

1. Give 3 examples of quantum phenomena that are unique to multi-level atom systems (more than 2 levels)

A: Electromagnetically Induced Transparency.

Lasing without inversion(LWI).

Stimulated Raman Adiabatic Passage (STIRAP).

Velocity Selective Coherent Population Trapping (VSCPT).

2. Can both STIRAP and optical pumping transfer 100 % of the population from one state to another?

A: Optical Pumping can since one state is always dark.

STIRAP can do it much faster because the rate of the state transfer is proportional to the amplitude of the excited state. However, there is a finite population in the excited state that leads to a small population in ground states due to spontaneous emission. In the adiabatic limit, this population goes to zero.

3. If you have have 50 % of population in two states, can STIRAP put 100 % into ONE state? Can optical pumping do this?

A: STIRAP can't since it relies on the adiabatic modification of the dark state to move the populations around. For the case of 50% of population in two states, we have a trivial case in which we keep one state dark at all times by only having one laser on. However, that is just optical pumping and it doesn't rely on any coherence in the population of states.

4. In STIRAP, what limits the fastest possible rate of population transfer?

A: STIRAP is rate limited by the two-photon Rabi frequency connecting the two states. STIRAP is also limited by the probability of spontaneous emission. The faster we try to transfer at given Rabi frequencies the more we couple to the excited state which increases the chances of emission. The transfer efficiency is limited by the coherence time between the two states.

5. How many photons are scattered during STIRAP?

A: The total number of scattered photons is equal to the total excited state population over the whole time of transfer times the rate of spontaneous emission from the excited state.