行政院國家科學委員會專題研究計畫 成果報告

超導渦漩運動與量子相干介質的可控光學特性研究
研究成果報告(精簡版)

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計畫主持人：楊宗哲

計畫參與人員：碩士班研究生-兼任助理人員：葉怡岑

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 ：本計畫涉及專利或其他智慧財產權，1 年後可公開查詢

中 華 民 國 101 年 12 月 11 日

中文摘要： 本計劃已完成二類子題，一類為具有三角及蜂巢晶格之超導体上，研究渦漩分佈及其動力學，以二維時間相依之Ginzburg-Landau方程式作數值模擬.另一類研究頻率敏感開關控制效應，在電磁誘發透明層狀介質中，以二光子共振誘發。同時，也針對一維光子晶體及圓柱中多層環狀結構探討其光學性質，針對太赫茲或微波區段，及就凹凸結構中表面電漿極化子的性質予以探討。在第一類裡，三角晶格中模擬的結果呈現在大範圍磁場上,渦漩皆捕獲在釘扎的洞內。然而具蜂巢晶格中，釘扎間的渦漩出現在相對低的磁場。當磁場增加下，新的渦漩再度進入釘扎洞內，但維持釘扎間的渦漩數目。對第二類，週期性層狀介質之單胞由電介質及EIT原子蒸氣組成。其結果呈現探測光頻率的小變化,引起反射率及透射率變化激烈，這就是可朔性頻率敏感的光學響應。另一主題應用設計性表面電漿極化子的概念,建構彎曲平行微帶線間可壓抑交叉干擾，經數值模擬及實驗驗證，其他相關子題也作簡略描述。

中文關鍵詞： 時間相依的Gingburg-Landan方程式，渦漩分佈，三角形晶格，蜂巢晶格，釘扎間的渦漩，週期層狀介質，電磁誘發透明，光子晶體，設計者表面電漿極化子，彎曲凹凸之微帶線，交叉干擾

英文摘要： In this project, we have done two category subjects in our research results. One category is to study the vortex distributions and dynamics in large superconductors with triangular and honeycomb arrays are investigated by numerical simulation of the two dimensional time-dependent Ginzburg-Landau equations. Another category is to study frequency-sensitive switching contril effect induced by two-photon resonance in an electromagnetic induced transition based layered medium. Also, the optical properties of one dimensional photonic crystal and multilayer annular ring structure in cylinder, spoof surface Plasmon polaritons (SPP) propagate in corrugated structure on metallic film for terahertz or microwave regime.

In the first category, the simulated results for film with regular triangular pinning hole array show up the vortices are all captured within the holes at wide range of magnetic fields. For film with regular honeycomb pinning array, the interstitial vortices appear at relatively low magnetic fields. With increase of magnetic field , the new vortices enter the holes again and keep the number of vortices at the interstitial positions unchanged.In second category, a periodic layered medium with unit cells consisting of a dielectric and an EIT (electromagnetically induced transparency) atomic vapor is suggested for light propagation manipulation. Such an EIT-based periodic layered medium exhibits a flexible frequency-sensitive optical response, where a very small change in probe frequency can lead to a drastic variation in reflectance and transmittance. Another subject related to apply the concept of designer surface plasmon polaritons to construct the bended parallel micro-strip lines suppress the crosstalk in between, which is realized by introducing subwavelength periodic corrugations onto the edges of one conventional microstrip line. he agreement between the numerical and experimental results is found well in this microstrip. Other related subjects are also briefly described in this report.

英文關鍵詞： time-dependent Ginzburg-Landau equation, vortex distribution, triangular array, honeycomb array, interstitial vortex, periodic layered medium, electromagnetically induced transparency, photonic crystal, designer surface Plasmon polariton, bended corrugated microstrip, cross-talk.

Study of Vortex motion in Superconductor and the Controllable Optics Properties of Quantum Coherent Media

Project Number: NSC 100- 2112-M-216-002

Project Investigator: Tzong-Jer Yang
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101, 11, 30

Abstract

In this project, we have done two category subjects in our research results. One category is to study the vortex distributions and dynamics in large superconductors with triangular and honeycomb arrays are investigated by numerical simulation of the two dimensional time-dependent Ginzburg-Landau equations. Another category is to study frequency-sensitive switching contril effect induced by two-photon resonance in an electromagnetic induced transition based layered medium. Also, the optical properties of one dimensional photonic crystal and multilayer annular ring structure in cylinder, spoof surface Plasmon polaritons (SPP) propagate in corrugated structure on metallic film for terahertz or microwave regime.

In the first category, the simulated results for film with regular triangular pinning hole array show up the vortices are all captured within the holes at wide range of magnetic fields. For film with regular honeycomb pinning array, the interstitial vortices appear at relatively low magnetic fields. With increase of magnetic field , the new vortices enter the holes again and keep the number of vortices at the interstitial positions unchanged. These results confirm our explanations of the experimental results we obtained earlier. In second category, a periodic layered medium with unit cells consisting of a dielectric and an EIT (electromagnetically induced transparency) atomic vapor is suggested for light propagation manipulation. Such an EIT-based periodic layered medium exhibits a flexible frequency-sensitive optical response, where a very small change in probe frequency can lead to a drastic variation in reflectance and transmittance. As the destructive quantum interference relevant to two-photon resonance arises in EIT atoms interacting with both control and probe fields, the controllable optical processes that depend sensitively on the external control field will take place in this EIT-based periodic layered medium. Such a frequency sensitive and field controlled optical behavior of reflection and transmission in the EIT photonic crystal can be applicable to designs of new devices such as photonic switches, photonic logic gates and photonic transistors, where one laser field can be controlled by the other one, and would have potential applications in the areas of integrated optical circuits and other related techniques (e.g., all-optical instrumentations). Another subject related to apply the concept of designer surface plasmon polaritons to construct the bended parallel micro-strip lines suppress the crosstalk in between, which is realized by introducing subwavelength periodic corrugations onto the edges of one conventional microstrip line. The transmission properties of such microstrip are numerically simulated. The suppression of the coupling between the bended corrugated microstrip and contentional microstrip is also measured experimentally in the time domain. The agreement between the numerical and experimental results is found well in this microstrip. Other related subjects are also briefly described in this report.

Keywords: time-dependent Ginzburg-Landau equation, vortex distribution, triangular array, honeycomb array, interstitial vortex, periodic layered medium, electromagnetically induced transparency, photonic crystal, designer surface Plasmon polariton, bended corrugated microstrip, cross-talk.

I. Introduction

In this year, my project covers two different topics. One focuses on study vortex distributions and dynamics in superconductor with regular pinning array by time-dependent Ginzburg-Landau equation. Another one focuses on study on frequency-sensitive optical response in a periodic layered medium with a unit cell consisting of a dielectric and an EIT atomic vapor. Also, the suppression of cross-talk between bended parallel microstrips via designer surface Plasmon polaritons is simulated and experimentally verified. I also cooperate with Prof. C.J. Wu to study properties of one dimensional different photonic crystal structures including annular ring in cylinder. Such cooperation, we come out several excellent results and published in well-known international journals. In the following sections, I shall divide into several sub-subjects I mention above to describe briefly. A more detail

I suggest reader to come to my publication lists to search the related paper you are interesting one.

II. Vortex distributions and dynamics in superconductor with regular pinning array

This part of work will be published in Journal of Superconductivity and Novel Magnetsim.

During the past two decades, the superconductors with different kinds of periodic pinning arrays have been explored intensively . The experimental results reveal clearly that the matching effect is present in all these kinds of samples. In the experiments, usually the critical current or magneto resistance as function of magnetic field is measured, and the microscopic pictures of vortex configurations or vortex dynamics are inferred.

There are a few experiments that the configurations and dynamics of vortices are directly observed by magnetic optics, MFM or Lorentz microscopy . However, the range of temperature and magnetic fields for these direct observation methods are quite limited. All these methods depend on the detection of the magnetic field of the vortices. The vortices can not be distinguished when the temperature is close to the critical currents and when the magnetic field is high. So the simulation study of vortex matter in these systems is still important. The experimental measurements combined with simulations will be an important way to understand the vortex matter physics in these systems. There are two major methods for simulation study. One is the molecular dynamic simulation. As shown in our previous reports, the molecular dynamic simulations method is straightforward. However, they are valid under the London approximation and the vortices are treated as classical point particles, so the results obtained for the high magnetic fields are not valid where the interaction between two vortices are very different from two isolated vortices. The other is based on the numerical solution of the Ginzburg-Landau(G-L) equations. Usually, the time dependent Ginzburg-Landau equations are solved using the link-variable method. Because G-L equations are precise when the temperature is close to the critical temperatures, they are very suitable to study most of the experiments.

The vortex distributions in superconductors with regular triangular and honeycomb arrays are investigated by numerical simulation of the 2-D time-dependent Ginzburg-Landau equations. Periodic boundary conditions are implemented through specific gauge transformations under lattice translations. In the parameter range we investigated, the magnetic fields are almost homogenous all over the sample, so we make one approximation to set the magnetic field homogeneous. The simulation results are presented for different magnetic fields. These results confirm our explanations of the experimental results we obtained earlier. For film with regular triangular pinning array, the vortices are all captured within the holes at wide range of magnetic fields. For film with regular honeycomb pinning array, the interstitial vortices appear at relatively low magnetic fields. With increase of magnetic field, the new vortices enter the holes again and keep the number of vortices at the interstitial positions unchanged. This kind of phenomenon can explain interesting critical current pattern in the experimental results. Further simulations will be made to explore the impact of the pinning size.

III. Frequency-Sensitive switching control effect induced by two-photon resonance in an EIT-based layered medium

In this part, the results have been written in a paper and to be published in Annalen der Physik.

Over the past two decades, the effects of atomic phase coherence have exhibited a number of physically interesting phenomena such as electromagnetically induced transparency (EIT) and the effects that are relevant to EIT, including light amplification without inversion, spontaneous emission cancellation, multi-photon population trapping, coherent phase control as well as photonic resonant left-handed media. EIT is such a quantum optical phenomenon that if one resonant laser beam propagates in a medium (e.g., an atomic vapor or a semiconductor-quantum-dot material), the beam will get absorbed; but if two resonant laser beams instead propagate inside the same medium, neither would be absorbed. Thus the opaque medium becomes a transparent one. Such an interesting optical behavior would lead to many applications, e.g., designs of new photonic and quantum optical devices. Since it can exhibit many intriguing optical properties and effects, EIT has attracted extensive attention of a large number of researchers in a variety of areas of optics, atomic physics and condensed state physics, and this enables physicists to achieve new novel results. For example, some unusual physical effects associated with EIT include the ultraslow light pulse propagation, the superluminal light propagation, and the light storage in atomic vapors, some of which are expected to be beneficial (and powerful) for developing new technologies in quantum optics and photonics.

Apart from EIT (and hence quantum coherence), in this paper, we shall also consider another artificial periodic dielectric: specifically, the EIT medium (an atomic vapor or a semiconductor-quantum-dot material) is embedded in the periodic host dielectric (e.g., GaAs). As is well known, photonic crystals, which are periodic arrangements of dielectrics, have captured wide attention in physics, materials science and other relevant fields (e.g., information science) due to its capacity of controlling light propagations. Here, we shall propose some new effects relevant to light propagation manipulation via EIT responses in artificial periodic dielectric. Such effects result from the combination of EIT and photonic crystals. This can be viewed as a new application of EIT for manipulating light wave propagations, which can exhibit a tunable reflectance and transmittance (induced by an external control field) and show extraordinary sensitivity to the frequency of the probe field. For example, a change of one part in 10^8 in the probe frequency w_p would lead to a dramatic change in the reflectance and transmittance of the EIT-based periodic layered medium, and therefore, it can be used for designing sensitive optical switches, photonic logic gates as well as tunable photonic transistor. Although there have been some investigations that are relevant to the tunable photonic crystals based on EIT media in the literature, yet less attention has been paid to the frequency-sensitive optical behavior that would be the most remarkable property of such a kind of periodic layered media.

In the literature, photonic logic gates designed based on new coherent materials, such as near-field optically coupled nanometric materials and double-control multilevel atomic media, have been suggested. It should be emphasized that the mechanism presented in this paper can be considered an alternative way to realize such a kind of photonic and quantum optical devices. Very recently, Abdumalikov et al. reported an experimental observation of EIT on a single artificial atom, and found that the propagating electromagnetic waves are allowed to be fully transmitted or backscattered. We will demonstrate in the present paper that such a full controllability of optical property of artificial media can also be achieved in the EIT-based layered structure, of which the reflectance can be either zero or large depending sensitively on the intensity of the external control field, and we expect that this would open a good perspective for its application in some new fields such as photonic microcircuits (or integrated optical circuits).

Since the microscopic electric polarizability as well as the electric permittivity of the EIT medium are caused by the atomic energy level transition processes from the ground state to the excited states, in which the quantum interference relevant to atomic phase coherence is involved, the reflectance and transmittance of an EIT-based periodic layered medium are shown to be quite sensitive to the probe frequency. In addition to the probe frequency-sensitive behavior, such an EIT-based periodic layered material can exhibit another property: specifically, the control field can be used to manipulate the optical response. We have indicated that the reflectance and transmittance in the case of large layer number *N* depend sensitively on the Rabi frequency of the control field. Thus, some new sensitively switchable devices that can find new applications in photonic quantum information processing can be achieved.

The present scheme can be generalized to a four-level EIT system, where two control fields and one probe field drive the atomic level transitions. Obviously, the optical response in such a four-level EIT-based photonic crystal would be more sensitive to the probe frequency than in a three-level EIT photonic crystal presented in this paper. Apart from this intriguing property, there are more interesting applications that we can suggest based on the four-level EIT photonic crystal, e.g., some examples of photonic devices (e.g., multi-input logic gates), in which the control fields and the transmitted probe field act as the input and output signals, respectively, can be designed. We expect that all these new optical properties relevant to quantum coherence, including their applications to photonic devices, could be realized experimentally in the near future.

IV. Channel spoof surface Plasmon polaritons

This part has been written in a paper and published in Key Engineering Materials Vol. 538 (2013) pp 305-307.

Surface plasmon polaritons (SPPs) are electromagnetic (EM) excitations propagating along the metal-dielectric interface, whose electromagnetic fields can be strongly confined to the near vicinity of the interface. This confinement leads to an enhancement of the electromagnetic field at the interface, resulting in an extraordinary sensitivity of SPPs to surface conditions. Thus, SPPs provide the possibility of concentrating and channeling light with subwavelength structures, which opens up a previously inaccessible length scale for optical research.

It is desired naturally to extend highly localized waveguiding and surface-enhanced effects to terahertz (THz) or microwave regimes. At these low frequencies, however, metals behave no longer like a plasma but resemble a perfect electric conductor (PEC), as their plasma frequencies are often in the ultraviolet part of the EM spectrum, and as a result, SPPs are highly delocalized on metal surfaces. To engineer surface plasmon at lower frequency, it was proposed that by cutting holes or grooves on a scale much smaller than the wavelength of probing radiation in metal surfaces to increase the penetration of the fields into the metal, the frequency of existing surface plasmons can be tailored at will. The existence of such geometry-controlled SPPs, named spoof SPPs, has recently been verified experimentally in the microwave regime.

A subwavelength guiding of channel plasmon polaritons (CPPs) is realized by a structured metallic groove at frequencies far below the plasma frequency of metal. The transmission coefficient of the spoof CPPs is experimentally verified at microwave frequencies.

V. Terahertz Plasmonic Microcavity with High Quality Factor and Ultrasmall Mode Volume

This part is to be published in Plasmonics.

Surface plasmon polaritons (SPPs) are electron density waves excited at the interfaces between metal and dielectric. Owning to their highly localized electromagnetic(EM) fields, they may be used for the transport and manipulation of photons on the subwavelength scales. Thus, plasmonic components seem to be a prime candidate for nanophotonic integrated circuits, combining the bandwidth of photonics along with nanoscale dimensions.While most studies of SPPs focus on the visible and infrared frequency ranges, there have been increasing interests in the study of SPPs in the terahertz regime. Considering that terahertz (THz) radiation bridges the gap between the optical (photonics) and microwave (electronics) regimes, it will offer significant potentials in many scientific and technological areas such as medical diagnostics, sensing, security imaging and communications.

However, SPPs show weakly confinement to flat metal surface in the THz regime due to the huge permittivity of metals. An effective approach to resolve this problem is to pattern metal surface, which may significantly improve the confinement of SPPs even in the perfect-conductor limit. These geometry controlled SPPs, named, *spoof* SPPs, have recently been verified in both the microwave and the THz regimes. The loss of spoof SPPs on textured real metal surface has also been investigated at THz frequencies. After that, the building of compact THz circuits has stood out as an important accomplishment and many designs of THz waveguides carrying tightly confined EM modes with subwavelength transverse cross section have been reported. In contrast, plasmonic resonant cavities working at THz frequencies have received less attention, for which the quality factor, *Q* (related to the dissipation rate of photons confined to the cavity), and the microcavity mode volume, *V* (the electric field strength per photon), are fundamental parameters. Though ring resonators can be constructed using spoof SPPs waveguides, the size of the device is generally several times of the resonance wavelength; otherwise, the radiation loss related to the bending geometry becomes considerable large. It was also reported that plasmonic cavity can be formed by introducing a defect into a textured metal surface, but the mode volume of the microcavity still seems somewhat large. In this paper, we present a terahertz plasmonic microcavity consisting of a circular hole and a cylindrical (metallic) core machined into a planar surface of a metal and demonstrate that it can possess ultrasmall mode volume [$0.000248(\lambda/2n)^3$] and high quality factor (up to 800). Compared to other THz microcavities, the present one is particularly compatible with the planar and monolithic technology and thus does not pose significant manufacturing problem.

In summary, a THz plasmonic microcavity that has a simple geometry and is particularly compatible with planar technology has been proposed and studied theoretically. Such type of microcavity sustains plasmonic modes and possesses attractive characteristics such as high quality factor, ultrasmall mode volume, and subwavelength physical size. Owning to these excellent features, the presented subwavelength microcavity has promising applications in the miniaturization and integration of THz optical components.

VI. Peculiar properties of one dimensional photonic crystal

This topic I cooperate with Prof. C.J. Wu to study. The results are written into several papers listed in my publication. The described results are not written here. You may directly see all these published papers.

VII. Future work

In the coming year, I will study Goos-Hachen shift effect in electromagnetically induced transparency medium, especially for mixed two gases. This work should be finished in this year. But NSC did not support my Ph.D. manpower. But anyway, I shall continue my interesting topics the application of Spoof surface Plasmon polariton concept to dig out peculiar properties of other new system—nanosystem. For multilayer system or one dimensional photonic crystal, I shall continue to cooperate with Prof. C.J. Wu to dig out peculiar properties of new system or try to give analytic expression.

VIII. Acknowledgement

I would say in this project we had done very rich results and applications. In applying patent of EIT system in 2011, the application fee was not supported by NSC. Hence this will be harmful to NSC not able to share patent. 12 papers are published and several conference papers are also published. My papers presented in the international conferences andinside country conferences. You may see my publication list. Hence I sincerely thank National Science Council to support my trip to attend International conference, project funding to let me do computer simulation.

VIIII. Publication list in 2011-2012, July

Tzong-Jer Yang

Professor, Department of Electrical Engineering,

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Highest Education: Ph.D. Northwestern University, 1976

Present Position: Professor in Ph. D. Program in Engineering Science, College of Engineering;Dept. of Electrical Engineering, **Chung Hua University,** Hsinchu, Taiwan. Aug., 2007 – July, 2011 (one year term. Each year must be renewed.).

Joined **National Chiao Tung University Faculty**: 1980, 08, then **retired in 2007 July**.

Session organizer and Session Chair:

(1). **Session organizer and Session Chair** in PIERS International conference 2008 in Hangzhou, China. (March 24-28).

(2). **Session organizer and Session Chair** in PIERS International conference 2008 in Cambridge, USA. (July 2-6).

(3). **Session Organizer** in PIERS International conference 2009 in Beijing, China. (March 23-28).

(4). **Session organizer and Session Chair** in PIERS International conference in Moscow, Russia. (Aug. 18-21, 2009).

(5). **Session organizer** in PIERS 2010 Xian , Xian, China. (March 22-26, 2010**)**.

(6). **Session organizer in PIERS international conference 2011 in Marrakesh, Morroco. (March 20-23, 2011).**

(7). **Session organizer and Session Chair in PIERS international conference 2011 in Suzhou, China. (Sept. 12-16, 2011).**

(8). Session organizer in PIERS 2012 Moscow, Russia. (August 17-23,2012).

Affiliation: members of APS (American Physical Society); Sigma Xi; AAPT(American Association of Physics Teacher); Chinese Physical Society; Chinese Society for Material Science (life member); The Electromagnetics Academy.

Publications: 2011- 2012, July

2011

1. Yang-Hua Chang, Chi-Chung Liu, **Tzong-Jer Yang**, Chien-Jang Wu, "Tunable multilayer narrowband filter containing an ultrathin metallic film and lithium niobate defect", **Optical and Quantum Electronics, 42, 359-365, 2011.**
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6. **H.T. Hsu, M.H. Lee, T.J. Yang, Y. C. Wang, and C. J. Wu**, "A multichanneled filter in a photonic crystal containing coupled defects", **Progress in Electromagnetics Research, Vol. 117, 379-392, 2011. (published on 15 June, 2011) (IF= 3.763)**
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9. **Tzong-Jer Yang**, Yuan-Fong Chau, Han-Hsuan Yeh, Zheng-Hong Jiang, Yao-Wei Huang, Kuang-Yu Yang, Di Ping Tsai, "Dispersion properties, birefringence and confinement loss of rotational elliptic air hole photonic crystal fiber", **Applied Physics A, Vol. 104, 857-861, 2011. (1.595)**
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19. Mei-Soong Chen, Chien-Jang Wu, **Tzong-Jer Yang**,

"Narrowband reflection-and transmission filter in an annular defective photonic crystal containing an ultrathin metallic film", **Optics Communications, 285, 3143-3149, 2012. (Published online 10 March, 2012) (IF= 1.314)**

20 H.C. Hung, C. J. Wu, **T. J. Yang**, and S. J. Chang, "Enhancement of near-infrared photonic band gap in a doped semiconductor photonic crystal", **PIER, 125, 219-235, 2012.** (2012-02-28) (IF=3.763)

21..Xi Chen, Xia Min Leng, Jing Xin Li, Yi-Tsen Yeh, The-Chau Liau, Jian Qi Shen, Yao-Hung Kao, **Tzong-Jer Yang**, "Experimental verification of circuit analog of three- and four-level electromagnetically induced transparency", **Advanced Materials Research** , Vols. 415-417,1340-1349, 2012. (Dec. 06, 2011,online published.) (EI)

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24. Zhen Gao , Linfang Shen, Xiaodong Zheng, Jin-Jei Wu, **Tzong-Jer Yang,** Dongxiao Yang, "Terahertz Plasmonic Microcavity with High Quality Factor and Ultrasmall Mode Volume", **Plasmonics, published online 15 June, 2012.(IF= 3.723)**

Papers Published in Conference Proceeding or Series:

1. Teh-Chau Liau, Jin-Jei Wu, Jian Qi Shen, **Tzong-Jer Yang**, "Frequency-Sensitive Optical Response via Tunable Band Structure in an EIT-Based Layered Medium"**,** ***Advanced Materials Research*** *Vols. 160-162 (2011) pp 1432-1439. Online available since 2010/Nov/11.*

Books

One Chapter in "Photonic Crystals—Introduction, Applicationjs and Theory", ISBN 978-953-51-0431-5, edited by Alessandro Massaro, Published by In Tech—Open Access Publisher in 30 March, 2012.

Papers Presented in Conferences:

1. **T.J. Yang**, R. Cao, Lance Horng, T. C. Wu, and C. M. Chen, "Simulation for superconducting thin films with honeycomb pinning arrays", **26th International conference of Low temperature physics,** August 10 to 17, Beijing, China.
2. Lance Horng, R. Cao, T.C. Wu, J.C. Lin , J. C. Wu, and **T.J. Yang**, "Multivertex state related pinning phenonmena in Nb thin films with square pinning arrays", **26th International conference of Low temperature physics**, August 10 to 17, Beijing, China.
3. Jin Jei Wu, Her-Lih Chiueh, **Tzong-Jer Yang**, Di Chi Tsai, Hung Erh Lin, Bear Hu, Ricardo Wu, Daniel Wang, Hung Jung Chang, Chun Cheng Li, and Ing-Jar Hsieh, "Low frequency surface Plasmon polaritons on a periodically structured metal strip with high confinement of fields", **PIERS 2011 Morrakesh,** March 20-23, Morocco.
4. Jin-Jei Wu, Tzong-Jer Yang, Her-Lih Chiueh, Linfang Shen, Wei-Lein Ouyang, "Novel Characteristics of Reducing Wide-band Crosstalk for Guiding Microwave in Corrugated Metal Strip Lines with Subwavelength Periodic Hairpin Slits", PEIERS 2011 in Suzhou, Sept. 12-16, China.
5. Wei-Hsiao Lin, Chien-Jang Wu, Tzong-Jer Yang, and Shoou-Jinn Chang, "Analysis of Multiple Filtering Properties in a Superconductor-dielectric Superlattice at Terahertz Frequency ", PEIERS 2011 in Suzhou, Sept. 12-16, China.
6. Teh-Chau Liau[1], Jin-Jei Wu[2], Jian Qi Shen[3,4*], **Tzong-Jer Yang[2,]** " **EIT-based Coherent Control Effect Sensitive to Probe Frequency and Control Field Intensity in a Periodic Layered Medium** ", PEIERS 2011 in Suzhou, Sept. 12-16, China.
7. **Tzong-Jer Yang**, Her-Lih Chiueh, Ing-Jar Hsieh, Jian Qi Shen, Ta Chun Hou, Jin Jei Wu, " Novel Characteristics for Reducing Crosstalk in Corrugated Metal Strip Lines with Subwavelength Periodic Hairpine Slits", **International Photonics Conference 2011.**(IPC 2011), Dec. 8-10,2011, Tainan, National Cheng Kung University.
8. **R. Cao, T.J. Yang, Lance Horng, T.C. Wu, "Ginzuburg-Landau study of superconductor with regular pinning array", presented in International conference on superconductivity and magnetism, 29 April- 4 May 2012, Kumburgaz, Istanbul, Turkey.**

ICSM　2012　伊斯坦堡，土耳其

I.　會議經過

我於 4 月 27 日下午 5 點 15 分搭乘華航班機到香港，在機場待到凌晨 12：25 乘土耳其航空到伊斯坦堡，這趟旅程充滿意想不到的事情發生。我本來是要乘下午 6 點 20 分的華航，卻在桃園高鐵站，華航地勤人員說，香港的天氣不穩定，下一班機可能會被取消或延後，看我要不要提前一小時乘 5 點 15 分的班機，我就這麼答應。然後 4 月 28 日凌晨 12：25 分乘上土耳其航空，在所有旅客均上飛機後，飛機也準備要走上起飛坪時，在機上發生一件怪事，竟有一土耳其人突然發生心臟不適。特別等醫護人員上來檢查是否可繼續搭乘飛機到伊斯坦堡，經檢查後，病人需滯留香港醫治，於是地勤人員需將他的行李拿出來，如此拖延二小時，飛機才開至起飛坪，等待塔上指示起飛在那又待了 1 小時才總算啟程。

4 月 28 日早上 9：00 到伊斯坦堡，乘巴士至市區旅館住宿，竟也要找旅館花了３小時半多。因為我與交大同事住在小旅館 Bern Hotel。隔天下午又乘車到 ICSM　2012 會場，並住入會場旅館，離開市區約２小時車程。如此在那兒待到 5 月 4 日晚上才離開到伊斯坦堡機場，於 5 月 5 日凌晨 12：55 乘土耳其航空去香港。而結束這次會議。

這次 ICSM　2012 會議室第三屆。參與人數約 600 人，但都是此一領域活躍的人物。諾貝爾得獎人 K. Alex. Muller 就給予銅高溫超導的一些獨有的特性作為起頭的演講，每一 session 的聽眾約充滿演講室，提問活躍。會後討論熱烈，常常看到小茶几上幾個人拿著電腦在討論問題。由於會議地點較偏僻，大家都聚在旅館裡聽演講，討論研究的課題，筆記做了厚厚，但只能挑些有興趣的東西來與國內的行家分享，所以底下我就將這些挑出來的東西來介紹。

II. 會議心得

我參加這次會議主要是參加我的好朋友 Prof. Elmut H. Brandt 的紀念演講會，也就是超導渦漩。一開始，Prof. Rudolf Huebenoer 講述 Meissner,Abrikosov 及走向渦漩材料之歷史,而提及 E.H.Brandt 在此一領域的貢獻，令人回憶以前與他的相處，Brandt 太太亦坐在前排聆聽。

Eli Zeldow 講他的演講內容中，提及 E.H.Brandt 逝世前訪問以色列的照片，並感謝 E.H.Brandt 對他研究的內容給予正面的建議。Adrian Crisan 在他的演講過程中,有關臨界電流的部分,提及 E.H.Brandt 的貢獻。最後 Cynthia Reichhardt 演講她最近有關 Vortex matter 的成果，她未提及 E.H.Brandt 的事蹟，底下我就開始介紹一些有興趣的主題和新觀念。

1. C.Reichhardt 講 Vortex Janming,Clogging in Nanostuctured Pinnning Arrays.她針對在第二類超導薄膜上做成 funnel 幾何狀之週期性釘扎格子，當外加一驅動力沿著渦漩容易流動的方向時，在某一匹配場，臨界電流的高峰會消失。更進一步發現在 funnel 尖處會有擁擠現象，此一擁擠引起渦漩相互作用力增強，整個 depinning 力跟著增加。還有一連串的 elastic 及 plastic vortex flow phase 出現，因而在傳輸曲線上會有 jumps 或 dips 出現。在所有 flow phase 中，funnel tips 處只能一次有一根 vortex 通過，這是 vortex-vortex 相互斥力造成。這種限制下，在固定的驅動力下，vortex 速度和近乎常數，不隨磁場增加，此行為相似於砂在 hourglass 的行為。

2. M.V.Milosevic 講 vortices in mesoscopic type-I superconductors.此主題他特別提到 vortex dynamics in type-I superconductor 是否可用 Landau 圖像來描述。即 Giant vortices 是可能的嗎？他認為 vortex matter is rich in mesocopic type-I superconductors due to the interaction with imposed（3D）confinement.

3. Vladimir Kresin 講 superconducting state of metallic clusters：potential for Room temperature superconductivity, Novel Nano-Based Tunneling Networks. Metallic cluster 含有 delocalized electrons, 其能階相似於原子或原子核之層狀結構，所以會形成類似的週期表。Metallic clusters 的質譜顯現 magic number. Magic clusters 的形狀為球形，在最高佔據層（HOS）之電子形成成對，會促成超導態。這種成對（pairing）相似於原子核內之成對。Metallic clusters 要達成超導態其臨界溫度公式相似於 BCS 之公式。以 Ga（N=168），其 Tc=160K。要達到室溫超導的條件是

（1）小的 HOS-LUS（最低未佔據態）間的能隙。（2）HOS 及 LUS 層之簡併要大。（3）slightly unoccupied shells 要小的分裂。例如，N=168，340，N=166。相干長度大略為 cluster size。Tc 漲落約 5%。能譜強烈的依據電子個數為奇數或偶數，此為 odd-even effect。clusters with superconducting pair correlation are promising blocks for tunneling networks, small nanoclusters form a new family of high Tc superconductors. 但存在 diamagnetism，即 Meissener effect 問題.

Ref：PRB 83,045510（2011）。PRB 84,064532（2011）。PRB 85,064518（2012）

4. A.M.Campell 講 AC Losses beyond the Bean Model.在缺乏 vortex cutting 之詳細圖像之下，走上巨觀層級的臨界態模型。John Clem 於 1982 年提出 Double critical state model，它 postulated a $J_{c\|}$ and a $J_{c\perp}$ for directions with respect to the local direction of $\vec{B}$。There is then a boundary on the $J_{\|}$，$J_{\perp}$ plane within which electric field $\vec{E}$ is zero。類似解釋材料的 Plastic deformation，在 yield surface 內材料是 elastic。今用在超導體的渦漩問題 yield surface 之截面是長方形（$J_{c\perp}$ 、$J_{c\|}$ 面），在長方形內，沒有電場。$J_{c\perp}$ 邊界由釘扎力決定，$J_{c\|}$ 邊界由 flux cutting 的 onset 決定。在此一模型，在 cutting 區，它是平行於 $\vec{B}$（磁場）或在 flux flow 區，它垂直於 $\vec{B}$。把二臨界電流密度及 yield surface 形狀取為現象參數，由實驗來決定，已能成功地解釋大部分的實驗結果。後來，人們把它推廣到具有各向異性釘扎中心的材料上，其 yield surface 是橢圓形。最近 John Clem 等人（2011）提出更一般的臨界態模型，postulate 二個非線性的 V-I 曲線，對 flow resistivity $E_{\perp} = \rho_f J_{\perp}$，及 cutting resistivity $E_{\|} = \rho_c J_{\|}$。

5. Tarek Guerfi 講 Evidence for an Anti-polar phase in High Temperature superconductors（HTS）Materials. Polarization for $YBCO_{6.9}$ is 0.19599 $\frac{C}{m^2}$ at T=300K，0.21004 $\frac{C}{m^2}$ at T=92k。$YBCO_{6.6}$ is 0.0398 $\frac{C}{m^2}$ at T=300K。$YBCO_{6.5}$ is zero。Oxygen content below 6.5，the polarization is less than zero。That is metal to insulator transition takes place。All HTS exhibit an Anti-polar phase in both normal and superconducting states。Insulator to metal and metal to superconducting phases, the polarization will change sign。A unified description of low and high Tc Superconductors is possible，if one considers electronic polarization in conventional materials，instead of ionic polarization in HTS。

III. 建議

這種會議集中在偏離大城市，有一好處，大家專心與會，獲益較多，但有一缺點，網路很難接通，無法接網與國內做信息上溝通。用手機耗費較高，很不划算。此次在土耳其大城市伊斯坦堡開會，費用偏高，建議國科會支持參與這類會議給予合理費用，增加參與者之意願。此次台灣參加人員，未有博士生或博士後人員參與，甚為可惜。

IV. 攜回資料

此次大會分發每位參與者有一本會議議程及（8G）USB 之會議論文摘要。歡迎國內有興趣者，來函索取會議論文摘要。

國科會補助計畫衍生研發成果推廣資料表

日期:2012/12/07

國科會補助計畫	計畫名稱: 超導渦漩運動與量子相干介質的可控光學特性研究
	計畫主持人: 楊宗哲
	計畫編號: 100-2112-M-216-002-　學門領域: 超導物理－理論

無研發成果推廣資料

100 年度專題研究計畫研究成果彙整表

計畫主持人：楊宗哲			計畫編號：100-2112-M-216-002-		

計畫名稱：超導渦漩運動與量子相干介質的可控光學特性研究

成果項目			量化			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）
			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		
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	1	1	30%		
		專書	0	0	100%		
	專利	申請中件數	1	1	50%	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	1	1	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	11	11	50%	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	1	1	50%	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	0	0	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。)	I am session organizer for PIERS 2012 Moscow. But NSC can not supprot me to travel there to attend that conference. NSC has expressed to me not to support above 70 age scientist to do research anymore, even he atill holds full time Professor position. This is what newspaper posted. NSC still cheats ROC society.

	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）

1About EIT-based layered medium,this is to be published in Annalen der Physik . 2.’’ Ginzburg-Landau study of superconductor with regular array’’, to be published in J. Sup Nov Magn..3.’’ Channel spoof surface plasmon polaritons and its experimental verification’’, KEM,538,305,2012. 4.’’ Terahertz Plasmonic Microcavity with High Quality Factor and Ultrasmall Mode Volume’, Plasmonics,published.

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）

In this project, we have done channel surface plasmon polaritons in transmission line, terahertz plasmonic microcavity,Ginzburg-Landau approach to study vortex pinning in regular array, frequency-sensitive switching control effect induce by two-photon resonace in EIT-based layered medium. These results are valuable in academic and application. For example, the reduced cross-talk in transmission line achived for channel spp; microcavity si found to be high quality factor and ultrasmall mode volume for terahertz region; there are many applications for EIT-based layered meidium; Ginzburg-Landua equation may be applied to study vortex pinning in regular pinng array

and found new explanation about the properties we had done previous structures. About EIT work, we are applying patent in ROC and USA.