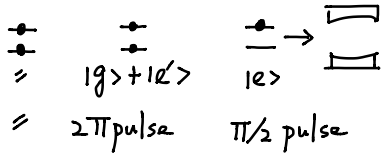
HW7. solution

1. GHZ

A. If 1st particle is ↑. The state is projected to $|\uparrow\uparrow\uparrow\uparrow\cdots\rangle$. There is no more entanglement.

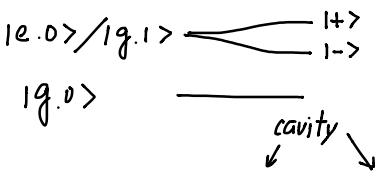
B. Serge Haroush's scheme: Bloch vector evolution: $\dot{U} = (\Omega, 0, -\Delta) \times U$



1st atom in $|e\rangle$

2nd and later atoms in $|g\rangle + |e'\rangle$, where e' does not couple to cavity. 2π pulse in the cavity to flip the phase in the cavity and after the cavity. one can do further operation to convert $|g\rangle + |e'\rangle \to |1\rangle$

$-|g\rangle + |e'\rangle \to |0\rangle$

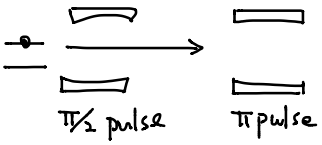


⇒ after 1st atom: $|\uparrow, 0\rangle + |\downarrow 1\rangle$

2nd atom: $|\uparrow, 00\rangle + |\downarrow 11\rangle$

3rd atom: $|\uparrow, 000\rangle + |\downarrow 111\rangle$

C.



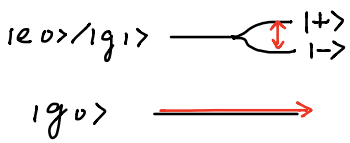
Cavity

1st passage gives $(|\uparrow 0\rangle + |\downarrow 1\rangle) \otimes |\downarrow\rangle$

2nd passage transfers atomic excitation to cavity completely: $|\uparrow 0 \downarrow\rangle - |\downarrow 0 \uparrow\rangle$

$= (|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle) \otimes |0\rangle$ (atom)

The transfer is the π pulse:



if atom $= |g\rangle$. 2nd passage leaves cavity in $|\downarrow\rangle$

if atom $= |e\rangle$. π-pulse transfers excitation to cavity $- |\uparrow\rangle$

(π-pulse gives "−" phase shift typically.)

2.A. Classically if you find 3 apples in 2 baskets. You know one has even # of apples. one has an odd # of apples.