行政院國家科學委員會專題研究計畫　期中進度報告

稀薄氣體玻仕-愛因斯坦凝結之研究(1/2)

計畫類別：個別型計畫
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執行單位：國立交通大學物理研究所

計畫主持人：江進福

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Keywords: Berry’s phase, nonlinear effects, dynamic tunneling, BEC

Abstract : We design theoretically a double-well condensate by applying a perturbing blue-detuned far-off resonance laser to a cigar-shaped Bose-Einstein condensate. And then apply another perturbing field to one of the well. The Berry’s phase is clearly obtained. The next topic we explored is the effect of nonlinear term in the Gross-Pitaesvkii equation on the tunneling. The strength of nonlinearity can be adjusted by the number of condensate atoms, and we can even change its sign by using different species of atoms. The basic equation of BEC is a nonlinear Schroedinger equation. The conventional tunneling results of the system is specially interesting. Another topic investigated in this project is the quantum dynamics of spinor condensate under magnetic field. The subject is currently under experiment in Chapman’s group if Georgia Tech. Theoretical study will be interested. Formal results of the project will be submitted for publication shortly.

摘要 ：計劃目前完成了以下工作

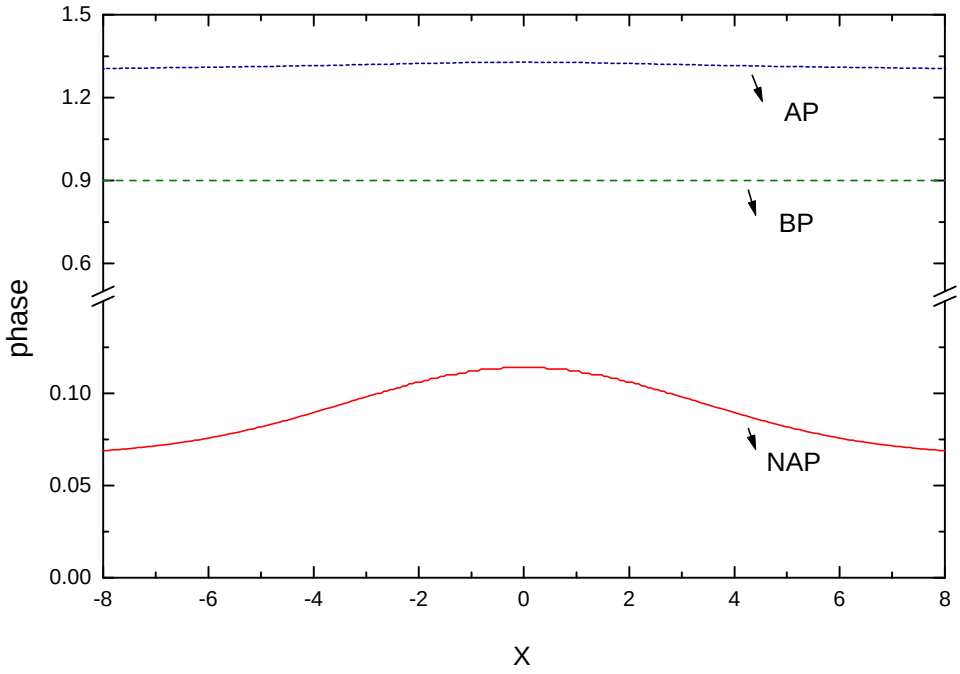
1. 雙井 Bose-Einsteion 凝結的 Berry 相位: 利用藍色離峰共振雷射,造成週期擾動, 已經解得乾淨的 Berry 相位.
2. Gross-Pitaevskii 方程式中,非線性項對量子力學穿透的效應.
3. 磁場對的 spinor Bose-Einsteion 凝結的量子動力學,這是配合 Georgia Tech.實驗而進行的研究

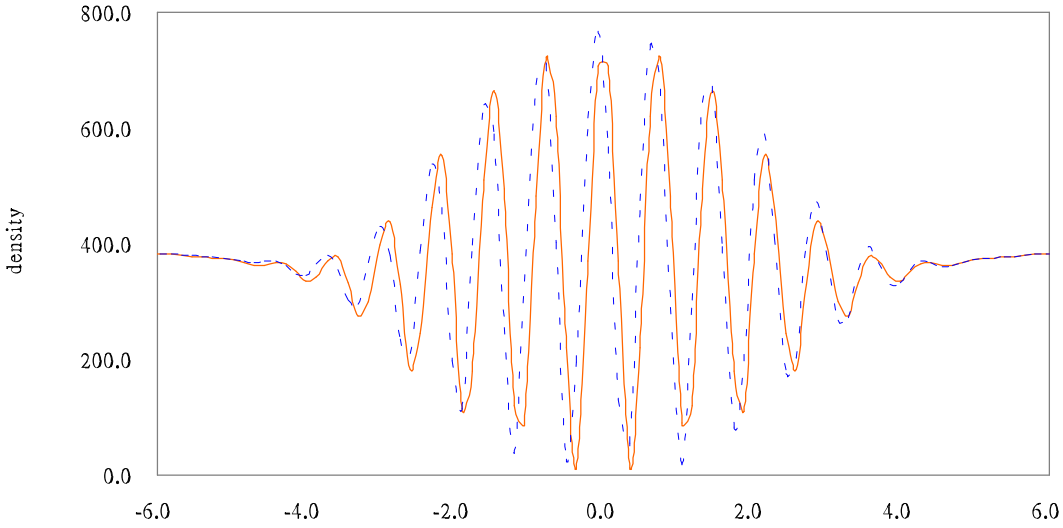
以上結果將於近期投稿

The time-evolution of BEC at very low temperature is well-described by the Gross-Pitaevskii equstion :

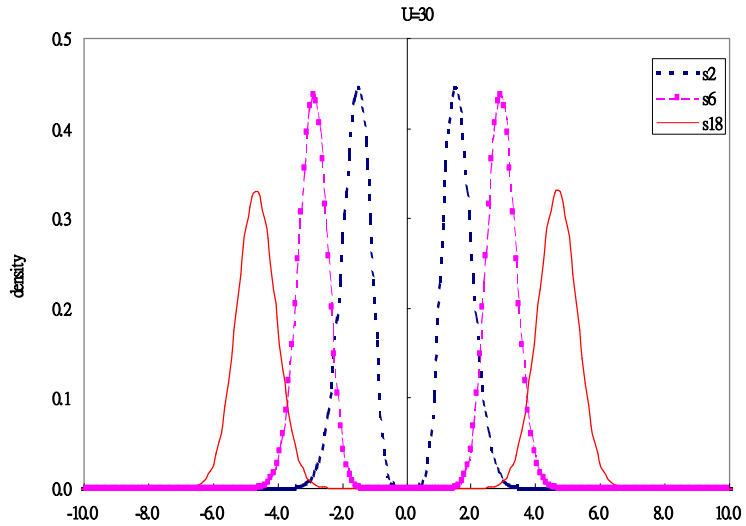
$$i\hbar\frac{\partial}{\partial t}\Phi(\mathrm{r},t)=(-\frac{\hbar^2\nabla^2}{2m}+\frac{m}{2}(\omega_x^2x^2+\omega_y^2y^2+\omega_z^2z^2))+\frac{4\pi\hbar^2a_s}{m}|\Phi(\mathrm{r},t)|^2)\Phi(\mathrm{r},t)$$

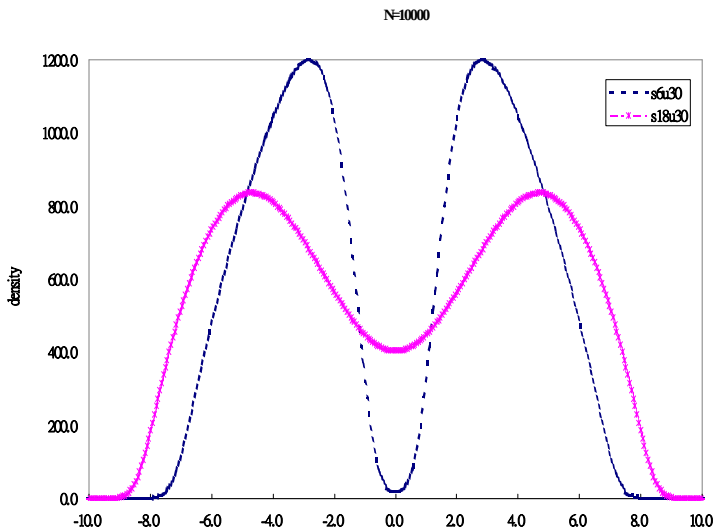
In the case of cigar-shaped confining potential, the system is one-dimensional. By adding a far-off resonant blue-detuned laser to the center of cloverleaf tarp will create a double-well system. We first adiabatically tune the strength of the perturbing barrier for one cycle. The clean Berry’s phase is obtained, while nonadiabatic perturbing is not able to get clean phase. The release of trap will produce interference pattern of density that enables the justification (see plot below :)

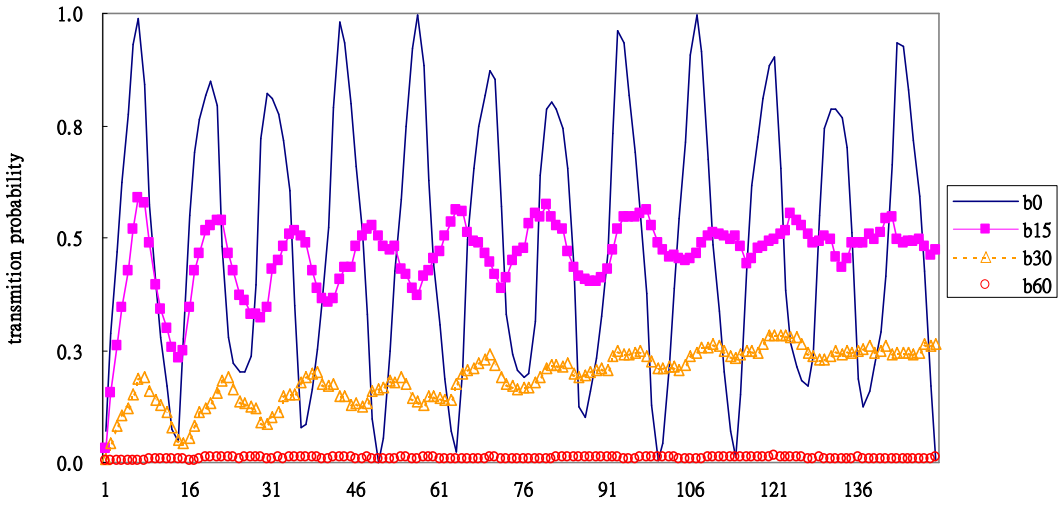

1.5
1.2
0.9
0.6
0.10
0.05
0.00
phase
AP
BP
NAP
-8
-6
-4
-2
0
2
4
6
8
X


800.0
600.0
400.0
200.0
0.0
density
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0

Next we study the dynamic tunneling effect in the BEC. We first construct a wave packet in the left well. This can be done by linear combination of the lowest and first excited BEC. Since it is not an eigenstate, as time goes on, it will evolve. The adjustments of strength of nonlinearity can be arrived by changing the central barrier, and by changing the number of atoms, scattering lengths etc. So there are many more to study than the linear Schroedinger system. The followings are some highlights of the study :







The results of this project are quite fruitful and details will be submitted for publications shortly.