行政院國家科學委員會專題研究計畫 成果報告

閘極局域量子元件的自旋極化操控與偵測
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 99-2112-M-009-007-
執 行 期 間 ：99 年 08 月 01 日至 101 年 04 月 30 日
執 行 單 位 ：國立交通大學電子物理學系（所）

計 畫 主 持 人 ：許世英

報 告 附 件 ：出席國際會議研究心得報告及發表論文

公 開 資 訊 ：本計畫可公開查詢

中 華 民 國 101 年 12 月 07 日

中 文 摘 要 ： 藉由在二微微電子器加諸負電位金屬閘極電子可被局域於小區域而形成一空腔，我們製作出微米尺度以下不同面積的電子空腔，在電導值與源極、汲極電位分析中發現有震盪產生，在外加垂值磁場的縱向磁電阻量測中發現兩種不同的量子干涉效應，在高磁場部分磁電阻隨磁場變化出現週期性震盪的磁電阻，經過分析發現與 Aharonov-Bohm 效應與磁通量週期變化的干涉效應相吻合，在低磁場的部分則是有負磁阻效應產生，這是由弱侷域效應所造成，並且在零磁場負磁阻波峰形式隨閘極電壓的變化，發現空腔形式在越負的閘極電壓電壓之下會由 chaotic 空腔變成 regular 空腔。在二維電子氣系統中，電子空腔其實是由閘極電壓產生位障侷域形成，因此在不同的偏壓情況下，閘極電壓影響二維電子氣的位障形式也會不同，原本設計成正方形(regular)的腔體才會在腔體的四個角落產生銳利的直角，在閘極電壓剛開始對二維電子氣產生影響時(負偏壓較小)，腔體內四個角落會有較圓滑的位障形式，表示腔體並沒有形成設計上的 regular 腔體，反而屬於 chaotic 腔體，其負磁阻曲線展現 Lorentzian 型式，當 Vsg 為較大負偏壓之後，負磁阻曲線會由 Lorentzian 轉變為線性形式，因此建議閘極電壓造成空腔位障形狀的改變，腔體形狀由 Chaotic 空腔轉變為 Regular 空腔。

中文關鍵詞： 閘極局域電子空腔、磁電阻、混沌狀、規則狀。

英 文 摘 要 ：

英文關鍵詞：

行政院國家科學委員會補助專題研究計畫 ■**成果報告** □**期中進度報告**

閘極局域量子元件的自旋極化操控與偵測

計畫類別：■個別型計畫　□整合型計畫
計畫編號：NSC99－2112－M－009－007
執行期間：99 年 8 月 1 日至 101 年 4 月 30 日

執行機構及系所：國立交通大學電子物理系

計畫主持人：許世英
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廖婉婷(碩士班一年級生)
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沈書文(學士班四年級生)

成果報告類型(依經費核定清單規定繳交)：□精簡報告　■完整報告

本計畫除繳交成果報告外，另須繳交以下出國心得報告：
□赴國外出差或研習心得報告
□赴大陸地區出差或研習心得報告
■出席國際學術會議心得報告
□國際合作研究計畫國外研究報告

中　華　民　國　101　年　7　月　30　日

行政院國家科學委員會專題研究計畫成果報告

閘極局域量子元件的自旋極化操控與偵測
Manipulation and detection of gate-confined quantum devices

計畫編號：NSC 99-2112-M-009-007
執行期限：99 年 8 月 1 日至 101 年 4 月 30 日
主持人：許世英　　國立交通大學電子物理系

一、中文摘要

藉由在二微微電子器加諸負電位金屬閘極電子可被局域於小區域而形成一空腔，我們製作出微米尺度以下不同面積的電子空腔，在電導值與源極、汲極電位分析中發現有震盪產生，在外加垂值磁場的縱向磁電阻量測中發現兩種不同的量子干涉效應，在高磁場部分磁電阻隨磁場變化出現週期性震盪的磁電阻，經過分析發現與 Aharonov-Bohm 效應與磁通量週期變化的干涉效應相吻合，在低磁場的部分則是有負磁阻效應產生，這是由弱侷域效應所造成，並且在零磁場負磁阻波峰形式隨閘極電壓的變化，發現空腔形式在越負的閘極電壓電壓之下會由 chaotic 空腔變成 regular 空腔。在二維電子氣系統中，電子空腔其實是由閘極電壓產生位障侷域形成，因此在不同的偏壓情況下，閘極電壓影響二維電子氣的位障形式也會不同，原本設計成正方形(regular)的腔體才會在腔體的四個角落產生銳利的直角，在閘極電壓剛開始對二維電子氣產生影響時(負偏壓較小)，腔體內四個角落會有較圓滑的位障形式，表示腔體並沒有形成設計上的 regular 腔體，反而屬於 chaotic 腔體，其負磁阻曲線展現 Lorentzian 型式，當 V_{sg} 為較大負偏壓之後，負磁阻曲線會由 Lorentzian 轉變為線性形式，因此建議閘極電壓造成空腔位障形狀的改變，腔體形狀由 Chaotic 空腔轉變為 Regular 空腔。

關鍵詞：閘極局域電子空腔、磁電阻、混沌狀、規則狀。

Abstract

Electrons are confined in a small region forming a cavity by negatively biasing a pair of metallic gate in a two dimensional electron gas. We have fabricated such electron cavities of different areas in submicron scale. Conductance oscillations are present in conductance-gate voltage characteristics and source-drain spectroscopy. In the presence of perpendicular magnetic field, two quantum interference effects take place in longitudinal resistances. In high magnetic fields, resistance oscillation occurs at a periodicity of magnetic flux due to Aharonov-Bohm effect. In low magnetic fields, a negative magnetoresistance is obtained and can be ascribed to weak localization effect. By varying gate voltage, the line shape of low field magnetoresistance would transits from Lorentzian to linear. We suggest that the transition may be resulted from the shape change of cavity from chaotic to regular with decreasing split gate voltage.

Keywords: gate-confined electron cavity, magnetoresistance, chaotic, regular.

二、緣由與目的

With advanced technology nowadays, fabricating a device with its dimension comparable with the mean free path of charge carrier is applicable. In such kind of so called mesoscopic systems, the motion of charge carrier is coherent and ballistic, and many fascinating physics are associated with these criteria. Quasi-one-dimensional wires and quantum dots are the typical examples by an artificial confinement in the two dimensional electron/hole gases at the interface of semiconductor heterostructures. The electrical properties are sensitive to the energy spectrum of the carrier arisen out of the confinement induced quantization.

During the past decades, the open quantum dots have attracted much attentions providing important insights in topics of electron-electron interaction, wavefunction interference, decoherence, and localization effects in addition to the charge and size quantization[1-4]. Besides, they have the valuable potential for application in future technologies such as a single photon detector[5] and a qubit of quantum computer[6]. Hence, it is necessary to understand the details of the artificial dots and cavities. Here, we demonstrate the evolution of the weak localization resistance peak form of a single cavity with its shape.

三、實驗方法

The two dimensional electron gas(2DEG) which forms at the interface of an $Al_xGa_{1-x}As/GaAs$ heterostructure was grown using MBE by Dr. Umansky at Wiezmann institute in Israel. Shubnikov-de Haas and Hall measurements were used to determine the areal electron density n. Mobility μ is about 1.6×10^6 cm^2/Vs and n is 1.4×10^{11}cm^{-2} corresponding to the elastic mean free path ℓ of ~10μm at low temperatures.

Electron beam lithography along with thermal deposition were used to fabricate metallic gates on (100) plane of the substrate. A pair of metallic gates with fork-like splitting fingers was fabricated. Therefore, an electron cavity can be formed by the depletion of 2DEG ~93nm beneath the negatively biased splitting finger gates. In this work, two cavities with different topological areas (~0.48 μm^2 for C1 and ~0.12 μm^2 for C2) but similar shapes were studied. On top of the gates, being isolated by a ~100nm thick dielectric layer of cross-linked Polymethylmethacrylate (PMMA), a top metallic gate was fabricated to control carrier concentration of cavity.

Measurements were performed in either a pumped ^{3}He cryostat or a dilution refrigerator with base temperatures of 0.27K and 40mK, respectively. Differential conductance measurement was carried out using standard four terminal ac lock-in techniques at 17 Hz with a small excitation voltage of 5μV. Samples were placed in the center of a 9T superconducting solenoid magnet. The magnetic field direction is always perpendicular with the 2DEG plane.

四、實驗結果

As shown in the insets of Fig.1, two fork-like gates embrace a rectangular region with two open ends of ~350 nm in width on the opposite sides serving as the entrance and exit. By negatively biasing the pair of metal gates, electrons can be confined in a small region forming a cavity. In figure 1, we plot the conductance versus the top gate voltage V_{tp} against a series of split gate voltage V_{sg} at T=45mK for both cavities, respectively. Using the top gate, carrier concentration and corresponding Fermi energy are varied. Evolution of curves follows fairly with the confinements V_{sg} and carrier concentration V_{tp}. In addition, there are some conductance oscillations below $2e^2/h$. They are present in the region where G is between 0.1 and 0.6 ($2e^2/h$) and not typical coulomb-blockade type oscillations for G< $0.1(2e^2/h)$ with exit and entrance quantum point contacts in the tunneling (weakly coupled to reservoirs) regime. With the source-drain spectroscopy, diamond structures can be obtained. All data indicate that cavities are indeed created and C1 is larger than C2 in confined area.

Charging energies are 0.7 and 1.7 meV under the similar conditions for cavities C1 and C2, respectively.

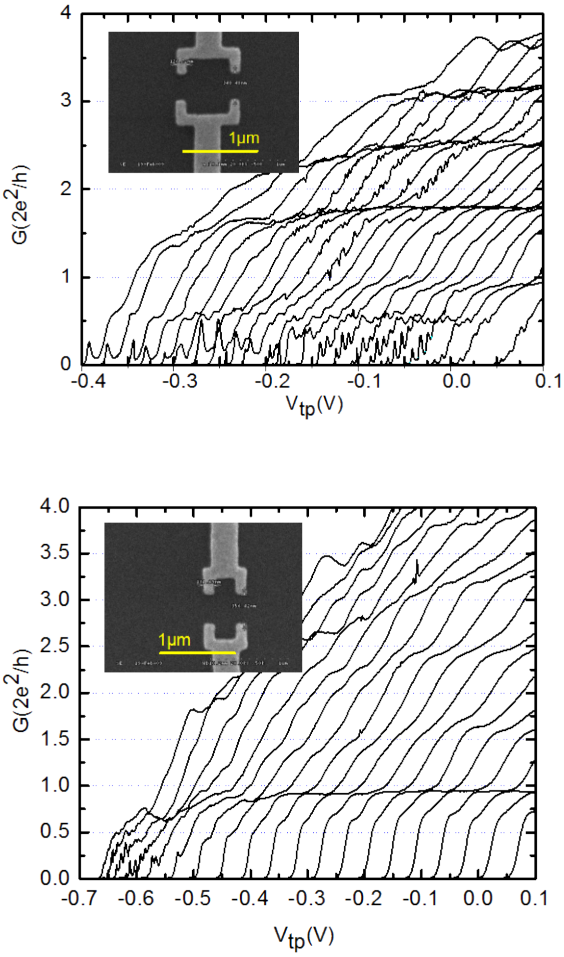

Fig. 1 Conductance versus the top gate voltage against the split gate voltage for two cavities, (top) C1 and (bottom) C2, at T=45mK. For cavity C1, V_{sg} is from –470 to –770 mV in 15 mV steps. For cavity C2, V_{sg} is from –300 to –640 mV in 20 mV steps. Insets: SEM images of the corresponding cavity.

A negative magnetoresistance behavior at low fields is generally observed in ballistic cavity analogous to the well-known weak localization effect in the weakly disordered samples. We show the traces of magnetoresistance with the split gate voltage for cavity C2 in Fig.2. As seen, in addition to SdH conductance oscillations at B> 0.1 T, resistance is the maximum at B=0 and decreases with increasing magnetic field symbolizing a negative magnetoresistance behavior. It is attributed to the constructive interference of time-reversal returned trajectories of ballistic electrons resulting in a enhancement of coherent backscattering and the resistance maximum in the absence of magnetic field. However, ballistic electrons are scattered at the boundaries of cavity differing from diffusive electrons in disordered samples. For the high fields, 3$\sim$5 T, magnetoresistance demonstrates periodic oscillation with a period of $\sim$90 mT. The scenario is due to interference of the opposite skipping orbits, clockwise along up half wall and counterclockwise along down half wall, in accord with Aharnov-Bohm effect. Period is determined by the magnetic flux and hence, the area of cavity can be estimated. Parameters from fits are listed in Table 1. The size of cavity is slightly reduced with more negatively biasing the split gates.

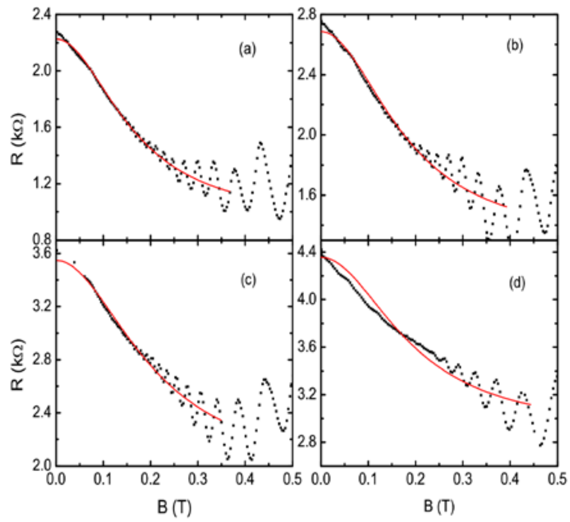

Fig. 2 Magnetoresistance of cavity C2 at T=0.3K for V_{tp} =0.1V. V_{sg} are (a) –0.25V, (b) –0.35V, (c) –0.45V, and (d)–0.50V, respectively. Solid lines are the Lorentzian fits to data using Eq.(1).

Earlier work by Baranger *et al.* demonstrated the interference leads to a negative magnetoresistance in ballistic cavities and argued the form can be influenced by the spatial symmetry and nonergodic paths[7]. The reflection coefficients at boundaries are sensitive to magnetic field via time-reversal symmetry. The difference of magnetoresistance arises between chaotic and regular cavity taken account for the effective area distribution enclosed by classical path with respect to the field scale. For a chaotic cavity with less spatial symmetry, the magnetoresistance has a Lorentzian dependence on magnetic field following[7]

$$R(B) = \frac{R}{1+\left(2B/\alpha_{cl}\Phi_o\right)^2}$$

where α_{cl} is the inverse of the area enclosed by a classical path and $\Phi_o=2\pi\hbar c/e$ is the flux quantum. Chang *et al*. reported that the Lorentzian behavior was observed for the chaotic stadium cavities and the almost linear behavior for the nonchaotic, circle cavities[8].

V_{sg} (mV)	ΔB (mT)	A (μm^2)	E_c (meV)	ΔE (meV)	$\Delta E/E_c$
–400	88.7	0.047	1.34	0.154	0.114
–450	97.0	0.043	1.47	0.168	0.114
–500	125.5	0.033	1.69	0.218	0.129

Table1 Parameters obtained from the fits.

Our rectangular shape cavity has a certain degree of symmetry and should be catalogued as regular. The Lorentzian dependence is not expected. Solid lines in figure 2 are the Lorentzian fits to data for different split gate voltages. Strikingly, the Lorentzian fits fall on top of the low field magnetoresitance curves in Figs.2(a), (b), and (c), meanwhile the fit departs from data in Fig.2(d) which the split gate voltage is the most negative. The electrostatic confinement of cavity is controlled by the split gate voltage. The cavity area and shape can be varied. Aharnov-Bohm effect in high magnetic fields reveals that the area are slightly decreased from (a) to (d) in turn as listed in Table 1. However, the evolution of magnetoresistance form implies that the dominant role is the cavity shape tuned by the split gate voltage. With the less negatively biasing, the confinement is smooth and cavity corners are rounded. Therefore, the most trajectories of the electrons are scrambled by the round corners and soft walls remain inside the cavity resulting in the Lorentzian type magnetoresistance similar to the chaotic cavity. With further increasing the negative bias, the confinement is deeper and cavity corners are sharp. In contract, it evolves from chaotic to regular dynamics. In fact, the low-field magnetoresistance is nearly linear in figure 2(d) as expected for a regular cavity[9,10].

四、結論

In summary, two cavities were created by negatively biasing a pair of fork-like metallic gate in two dimensional electron gases. Evolution of the low field magnetoresistance of the rectangular cavities was investigated. By increasing split gate voltage (less negative), the form of low field magnetoresistance would transits from Lorentzian to linear. In comparison with theory account for interference of ballistic electrons bounced in the cavity, the behavior implies that cavity shape changes from regular to chaotic with less confinement.

ACKNOWLEDGEMENTS

We acknowledge the high mobility samples from V. Umansky at Wiezmann institute.

五、參考文獻

1. L. P. Kouwenhoven, C. M. Marcus, P.L. McEuen, S. Tarucha, R.M. Westervelt, and N.S. Wungreen, “Mesoscopic electron transport” ed. by Sohn *et al.*, NATO ASI, Ser. E, (Kluwer), (1997).
2. J.P. Bird, D.K. Ferry, A.P.S. deMoura, Y.C. Lai, and K.M. Indlekfoer, Rep. Prog. Phys. **66**, 583 (2003).
3. S. Ihnatsenka, I.V. Zozoulenko, and M. Willander, Phys. Rev. B **75**, 235307 (2007).
4. S. Faniel, B. Hackens, A. Vlad, L.

Moldovan, C. Gustin, B. Habib, S. Melinte, M. Shayegan, and V. Bayot, Phys. Rev. B **75**, 193310 (2007).
5. S. Komiyama, O. Astafiev, V. Antonov, H. Hirai, and T. Kutsuwa, Nature **403**, 405 (2000).
6. P. Recher, E.V. Sukhorukov, and D. Loss, Phys. Rev. Lett. **85**, 1962 (2000).
7. H.U. Baranger, R.A. Jalabert, and A.D. Stone, Phys. Rev. Lett. **70**, 3876 (1993).
8. A.M. Chsng, H.U. Baranger, L.N. Pfeiffer, K.W. West, Phys. Rev. Lett. **73**, 2111 (1994).
9. J.P. Bird, D.M. Oltona, R. Newbury, R.P. Taylor, K. Ishibashi, M. Stopa, Y. Aoyagi , T. Sugano, and Y. Ochiai, Phys. Rev. B **52**, 14336 (1995).
10. I. V. Zozoulenko and K. F. Berggen, Phys. Rev. B **54**, 5823 (1996).

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期： 100 年 9 月 17 日

計畫編號	NSC 99－2112－M－009－007		
計畫名稱	閘極局域的開放式量子點與一維窄通道的抽運傳輸、整流、與自旋極化機制		
出國人員姓名	許世英	服務機構及職稱	國立交通大學電子物理系 教授
會議時間	100 年 8 月 10 日 至 100 年 8 月 17 日	會議地點	Beijing(北京), China(中國)
會議名稱	(中文)第二十六屆國際低溫物理會議 (英文)The 26th international conference on low temperature physics		
發表論文題目	(中文)閘極局域空腔體之磁電傳輸 (英文)Magneto-transport of gate confined cavities		

本屆低溫會議於八月十日至十七日假中國北京舉行，研討內容主要分為五大項目，

A) 量子氣體、流體、固體 (Quantum Gases, Fluids, and Solids)

B) 超導體 (Superconductivity)

C) 磁學與量子相變 (Magnetism and Quantum Phase Transition)

D) 凝態物質之電性量子傳輸 (Electronic Quantum Transport in Condensed Matter)

E) 低溫技術與應用(Cryogenic technologies and Applications)

共計有上千篇的論文發表。

一、參加會議經過

8/9 早上搭乘 9:20AM 長榮航空從桃園直飛北京班機，與系上吳光雄老師及數位博士生同行，在機場又碰到同步輻射陳老師等，北京台北大約 2 個半小時不算遠，但由於起飛前不知為何滯留在飛機上 40~50 分，稍延誤至下午 1:00 左右才抵達；窗外看似霧茫茫，實則應是砂塵漫飛。搭乘機場快捷到地鐵轉運輾轉到距離 hotel 最近的奧體中心站，一路上乘客眾多，不是上班時段為何還這麼擁擠?頓時感受人口的壓力，出了地鐵，有點傻眼了，竟在奧運公園的南側入口，而 hotel 在東側口外，一行人拖著行李浩浩蕩蕩通過安檢進入園區，夾雜在眾多遊客與小販間，無心欣賞鳥巢水立方等指標性奧運建築，只想著快速通過吵雜人群，無奈路程遙遙，花了近 2~30 分才到達 hotel，Check in 後趕緊拆箱整理，已是傍晚了；正想與夥伴們到附近走走順道吃個晚餐，結果來個傾盆大雨、雷雨交加，寸步難行的一晚。

8/10 由於下午才開始註冊，早上就到頤和園、圓明園走走，發現這城市真的就是人多地廣，幾乎任何時刻，不論在地鐵站、街道、廣場、或公園就是跟著一大群人賣力向前走，永遠熱鬧滾滾；頤和園、圓明園真的很遼闊，礙於時間只能針對少數景點走馬

看花，下午趕著到北京國際會議中心的會場報到，拿了本次的議程與所有的 abstracts 的 flash，晚上大會備有 reception，就與陸續來報到的朋友聊天用餐，享用食物，飽餐一頓。回旅館註記了明天該聽的演講與該看的壁報，今年似乎鐵砷基超導體與 topological insulator 是大會兩大主軸。

8/11 趕著一大早的開幕式，其中我論文指導老師之指導老師 Bob Hallock 代表 IUPAP 致辭，而在 Brown 大學的老師 Dr.Maris 也獲得 London Prize，真是高興；好久沒看見他們了，資深但依然活躍在物理領域。早上就是由今年三位 London prize 和一位 Simon prize 得獎者開講研究成果。下午就正式分五個 parallel sessions 依不同的主題進行，4:00~6:30PM 則是壁報時段，相當緊湊。

8/12 早上比較有興趣的是 session B1 和 B2 超導的新穎現象與新超導物質，雖然現在個人的研究已少涉獵超導這領域，不過還是值得關心；Birge 和之前博士後研究實的指導老師 Pratt 合作發表在鐵磁材料的 Josephson Junctions 觀察到 spin-triplet 的超導性質，雖然超導鐵磁混合系統在十幾年前就已知具有長尺度的鄰近效應(long range proximity effect)，但他們在 12-28nm 厚的 Co 層仍測得超導電流，而且藉由加入 PdNi 或 CuNi 數 nm 厚薄夾層可以最佳化其超導電流特徵值，MSU Pratt group 利用之前做 CPP multilayer 的技術延伸至此微米尺度 CPP 多層之 Josephson Junctions 上，他們認為這系統的超導不同於 Sr_2RuO_4 的 p wave 超導(接續 Budakian 的演講)，可以是具偶數軌道攪動量的 s wave，因此即使系統存在無序性但仍有完整的超導性。

晚上因為慶祝超導被發現100周年，特別於7:30PM邀請Peter Kes, Georg Bednorz, Frank Steglich, Douglas Scalapino四位作專題演講，kes的投影片展示Onnes的手稿與其當時實驗室照片，並聽聞當時他們發現超導的故事，真是栩栩如生相當傳奇。Bednorz講述高溫超導的發現歷史與目前的相關應用，日本JR在2005年第一個採用高溫超導線在磁浮列車的電磁鐵電源供應上，而磁浮列車車速達300mile/hr，其它大概美歐洲的電力網等都陸續在推廣中，較新的是magnetic Billet heater是一款以HTC作的感應式加熱器，號稱可減少55%能量損耗與增加25%效能。Steglichru從Kondo effect介紹而延伸至heavy fermion特性，進而到反鐵磁交換偶合媒介之d type heavy fermion superconductor，雖然1979就已發現$CeCu_2Si_2$的超導行為(Tc~0.6K)，但今年2011 在nature physics和PRL都仍有文章揭露$CeCu_2Si_2$的超導性來自spin density wave fluctuation；今年新發現的$PuCoIn_5$的超導溫度為2.5K。Scalapino剛好接續講非傳統性超導，整合前二位的內容；晚上節目真是精采，結果回到旅館已將近午夜，沒想到平日進出的旅館區門居然關了，著實下了一跳，幸虧等到裡面閒逛的居民告知另一側有管控門，繞了一大圈才回到旅館，真是從沒想過會發生的事。

8/13主要還是超導相關的研究報告：包含近期heavy fermion superconductors與鐵基系列的超導體，大部分時間都在convention Hall 3，下午的壁報時間也趁機詢問了一些大陸地區做電磁鐵的廠商，現在液氦價位高，計畫經費又少情況下，能夠不用超導磁鐵就盡量不用，但配合低溫系統開口為5cm直徑的電磁鐵只可產生中心點2.6kOe磁場又稍小了些，希望能換個磁鐵加大到2~3倍，就非常適合；本想目前台灣已幾乎找不到生產廠商，而歐美價位又非常高，因此改詢問大陸區域，結果原來價位也今非昔比，一路高

漲與歐美相差無幾，真是挫折。
8/15 聽了好些場naowire/nanotube(session D早上)與topological insulator(session D下午)的演講。席間碰到數位在美讀書時認識的朋友，他們目前都已在美國任教多年，好久沒碰面了，真是難得的機緣。
8/16 下午壁報時段該展示我們的研究"Magnetotransport of Gate confined Cavities"，午餐過後就找時間將壁報一張張貼起來，順便也先看看鄰近的壁報，在同一時段的領域也較接近，本來低維度電子電洞系統在國際低溫會議向來就並不是主要群，在超導體、低溫液態氦(超流體)、低溫技術與最近崛起之topological insulator之外，因此通常都安排在最後二天的幾場sessions，不過由於此會議規模大，所以還是有相當之內容可期。法國Y. Jin group以quantum point conatct架構一維彈道式場效電晶體，據稱電壓放大率在低溫下大於1，藉由閘極電壓控制QPC在最低的sub-band以達高電導值(transconductance)，並由其高能隙(level spacing)降低輸出電導值；Princeton U. K.West和P.Anderson等實驗與理論團隊並肩探討二維GaAs異質介面電子強關聯下的電子電子作用，舊題材但有新看法；如同雖然我們這次發表的題材不是很新穎但卻有系統性的成果，更可釐清明朗的機制，

二、與會心得

這次不曉得為什麼會有好些壁報未參加，歐美做低維度電子電洞系統或無序弱局域電性傳輸的缺席甚多，參與的人主要還是大陸本土學者學生居多，而且主力是鐵砷基超導體與 topological insulator，會議題材變少了，雖然仍有傳統 Helium 超流體、低溫系統或高溫超導體等，不過好像被邊緣化了，或許因為中國大陸最近數年都主攻那兩大領域，因此如此大型國際會議也意識型態地稍微偏頗自己喜好，行地主優勢。在這七八天緊密的演講-壁報討論節目下，收穫還是相當多。出國參與國際會議是最有效，直接地增進新知的方法，免除在資料期刊上查閱上的遺漏，面對面的溝通，也能藉此提供外國學者得知我們的研究成果，使其了解台灣方面於物理研究上的盡力。

三、考察參觀活動(無是項活動者略)

四、建議

感謝國科會給予的經費補助，此行獲益良多。希望學校與國科會能繼續補助國際之學術交流活動。基於氦在地球非常有限的存量，若要從事低溫實驗，設置液化機是刻不容緩的事情，希望學校能配合國科會在校內設置。

五、攜回資料名稱及內容

Program bulletin, abstract flash, reprints, 產品介紹與中國物理學會與中科院物理所合編的物理期刊數期。

六、其他

會議壁報


Magnetotransport of Gate confined Cavities
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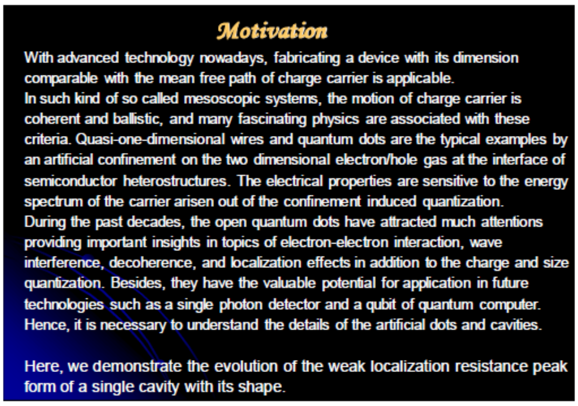
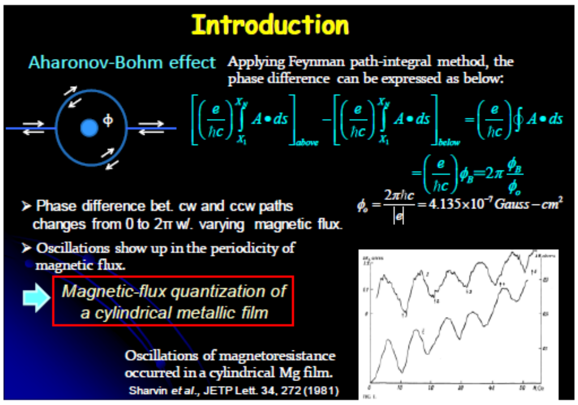
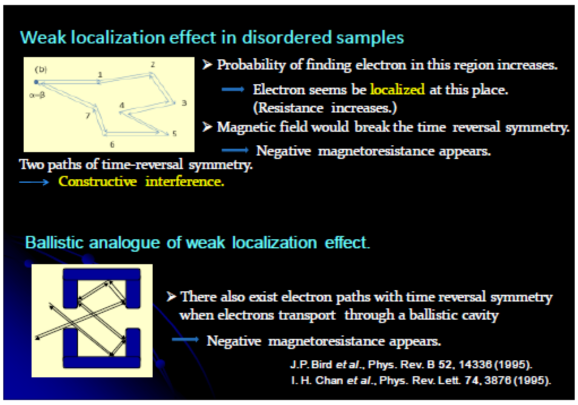
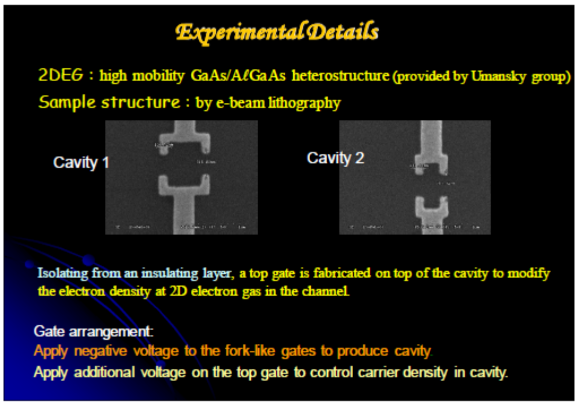
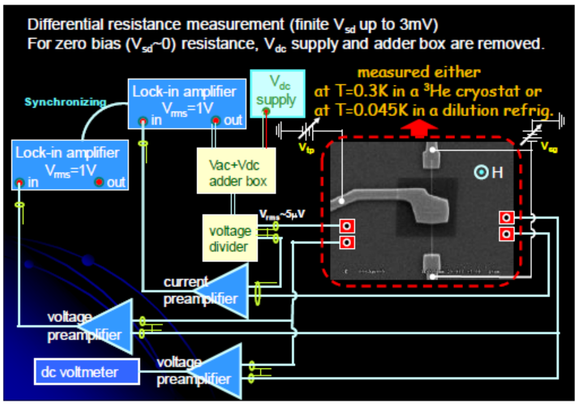
Weizmann institute of Science, Israel
NSC99-2112-M-009-007 and MOE ATU
August 16, 2011
電子物理系
NCTU Electrophysics


Motivation
With advanced technology nowadays, fabricating a device with its dimension comparable with the mean free path of charge carrier is applicable.
In such kind of so called mesoscopic systems, the motion of charge carrier is coherent and ballistic, and many fascinating physics are associated with these criteria. Quasi-one-dimensional wires and quantum dots are the typical examples by an artificial confinement on the two dimensional electron/hole gas at the interface of semiconductor heterostructures. The electrical properties are sensitive to the energy spectrum of the carrier arisen out of the confinement induced quantization.
During the past decades, the open quantum dots have attracted much attentions providing important insights in topics of electron-electron interaction, wave interference, decoherence, and localization effects in addition to the charge and size quantization. Besides, they have the valuable potential for application in future technologies such as a single photon detector and a qubit of quantum computer.
Hence, it is necessary to understand the details of the artificial dots and cavities.
Here, we demonstrate the evolution of the weak localization resistance peak form of a single cavity with its shape.


Introduction
Aharonov-Bohm effect
Applying Feynman path-integral method, the phase difference can be expressed as below:
$\phi_o = \frac{2\pi\hbar c}{|e|} = 4.135\times10^{-7}\ Gauss-cm^2$
➤ Phase difference bet. cw and ccw paths changes from 0 to 2π w/. varying magnetic flux.
➤ Oscillations show up in the periodicity of magnetic flux.
Magnetic-flux quantization of a cylindrical metallic film
Oscillations of magnetoresistance occurred in a cylindrical Mg film.
Sharvin et al., JETP Lett. 34, 272 (1981)


Weak localization effect in disordered samples
➤ Probability of finding electron in this region increases.
Electron seems be localized at this place.
(Resistance increases.)
➤ Magnetic field would break the time reversal symmetry.
Negative magnetoresistance appears.
Two paths of time-reversal symmetry.
Constructive interference.
Ballistic analogue of weak localization effect.
➤ There also exist electron paths with time reversal symmetry when electrons transport through a ballistic cavity
Negative magnetoresistance appears.
J.P. Bird et al., Phys. Rev. B 52, 14336 (1995).
I. H. Chan et al., Phys. Rev. Lett. 74, 3876 (1995).

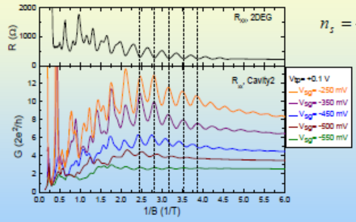

Experimental Details
2DEG : high mobility GaAs/AℓGaAs heterostructure (provided by Umansky group)
Sample structure : by e-beam lithography
Cavity 1
Cavity 2
Isolating from an insulating layer, a top gate is fabricated on top of the cavity to modify the electron density at 2D electron gas in the channel.
Gate arrangement:
Apply negative voltage to the fork-like gates to produce cavity
Apply additional voltage on the top gate to control carrier density in cavity.


Differential resistance measurement (finite V_{sd} up to 3mV)
For zero bias (V_{sd}~0) resistance, V_{dc} supply and adder box are removed.
measured either
at T=0.3K in a ^{3}He cryostat or
at T=0.045K in a dilution refrig.
Synchronizing
Lock-in amplifier
V_{rms}=1V
in
out
V_{dc}
supply
Vac+Vdc
adder box
voltage
divider
current
preamplifier
voltage
preamplifier
dc voltmeter
H

Results and Discussion

de Haas Oscillations of 2DEG & Cavity 2.

The formation of the cavity does not affect carrier concentration n_s.

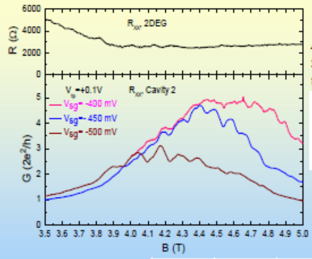


$$n_s = \frac{2e}{h}\frac{1}{(1/B_1)-(1/B_2)}$$

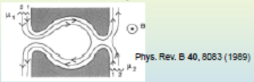
Error:±3%

	2DEG	Cavity2				
V_{sg} (mV)		-250	-350	-450	-500	-550
n_s (cm^{-2})	1.37X10[11]	1.39X10[11]	1.31X10[11]	1.41X10[11]	1.31X10[11]	1.35X10[11]

Oscillations in periodicity of magnetic flux at high magnetic fields (B>3T)



At high magnetic fields, edge states form and electrons can transport along the wall of the cavity.



Phys. Rev. B 40, 8083 (1989)

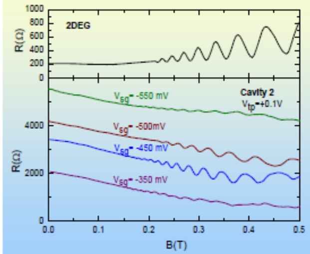
In consistence with the interference condition of AB effect.

Areas estimated from the periodicity of magnetic flux are reasonable.

V_{sg} (mV)	ΔB (mT)	A (μm^2)	R (nm)	E_c (meV)	ΔE(μeV)	ΔE/E_c
-400	88.7	0.047	128	1.34	153	0.114
-450	97.0	0.043	117	1.47	167	0.114
-500	125	0.033	102	1.69	217	0.129

Negative magnetoresistance at low fields (B<0.5T)

Magnetoresistance curves of cavity for different V_{sg} and V_{tp} demonstrate **negative magentoresistances** at low fields.



Theoretical calculation of semiclassical dynamics in quantum cavities of different shapes (chaotic/regular).

Lorentzian

chaotic → $\langle \delta R_D(B)\rangle = \mathcal{R}/[1+(2B/\alpha_{cl}\phi_0)^2]$

regular → $\langle \delta R_D(B)\rangle \propto |B|$ for small $|B|$

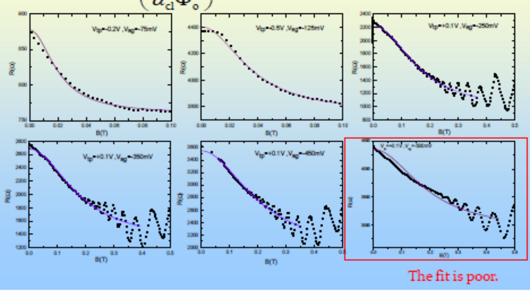
Linear

H. U. Baranger *et al.*, Phys. Rev. Lett. 70, 3876 (1993).
J.P. Birds *et al.*, Rep. Prog. Phys. 66, 583 (2003).

Fit magnetoresistance to the Lorentzian function

$$R(B) = R_0 - \frac{\Delta}{1+\left(\frac{2B}{\alpha_{cl}\Phi_o}\right)^2}$$

Adjustable variables: R_o (Ω), Δ (Ω), α_{cl} (cm)$^{-1}$



The fit is poor.

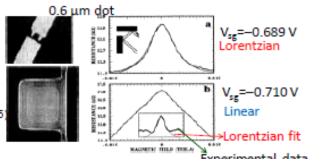
Previous Reports

Gate biasing induced line shape transition from Lorentzian to linear in magnetoresistance characteristics.

- *Lead induced transition to chaos in ballistic mesoscopic billiards*

The line shape of MR curves transits from Lorentzian to linear with increasing negative biasing.

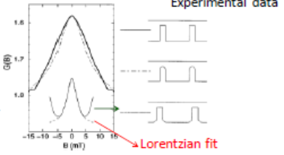
J.P. Bird *et al.*, Phys. Rev. B52, 14336 (1995)



- *Ballistic weak localization in regular and chaotic quantum–electron billiards*

Cavities with rounded corner have the zero field weak localization peak shape.

Zozoulenko *et al.*, Phys. Rev. B 54, 5823 (1996).



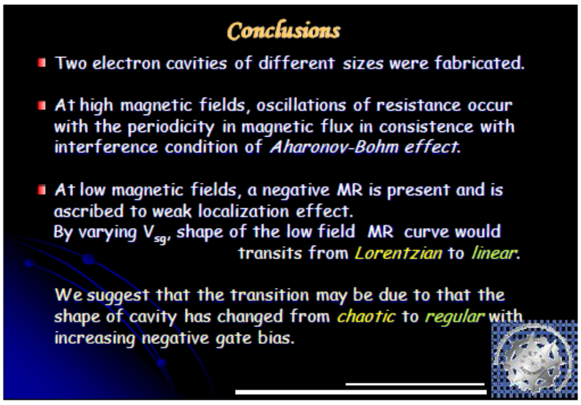
Effective area: $S = (2\pi\alpha)^{-1}$ for the ergodic motion

Area enclosed by classical trajectories (~ the area of cavity) $S \propto \frac{1}{\alpha} \propto \frac{1}{V_{sg}}$

V_{tp}(V)	V_{sg}(mV)	α (μm^{-1})	S (μm^2)	A_{AB} (μm^2)
+0.1	-250	79.1	0.002	
+0.1	-350	87.3	0.0018	
+0.1	-450	98.9	0.0016	0.047
+0.1	-500	94.9	0.0017	0.043
+0.1	-550	47.4	0.0034	0.033

Transition in line shape from Lorentzian to linear.

Lorentzian fits are poor.


Conclusions
Two electron cavities of different sizes were fabricated.
At high magnetic fields, oscillations of resistance occur with the periodicity in magnetic flux in consistence with interference condition of Aharonov-Bohm effect.
At low magnetic fields, a negative MR is present and is ascribed to weak localization effect.
By varying V_{sg}, shape of the low field MR curve would transits from Lorentzian to linear.
We suggest that the transition may be due to that the shape of cavity has changed from chaotic to regular with increasing negative gate bias.

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：100 年 9 月 17 日

計畫編號	NSC 99－2112－M－009－007		
計畫名稱	閘極局域的開放式量子點與一維窄通道的抽運傳輸、整流、與自旋極化機制		
出國人員姓名	許世英	服務機構及職稱	國立交通大學電子物理系教授
會議時間	100 年 8 月 10 日 至 100 年 8 月 17 日	會議地點	Beijing(北京), China(中國)
會議名稱	(中文)第二十六屆國際低溫物理會議 (英文)The 26th international conference on low temperature physics		
發表論文題目	(中文)閘極局域空腔體之磁電傳輸 (英文)Magneto-transport of gate confined cavities		

本屆低溫會議於八月十日至十七日假中國北京舉行，研討內容主要分為五大項目，

A) 量子氣體、流體、固體 (Quantum Gases, Fluids, and Solids)

B) 超導體 (Superconductivity)

C) 磁學與量子相變 (Magnetism and Quantum Phase Transition)

D) 凝態物質之電性量子傳輸 (Electronic Quantum Transport in Condensed Matter)

E) 低溫技術與應用(Cryogenic technologies and Applications)

共計有上千篇的論文發表。

一、參加會議經過

8/9 早上搭乘 9:20AM 長榮航空從桃園直飛北京班機，與系上吳光雄老師及數位博士生同行，在機場又碰到同步輻射陳老師等，北京台北大約 2 個半小時不算遠，但由於起飛前不知為何滯留在飛機上 40~50 分，稍延誤至下午 1:00 左右才抵達；窗外看似霧茫茫，實則應是砂塵漫飛。搭乘機場快捷到地鐵轉運輾轉到距離 hotel 最近的奧體中心站，一路上乘客眾多，不是上班時段為何還這麼擁擠?頓時感受人口的壓力，出了地鐵，有點傻眼了，竟在奧運公園的南側入口，而 hotel 在東側口外，一行人拖著行李浩浩蕩蕩通過安檢進入園區，夾雜在眾多遊客與小販間，無心欣賞鳥巢水立方等指標性奧運建築，只想著快速通過吵雜人群，無奈路程遙遙，花了近 2~30 分才到達 hotel，Check in 後趕緊拆箱整理，已是傍晚了；正想與夥伴們到附近走走順道吃個晚餐，結果來個傾盆大雨、雷雨交加，寸步難行的一晚。

8/10 由於下午才開始註冊，早上就到頤和園、圓明園走走，發現這城市真的就是人多地廣，幾乎任何時刻，不論在地鐵站、街道、廣場、或公園就是跟著一大群人賣力向前走，永遠熱鬧滾滾；頤和園、圓明園真的很遼闊，礙於時間只能針對少數景點走馬

看花，下午趕著到北京國際會議中心的會場報到，拿了本次的議程與所有的 abstracts 的 flash，晚上大會備有 reception，就與陸續來報到的朋友聊天用餐，享用食物，飽餐一頓。回旅館註記了明天該聽的演講與該看的壁報，今年似乎鐵砷基超導體與 topological insulator 是大會兩大主軸。

8/11 趕著一大早的開幕式，其中我論文指導老師之指導老師 Bob Hallock 代表 IUPAP 致辭，而在 Brown 大學的老師 Dr.Maris 也獲得 London Prize，真是高興；好久沒看見他們了，資深但依然活躍在物理領域。早上就是由今年三位 London prize 和一位 Simon prize 得獎者開講研究成果。下午就正式分五個 parallel sessions 依不同的主題進行，4:00~6:30PM 則是壁報時段，相當緊湊。

8/12 早上比較有興趣的是 session B1 和 B2 超導的新穎現象與新超導物質，雖然現在個人的研究已少涉獵超導這領域，不過還是值得關心；Birge 和之前博士後研究實的指導老師 Pratt 合作發表在鐵磁材料的 Josephson Junctions 觀察到 spin-triplet 的超導性質，雖然超導鐵磁混合系統在十幾年前就已知具有長尺度的鄰近效應(long range proximity effect)，但他們在 12-28nm 厚的 Co 層仍測得超導電流，而且藉由加入 PdNi 或 CuNi 數 nm 厚薄夾層可以最佳化其超導電流特徵值，MSU Pratt group 利用之前做 CPP multilayer 的技術延伸至此微米尺度 CPP 多層之 Josephson Junctions 上，他們認為這系統的超導不同於 Sr_2RuO_4 的 p wave 超導(接續 Budakian 的演講)，可以是具偶數軌道攪動量的 s wave，因此即使系統存在無序性但仍有完整的超導性。

晚上因為慶祝超導被發現100周年，特別於7:30PM邀請Peter Kes, Georg Bednorz, Frank Steglich, Douglas Scalapino四位作專題演講，kes的投影片展示Onnes的手稿與其當時實驗室照片，並聽聞當時他們發現超導的故事，真是栩栩如生相當傳奇。Bednorz講述高溫超導的發現歷史與目前的相關應用，日本JR在2005年第一個採用高溫超導線在磁浮列車的電磁鐵電源供應上，而磁浮列車車速達300mile/hr，其它大概美歐洲的電力網等都陸續在推廣中，較新的是magnetic Billet heater是一款以HTC作的感應式加熱器，號稱可減少55%能量損耗與增加25%效能。Steglichru從Kondo effect介紹而延伸至heavy fermion特性，進而到反鐵磁交換偶合媒介之d type heavy fermion superconductor，雖然1979就已發現$CeCu_2Si_2$的超導行為(Tc~0.6K)，但今年2011 在nature physics和PRL都仍有文章揭露$CeCu_2Si_2$的超導性來自spin density wave fluctuation；今年新發現的$PuCoIn_5$的超導溫度為2.5K。Scalapino剛好接續講非傳統性超導，整合前二位的內容；晚上節目真是精采，結果回到旅館已將近午夜，沒想到平日進出的旅館區門居然關了，著實下了一跳，幸虧等到裡面閒逛的居民告知另一側有管控門，繞了一大圈才回到旅館，真是從沒想過會發生的事。

8/13主要還是超導相關的研究報告：包含近期heavy fermion superconductors與鐵基系列的超導體，大部分時間都在convention Hall 3，下午的壁報時間也趁機詢問了一些大陸地區做電磁鐵的廠商，現在液氦價位高，計畫經費又少情況下，能夠不用超導磁鐵就盡量不用，但配合低溫系統開口為5cm直徑的電磁鐵只可產生中心點2.6kOe磁場又稍小了些，希望能換個磁鐵加大到2~3倍，就非常適合；本想目前台灣已幾乎找不到生產廠商，而歐美價位又非常高，因此改詢問大陸區域，結果原來價位也今非昔比，一路高

漲與歐美相差無幾，真是挫折。

8/15 聽了好些場naowire/nanotube(session D早上)與topological insulator(session D下午)的演講。席間碰到數位在美讀書時認識的朋友，他們目前都已在美國任教多年，好久沒碰面了，真是難得的機緣。

8/16 下午壁報時段該展示我們的研究”Magnetotransport of Gate confined Cavities”，午餐過後就找時間將壁報一張張貼起來，順便也先看看鄰近的壁報，在同一時段的領域也較接近，本來低維度電子電洞系統在國際低溫會議向來就並不是主要群，在超導體、低溫液態氦(超流體)、低溫技術與最近崛起之topological insulator之外，因此通常都安排在最後二天的幾場sessions，不過由於此會議規模大，所以還是有相當之內容可期。法國Y. Jin group以quantum point conatct架構一維彈道式場效電晶體，據稱電壓放大率在低溫下大於1，藉由閘極電壓控制QPC在最低的sub-band以達高電導值(transconductance)，並由其高能隙(level spacing)降低輸出電導值；Princeton U. K.West和P.Anderson等實驗與理論團隊並肩探討二維GaAs異質介面電子強關聯下的電子電子作用，舊題材但有新看法；如同雖然我們這次發表的題材不是很新穎但卻有系統性的成果，更可釐清明朗的機制，

二、與會心得

這次不曉得為什麼會有好些壁報未參加，歐美做低維度電子電洞系統或無序弱局域電性傳輸的缺席甚多，參與的人主要還是大陸本土學者學生居多，而且主力是鐵砷基超導體與 topological insulator，會議題材變少了，雖然仍有傳統 Helium 超流體、低溫系統或高溫超導體等，不過好像被邊緣化了，或許因為中國大陸最近數年都主攻那兩大領域，因此如此大型國際會議也意識型態地稍微偏頗自己喜好，行地主優勢。在這七八天緊密的演講-壁報討論節目下，收穫還是相當多。出國參與國際會議是最有效，直接地增進新知的方法，免除在資料期刊上查閱上的遺漏，面對面的溝通，也能藉此提供外國學者得知我們的研究成果，使其了解台灣方面於物理研究上的盡力。

三、考察參觀活動(無是項活動者略)

四、建議

感謝國科會給予的經費補助，此行獲益良多。希望學校與國科會能繼續補助國際之學術交流活動。基於氦在地球非常有限的存量，若要從事低溫實驗，設置液化機是刻不容緩的事情，希望學校能配合國科會在校內設置。

五、攜回資料名稱及內容

Program bulletin, abstract flash, reprints, 產品介紹與中國物理學會與中科院物理所合編的物理期刊數期。

六、其他

會議壁報


Magnetotransport of Gate confined Cavities
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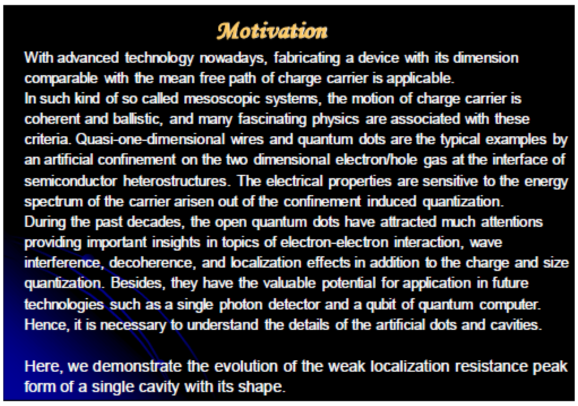
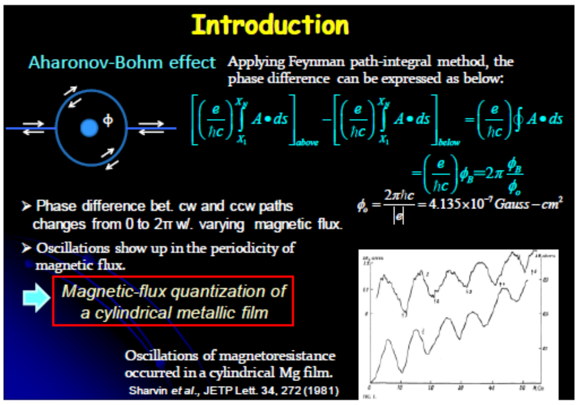
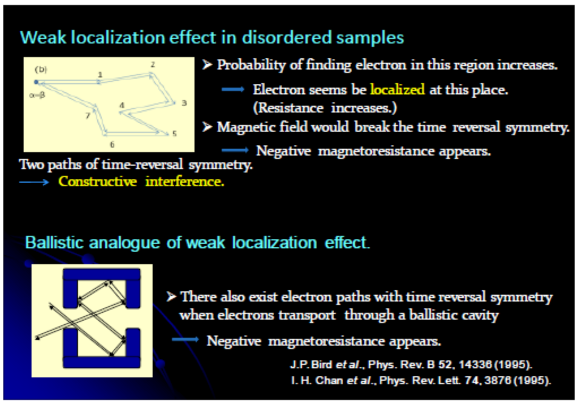
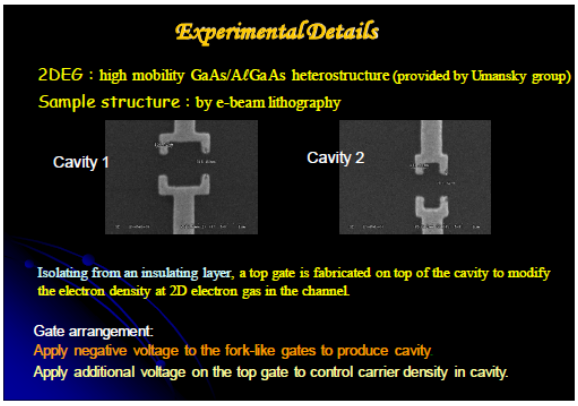
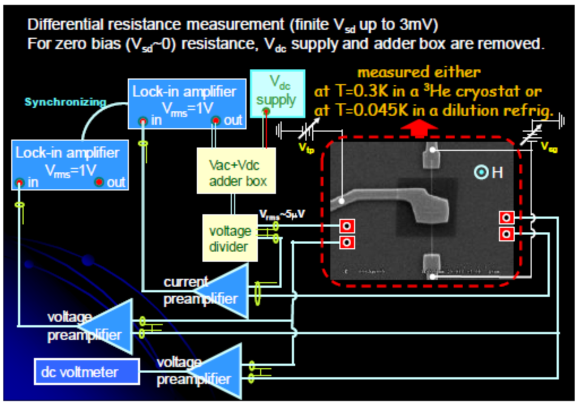
NSC99-2112-M-009-007 and MOE ATU
August 16, 2011
電子物理系
NCTU Electrophysics


Motivation
With advanced technology nowadays, fabricating a device with its dimension comparable with the mean free path of charge carrier is applicable.
In such kind of so called mesoscopic systems, the motion of charge carrier is coherent and ballistic, and many fascinating physics are associated with these criteria. Quasi-one-dimensional wires and quantum dots are the typical examples by an artificial confinement on the two dimensional electron/hole gas at the interface of semiconductor heterostructures. The electrical properties are sensitive to the energy spectrum of the carrier arisen out of the confinement induced quantization.
During the past decades, the open quantum dots have attracted much attentions providing important insights in topics of electron-electron interaction, wave interference, decoherence, and localization effects in addition to the charge and size quantization. Besides, they have the valuable potential for application in future technologies such as a single photon detector and a qubit of quantum computer.
Hence, it is necessary to understand the details of the artificial dots and cavities.
Here, we demonstrate the evolution of the weak localization resistance peak form of a single cavity with its shape.


Introduction
Aharonov-Bohm effect
Applying Feynman path-integral method, the phase difference can be expressed as below:
$\left[\left(\frac{e}{\hbar c}\right)\int_{X_i}^{X_f} A\bullet ds\right]_{above} - \left[\left(\frac{e}{\hbar c}\right)\int_{X_i}^{X_f} A\bullet ds\right]_{below} = \left(\frac{e}{\hbar c}\right)\oint A\bullet ds$
$=\left(\frac{e}{\hbar c}\right)\phi_B = 2\pi\frac{\phi_B}{\phi_o}$
$\phi_o = \frac{2\pi\hbar c}{|e|} = 4.135\times10^{-7}\ Gauss-cm^2$
➢ Phase difference bet. cw and ccw paths changes from 0 to 2π w/. varying magnetic flux.
➢ Oscillations show up in the periodicity of magnetic flux.
Magnetic-flux quantization of a cylindrical metallic film
Oscillations of magnetoresistance occurred in a cylindrical Mg film.
Sharvin et al., JETP Lett. 34, 272 (1981)


Weak localization effect in disordered samples
➢ Probability of finding electron in this region increases.
Electron seems be localized at this place.
(Resistance increases.)
➢ Magnetic field would break the time reversal symmetry.
Negative magnetoresistance appears.
Two paths of time-reversal symmetry.
Constructive interference.
Ballistic analogue of weak localization effect.
➢ There also exist electron paths with time reversal symmetry when electrons transport through a ballistic cavity
Negative magnetoresistance appears.
J.P. Bird et al., Phys. Rev. B 52, 14336 (1995).
I. H. Chan et al., Phys. Rev. Lett. 74, 3876 (1995).

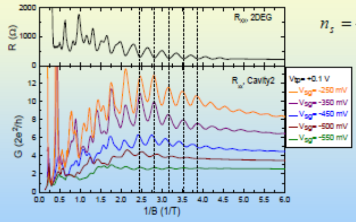

Experimental Details
2DEG : high mobility GaAs/AℓGaAs heterostructure (provided by Umansky group)
Sample structure : by e-beam lithography
Cavity 1
Cavity 2
Isolating from an insulating layer, a top gate is fabricated on top of the cavity to modify the electron density at 2D electron gas in the channel.
Gate arrangement:
Apply negative voltage to the fork-like gates to produce cavity
Apply additional voltage on the top gate to control carrier density in cavity.


Differential resistance measurement (finite V_{sd} up to 3mV)
For zero bias (V_{sd}~0) resistance, V_{dc} supply and adder box are removed.
Synchronizing
Lock-in amplifier V_{rms}=1V in out
Lock-in amplifier V_{rms}=1V in out
V_{dc} supply
measured either
at T=0.3K in a ^{3}He cryostat or
at T=0.045K in a dilution refrig.
V_{tp}
V_{sg}
H
Vac+Vdc adder box
V_{rms}~5μV
voltage divider
current preamplifier
voltage preamplifier
dc voltmeter
voltage preamplifier

Results and Discussion

de Haas Oscillations of 2DEG & Cavity 2.

The formation of the cavity does not affect carrier concentration n_s.

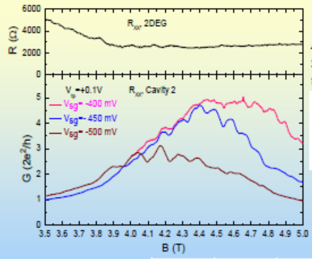


$$n_s = \frac{2e}{h}\frac{1}{(1/B_1)-(1/B_2)}$$

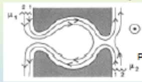
Error:±3%

	2DEG	Cavity2				
V_{sg} (mV)		-250	-350	-450	-500	-550
n_s (cm^{-2})	1.37X10^{11}	1.39X10^{11}	1.31X10^{11}	1.41X10^{11}	1.31X10^{11}	1.35X10^{11}

Oscillations in periodicity of magnetic flux at high magnetic fields (B>3T)



At high magnetic fields, edge states form and electrons can transport along the wall of the cavity.



Phys. Rev. B 40, 8083 (1989)

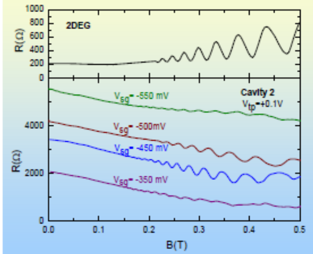
In consistence with the interference condition of AB effect.

Areas estimated from the periodicity of magnetic flux are reasonable.

V_{sg} (mV)	ΔB (mT)	A (μm^2)	R (nm)	E_c (meV)	ΔE(μeV)	ΔE/E_c
-400	88.7	0.047	128	1.34	153	0.114
-450	97.0	0.043	117	1.47	167	0.114
-500	125	0.033	102	1.69	217	0.129

Negative magnetoresistance at low fields (B<0.5T)

Magnetoresistance curves of cavity for different V_{sg} and V_{tp} demonstrate **negative magentoresistances** at low fields.



Theoretical calculation of semiclassical dynamics in quantum cavities of different shapes (chaotic/regular).

Lorentzian

chaotic→ $\langle \delta R_D(B)\rangle = \mathcal{R}/[1+(2B/\alpha_{cl}\phi_0)^2]$

regular→ $\langle \delta R_D(B)\rangle \propto |B|$ for small $|B|$

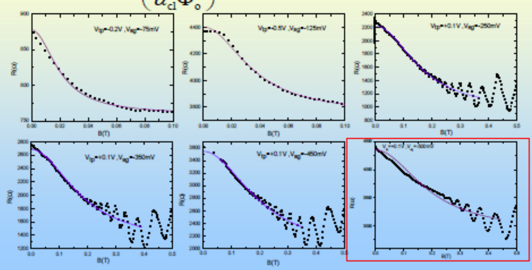
Linear

H. U. Baranger *et al*., Phys. Rev. Lett. 70, 3876 (1993).
J.P. Birds *et al*., Rep. Prog. Phys. 66, 583 (2003).

Fit magnetoresistance to the Lorentzian function

$$R(B) = R_0 - \frac{\Delta}{1+\left(\frac{2B}{\alpha_{cl}\Phi_o}\right)^2}$$

Adjustable variables: R_o (Ω), Δ (Ω) , α_{cl} (cm)$^{-1}$



The fit is poor.

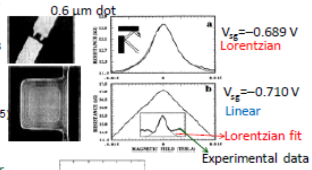
Previous Reports

Gate biasing induced line shape transition from Lorentzian to linear in magnetoresistance characteristics.

- *Lead induced transition to chaos in ballistic mesoscopic billiards*

The line shape of MR curves transits from Lorentzian to linear with increasing negative biasing.

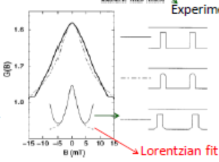
J.P. Bird *et al*., Phys. Rev. B52, 14336 (1995)



- *Ballistic weak localization in regular and chaotic quantum–electron billiards*

Cavities with rounded corner have the zero field weak localization peak shape.

Zozoulenko *et al*., Phys. Rev. B 54, 5823 (1996).



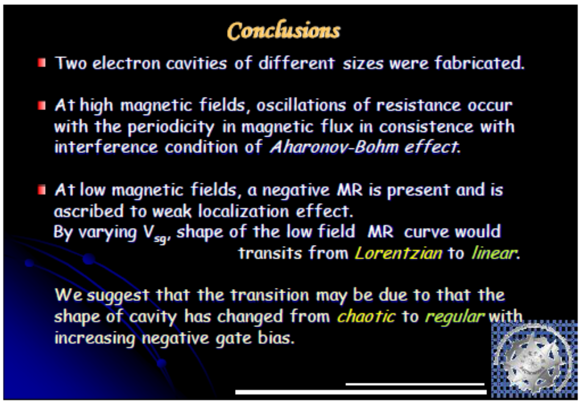
Effective area: $S=(2\pi\alpha)^{-1}$ for the ergodic motion

Area enclosed by classical trajectories (~ the area of cavity) $S \propto \frac{1}{\alpha} \propto \frac{1}{V_{sg}}$

V_{tp} (V)	V_{sg} (mV)	α (μm^{-2})	S (μm^2)	A_{AB} (μm^2)
+0.1	-250	79.1	0.002	
+0.1	-350	87.3	0.0018	
+0.1	-450	98.9	0.0016	0.047
+0.1	-500	94.9	0.0017	0.043
+0.1	-550	47.4	0.0034	0.033

Transition in line shape from Lorentzian to linear.

Lorentzian fits are poor.


Conclusions
Two electron cavities of different sizes were fabricated.
At high magnetic fields, oscillations of resistance occur with the periodicity in magnetic flux in consistence with interference condition of Aharonov-Bohm effect.
At low magnetic fields, a negative MR is present and is ascribed to weak localization effect.
By varying V_{sg}, shape of the low field MR curve would transits from Lorentzian to linear.
We suggest that the transition may be due to that the shape of cavity has changed from chaotic to regular with increasing negative gate bias.

國科會補助計畫衍生研發成果推廣資料表

日期:2012/10/17

國科會補助計畫	計畫名稱: 閘極局域量子元件的自旋極化操控與偵測
	計畫主持人: 許世英
	計畫編號: 99-2112-M-009-007- 學門領域: 其他凝體－實驗

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：許世英　**計畫編號：**99-2112-M-009-007-

計畫名稱：閘極局域量子元件的自旋極化操控與偵測

成果項目			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比	單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	6	6	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	6	6	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	3 碩士論文

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 □未發表之文稿 ■撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

原本計畫為三年, 並設置 3 軸磁場, 以磁聚焦法偵測量子線與量子點因 Zemann splitting 導致的自旋極化和複合式量子系統之自旋電流之研究, 但因計畫只核定一年, 另外無任何設備費補助以及材料費緊縮下(本計畫核定經費中約半數為外掛之系業務助理薪資), 實驗的進行非常困難, 不過我們還是在閘極局域的空腔系統探討了量子干涉效應, 並了解其對應的磁電性傳輸與腔體的局域環境之相關性, 這對之後繼續探討複合式量子系統之自旋電流有相當大的幫助.