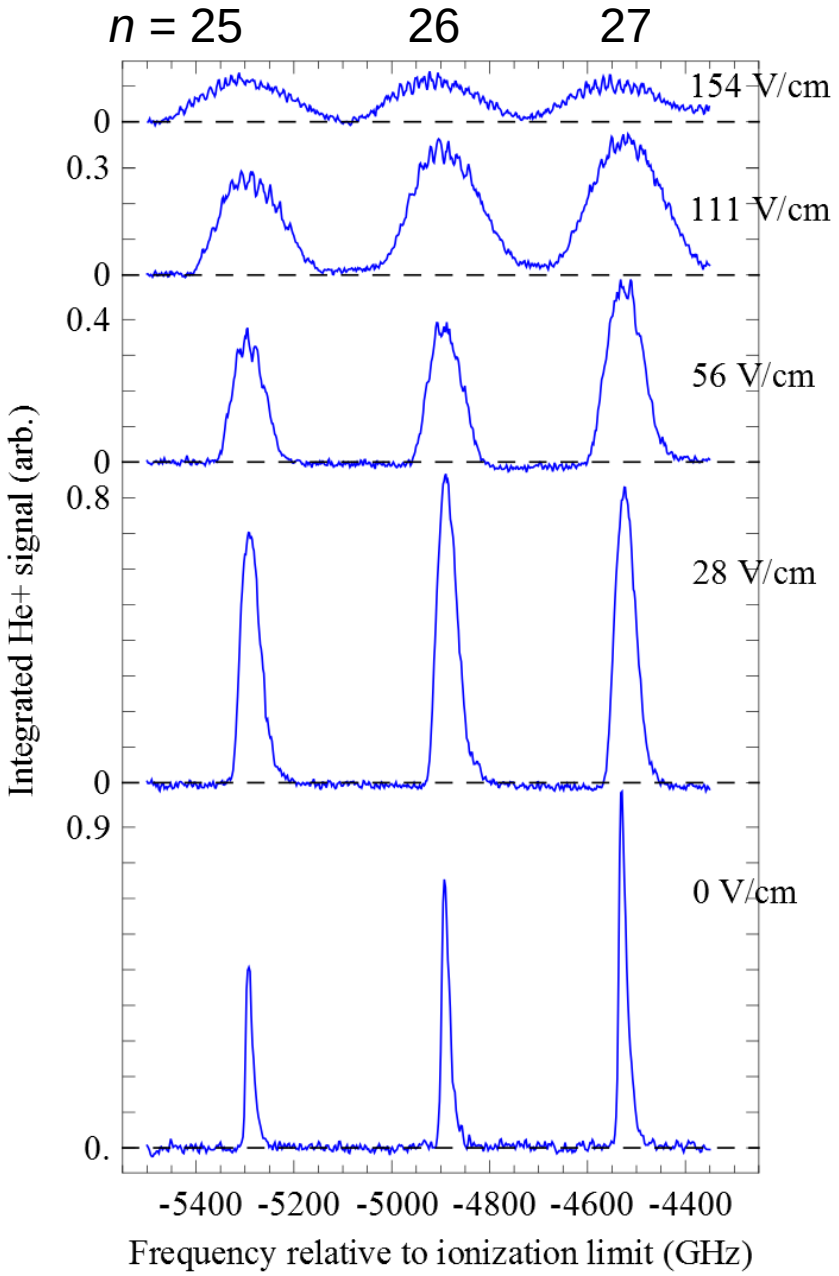




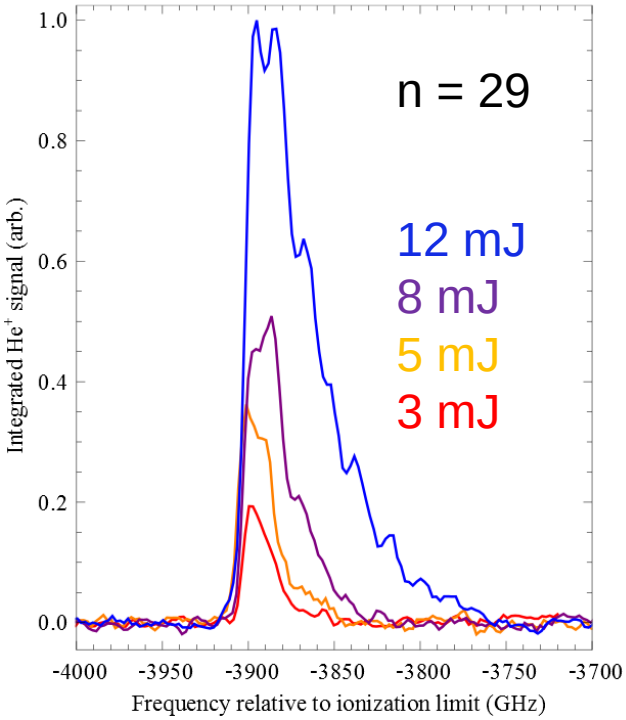
Stark states

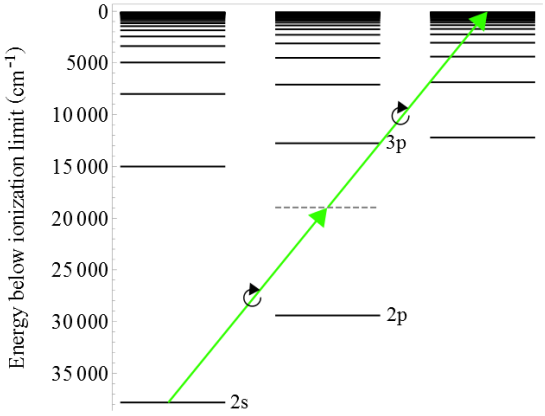




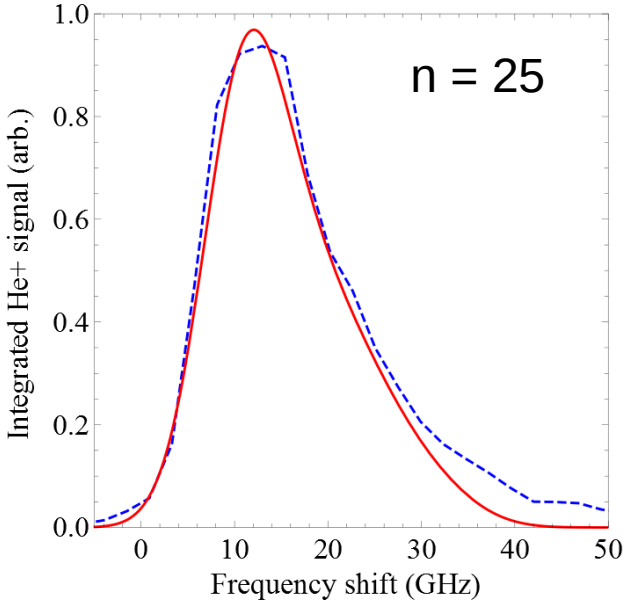


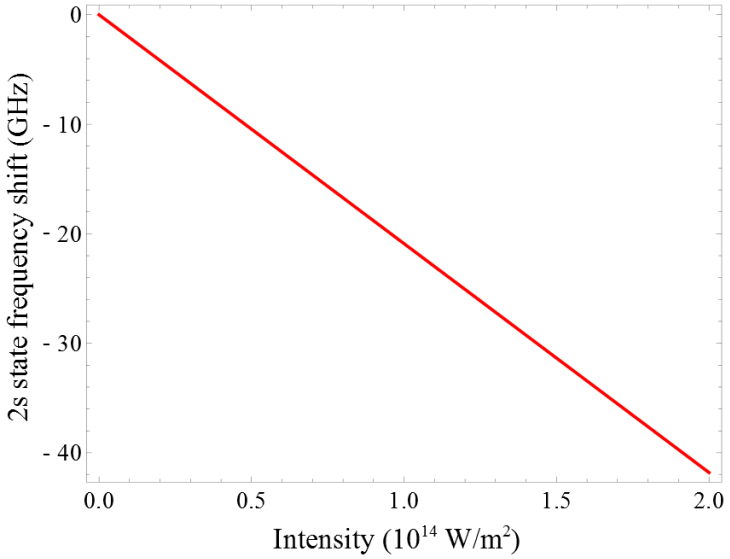
ac Stark shift



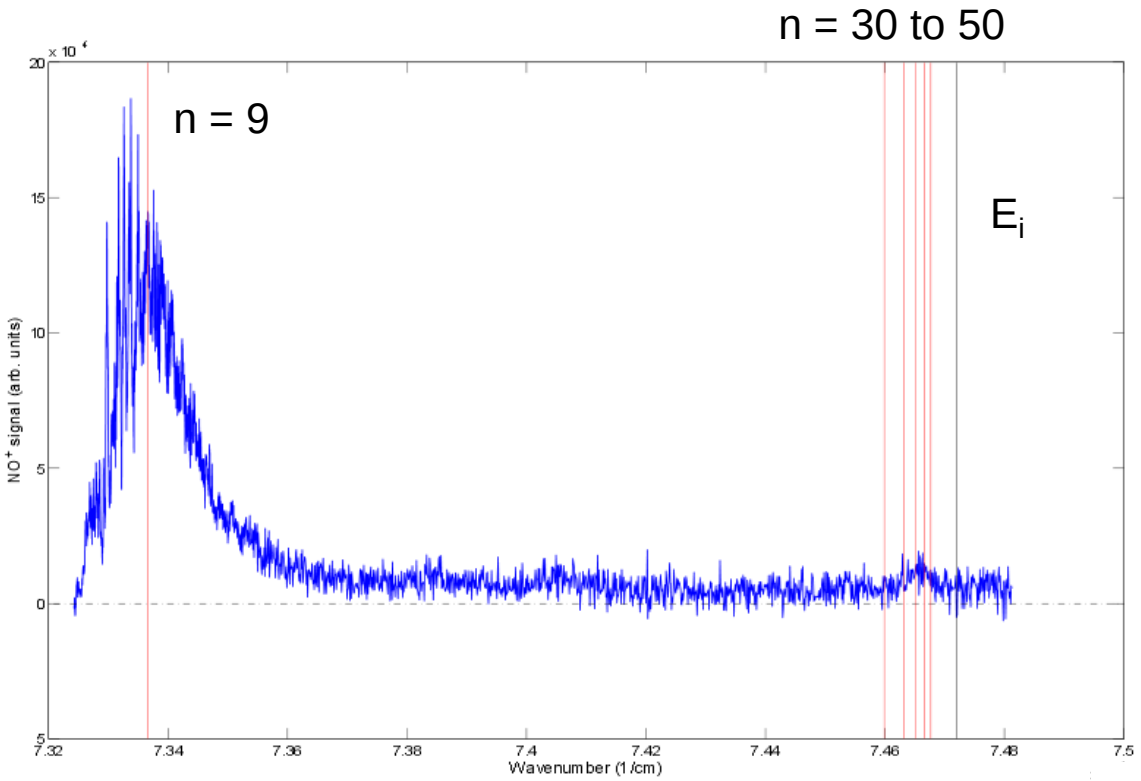


ac Stark shift





NO: 3-photon transitions



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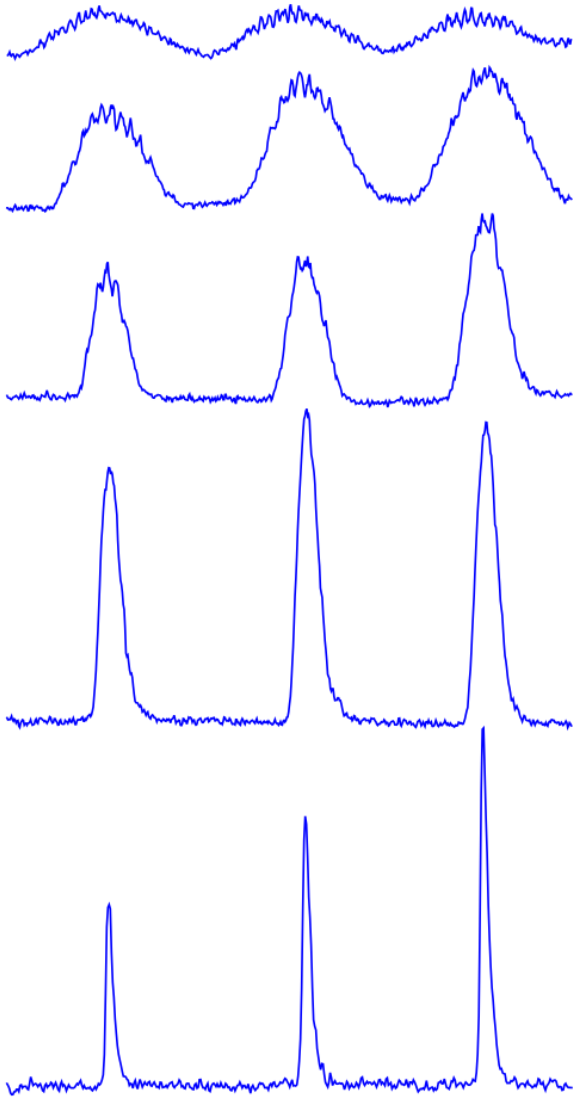

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