A nugget from FOCUS:

**Coherent Population Transfer of $^{85}\text{Rb}$ Atoms into Rydberg States**

Tara Cubel, Kevin Teo, Vladimir Malinovsky, Jeff Guest, Aaron Reinhard, Brenton Knuffman, Paul Berman, and Georg Raithel

Recently, quantum information processing methods have been proposed that involve the efficient transfer of atoms from ground states into high-lying Rydberg states. Stimulated Raman Adiabatic Passage (STIRAP) is a robust method for achieving this transfer. We have performed STIRAP on $^{85}\text{Rb}$ atoms using two laser pulses resonant with the 5S->5P and the 5P->44D transitions. The data in figure (a) show that, as expected, the excitation probability is greatest when the upper transition (5P->44D) STIRAP pulse precedes the lower transition (5S->5P) STIRAP pulse. To determine the excitation efficiency, two identical STIRAP sequences have been applied to the same atoms. The second STIRAP sequence excites the atoms left over after the first STIRAP sequence. A detailed analysis of the signal reduction of the second sequence relative to the signal of the first sequence, shown in Figure (a), has shown that the excitation efficiency reaches a maximum of 70%. This is seen in Figure (b), where we show values of the Rydberg excitation efficiency vs. the central Rabi frequency of the upper transition, $\Phi_b^0/(2\sigma)$, and position r. This work is the first quantitative demonstration of STIRAP into Rydberg states using narrow-bandwidth laser pulses.

Using state-selective field ionization, we could identify a high sensitivity of the excited Rydberg atoms to population transfer into neighboring n-levels. These collisions occur within just a few hundred nanoseconds after excitation, and are thought to be responsible for disagreements between theory and experiment in the range $\Delta T>0$ of Figure (a).
Coherent Population Transfer of Atoms into Rydberg States

Tara Cubel, Kevin Teo, Vladimir Malinovksy, Jeff Guest, Aaron Reinhard, Brenton Knuffman, Paul Berman, and Georg Raithel, University of Michigan

Stimulated Raman Adiabatic Passage (STIRAP) is a robust method for efficient transfer of atoms from ground states into high-lying Rydberg states. We have quantitatively studied the excitation efficiency of such a scheme using cold Rb atoms. An influence of collisions on the excitation has been observed.

(a) Rydberg excitation vs STIRAP pulse delay for a pair of STIRAP sequences applied to the same atoms. The efficiency is greatest when the upper-transition (5P→4D) STIRAP pulse precedes the lower-transition one (5S→5P). The signal difference between 1st and 2nd sequence is used to calculate the absolute efficiency, which is found to be ~70%.

(b) Calculated efficiency of the Rydberg-state excitation vs. the central Rabi frequency of the upper transition, $\Omega_b/(2\pi)$, and radial position $r$ in the laser beam. The Rabi frequency of the lower transition is ~10MHz. The detailed calculations confirm that the excitation efficiency in our experiment is ~70%.

(c) Evidence of collisions. Within a few 100ns after STIRAP excitation, the atoms undergo state-changing collisions. This is seen is state-selective field ionization spectra. The collisions are thought to explain the experiment-theory disagreement in the range $\Delta T>0$ seen in Fig (a).

Center for the Advancement of Frontiers in Optical Coherent and Ultrafast Science
The University of Michigan and the University of Texas at Austin
NSF Award 0114336