Driving Rabi Oscillation by Adiabatic Pulse due to Initial Atomic Coherence

Xingchen Zhao\textsuperscript{1}, Zhenhuan Yi\textsuperscript{1}, Hichem Eleuch\textsuperscript{1}, Anatoly A. Svidzinsky\textsuperscript{1}, and Marlan O. Scully\textsuperscript{1,2}

\textsuperscript{1}Texas A&M University, College Station, TX 77843, USA
\textsuperscript{2}Bayor University, Waco, TX 76706, USA

Rabi oscillations are the cyclic behavior of a two-level quantum system interacting with an electromagnetic field. In the adiabatic approximation, Rabi oscillations are not expected to appear because the evolution of population follows a specific eigenstate of the system. However, for some applications there is a need for driving Rabi oscillations by adiabatic and far-detuned pulses \cite{1}. Here we are developing an experimental platform to observe the population evolution of such a quantum system. We use Zeeman levels of $^{87}$Rb $5S_{1/2}$ state as a two-level system and RF pulse as the driving field \cite{2,3}. We probe the population of upper level by sending two laser pulse sequences and expect that Rabi oscillation will be produced if there is an initial atomic coherence of the relevant two levels.

Without initial atomic coherence:

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1a.png}
\caption{(a-1). Pulse sequences to observe the population evolution without and with initial atomic coherence, respectively. (a-2) The expected results of (a-1) & (b-1), respectively.}
\end{figure}

With initial atomic coherence:

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1b.png}
\caption{(b-1) Pulse sequences to observe the population evolution without and with initial atomic coherence, respectively. (b-2) The expected results of (a-1) & (b-1), respectively.}
\end{figure}

\begin{align}
|\psi(t)\rangle &= i \sin \left( \frac{\Omega t}{2} \right) |a\rangle + \cos \left( \frac{\Omega t}{2} \right) |b\rangle \\
\text{(1) } \Omega t &= \frac{\pi}{2} : |\psi(t)\rangle &= i \sqrt{\frac{2}{3}} |a\rangle + \frac{1}{\sqrt{3}} |b\rangle \\
\text{(2) } \Omega t &= \frac{2\pi}{3} : |\psi(t)\rangle &= i \frac{2}{3} |a\rangle + \frac{1}{\sqrt{3}} |b\rangle
\end{align}

The quantity we are interested in: $-\ln(I_1/I_2) = N\sigma L (1 - \rho_{ab})$

References