Abstract

Driving atoms from an initial to a final state of the same parity via an intermediate state of opposite parity is most efficiently done using STIRAP[1], because it doesn’t populate the intermediate state. We populate Rydberg states of He (n = 24) in a beam of average velocity 1070 m/s by having them cross two laser beams in a tunable dc electric field of ~100 V/cm. By varying the relative position of these beams we can vary the order and overlap encountered by the atoms. We vary the dc field to sweep across several Stark states of the Rydberg manifold. We measure the absolute efficiency using a curved wavefront light beam of 1083nm to deflect residual 23S1 atoms out of the atomic beam, and we measure their flux with and without the STIRAP beams. This uncontaminated measurement has high absolute accuracy.

What is STIRAP?

Stimulated Rapid Adiabatic Passage

**Theory of STIRAP**

**Hamiltonian** [2]

For two-photon resonance $\Delta_p = -\Delta_s = \Delta$

$$H(t) = \frac{\hbar}{2} \begin{bmatrix} 0 & \Omega_p(t) & 0 \\ \Omega_p(t) & 2\Delta - i\Omega_s(t) & 0 \\ 0 & 0 & -i\Omega_s(t) \end{bmatrix}$$

**Solution**

Eigenstates for $\Gamma_z = \Gamma_s = 0$

$|1\rangle$: Decay rate of level $i$

$$|a^+\rangle = \sin\theta \sin\varphi |1\rangle + \cos\theta |2\rangle + \cos\theta \sin\varphi |3\rangle$$

$$|a^-\rangle = \cos\theta |1\rangle - \sin\theta |2\rangle$$

Mixing angles

$$\tan \theta(t) = \frac{\Omega_p(t)}{\Omega_s(t)}$$

$$\tan 2\varphi(t) = \sqrt{\Omega_p^2(t) + \Omega_s^2(t)} / \Delta$$

**STIRAP results**

Experimental implementation of STIRAP

Energy levels of He Triplet states in an electric field

<table>
<thead>
<tr>
<th>State</th>
<th>Energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3</td>
<td>0.39462</td>
</tr>
<tr>
<td>P2</td>
<td>0.37332</td>
</tr>
<tr>
<td>S1</td>
<td>0.34495</td>
</tr>
<tr>
<td>S1'</td>
<td>0.34546</td>
</tr>
<tr>
<td>P2'</td>
<td>0.37332</td>
</tr>
<tr>
<td>S1'</td>
<td>0.34495</td>
</tr>
</tbody>
</table>

STIRAP results

**Autler-Townes splitting**

**References**


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