Coherent Control and Cold Molecules

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Most of the experiments on photoassociation of cold atoms and formation of cold molecules are using cw lasers. We have done theoretical work on the possibility of shaping laser pulses in view of optimizing the production of molecules :

- We have developed a time-dependent analysis of photoassociation of cold atoms using *chirped laser pulses*. We show how the 5 parameters defining a chirped pulse can be optimized to define a "photoassociation window", i.e. a range of distances $R_L \pm \Delta R$ where the population of the initial continuum state, describing the collision of two ground state cold atoms, is totally transferrred to vibrational levels v' of an excited electronic molecular state. Among many possible applications, I shall present a focussing process, forming a coherent combination of vibrational v' wavefunctions, peaked at a distance where transfer to bound vibrational levels v of the ground electronic state is efficient.

- Presently ultracold stable molecules are formed in high vibrational levels v of the ground electronic state, whatever the process considered (photoassociation and stabilization, or Feshbach resonances or three-body recombination). We have shown [2] that optimal control theory can be used to obtain laser pulses which transfer the molecules from a high vibrational level v to the ground level $v = 0$. The optimal control algorithm has been developed by J. Palao [3]. A series of shaped pulses is transferring population from levels of the Na_2 $X^1\Sigma_g^+$ state to levels of the A $^1\Sigma_u^+$ state and back, following a scheme that is reversed from the Franck Condon pumping scheme successfully developed in spectroscopy experiments [4] to transfer population from the $v = 0$ to the last least bound level of Na_2 $X^1\Sigma_g^+$. In the present two-channel calculations, after a few steps, 99% of the population is transferred to the $v = 0$ level. Elimination of possible loss channels will be discussed.

- Application to formation of molecules in an atomic condensate is under progress [5].

References

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