

The 10th Annual Conference of The Physical Society of Hong Kong

June 4 2005

**Venue: Academic Building (LT 5,7,8,9)
City University of Hong Kong**

Organized by: The Physical Society of Hong Kong

Participating Organizations:

Department of Applied Physics, The Hong Kong Polytechnic University

Department of Physics, Hong Kong Baptist University

Department of Physics, Hong Kong University of Science and Technology

Department of Physics, The Chinese University of Hong Kong

Department of Physics, The University of Hong Kong

Department of Physics and Materials Science, City University of Hong Kong

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The Tenth Annual Conference of the Physical Society of Hong Kong (4 th June 2005)				
9:00 a.m.	Registration (outside Lecture Theatre 9 (LT9))			
9:15 a.m.	Welcome Speech (LT9)			
9:25-10:25 a.m.	Plenary talk (LT9) Chaired by: K S Chan Title: Focusing with negative medium Professor C T Chan, Department of Physics, HKUST			
Session	CME1(LT9)	CMT1(LT8)	INT1 (LT7)	PRESS (LT5)
<i>Chaired by:</i>	<u>W Y Tam</u>	<u>R O Zhang</u>	<u>H F Chau</u>	<u>H F Cheung</u>
10:30 a.m.	P Y Cheng HKBU3	B Hu HKBU6	H Guo CU1	PRESS Workshop
10:45 a.m.	S Luo CITYU5	S L Sun CITYU9	B Hu HKBU2	
11:00 a.m.	<i>COFFEE BREAK</i>	<i>COFFEE BREAK</i>	<i>COFFEE BREAK</i>	
11:15 a.m.	T L Cheung CITYU3	S W Cheng CITYU8	G Dong HKBU4	
11:30 a.m.	Y F Mei CITYU1	INV SQ Shen HKU5	G L Li HKU4	
11:45 a.m.	Y J Wang UST13	INV SQ Shen HKU5	T Li HKU1	
12:00 p.m.	AGM (LT9) Chaired by P. M. Hui			
12:30 p.m.				
1:00 p.m.	Lunch			
Session	CME2 (LT9)	CMT2(LT8)	INT2 (LT7)	PC (LT5)
<i>Chaired by:</i>	<u>PM Hui (K S Chan from 5:00pm)</u>	<u>S O Shen</u>	<u>D Ong</u>	<u>K S Wong</u>
2:00 p.m.	F K Lee UST3		INV R Chan HKBU1	
2:15 p.m.	X Zhang UST11	J T K Wan UST6	INV R Chan HKBU1	M H Kok UST10
2:30 p.m.	G Wu HKBU5	B A Foreman UST2	S Liang HKBU10	L Wu UST8
2:45 p.m.	WW Wu HKBU14	Y J Wang CITYU7	S Hui HKBU11	L Wu UST9
3:00 p.m.	K L Tong HKBU12	C S Lin CITYU6	CH Cai HKBU13	J Xu UST14
3:15 p.m.	<i>COFFEE BREAK</i>	<i>COFFEE BREAK</i>	<i>COFFEE BREAK</i>	<i>COFFEE BREAK</i>
3:30-4:30 p.m.	Plenary talk (LT9) Chaired by K S Chan Title: The New Spin on Semiconductors Professor Shou-Cheng Zhang, Department of Physics, Stanford University			
4:35 p.m.	K L Ma CITYU2	Y Zhou UST12	K H Ho HKU3	J C W Lee UST5
4:50 p.m.	T Y Lui CITYU4	J Ng UST4	W C Man HKU2	Z Hang UST1
5:05 p.m.	K M Ng HKBU8	J Wang HKBU7	W S Tam CU2	J T K Wan UST7
5:20pm	S K Ho HKBU9			

CMT: Condensed matter theory

CME: Condensed matter experiment

PC: Photonic Crystals and Related Topics

INT Interdisciplinary Physics

INV Invited Talk

PRESS: Physics Research Experiences for Sixth-form Students

Time	Registration
9:00 am	Outside Lecture theatre 9 (LT9)

Time	Welcome Speech
9:15 am	Lecture Theatre 9 (LT9)

Time	Plenary Talks (LT9) Session Chair: K S Chan
9:25-10:25 am	“Focusing with negative medium” Prof. C T Chan, HKUST
3:30-4:30 pm	“The New Spin on Semiconductors” Prof. Shou-Cheng Zhang, Stanford University

Time	CME1 (LT9) Session Chair: W Y Tam
10:30 am CME1-1	HKBU3: Concentration effect on the photoluminescence and lifetime of Eu ³⁺ activated YAl ₃ B ₄ O ₁₂ <u>Pui Yan Cheng</u> , Jian Xu, Ka Man Ng, and Kok Wai Cheah. Baptist University
10:45 am CME1-2	CITYU5: “Buried tungsten silide layer in silicon on insulator substrate by Smart-Cut” Suhua Luo, Weili Liu, Miao Zhang, Chenglu Lin, Z T Song & Paul K Chu. City University of Hong Kong
11:00 am	Coffee Break
11:15 am CME1-3	CITYU3: “Thermal and Mechanical Properties of Cu-Zr-Al Bulk Metallic Glasses” T. L. Cheung and C. H. Shek. City University of Hong Kong
11:30 am CME1-4	CITYU1: “Room-temperature Electrosynthesized ZnO film with Strong (0002) Orientation” Y. F. Mei, and G. G. Siu. City University of Hong Kong
11:45 am CME1-5	UST13: “Time evolution study of spinodal dewetting” Y J Wang and O K C Tsui. HKUST

Time	CME2 (LT9) Session Chair: P M Hui/K S Chan
2:00 pm CME2-1	UST3:“Substrate Patterning for Liquid Crystal Alignment by Optical Interference” Xuemin Lu, <u>Fuk Kay Lee</u> , F. C. Xie, Ping Sheng, H. S. Kwok, W. Y. Tam, & Ophelia K C. Tsui. HKUST
2:15 pm CME2-2	UST11:“Autophobic Dewetting of Polystyrene Films” <u>Xueyun Zhang</u> and Ophelia K. C. Tsui, HKUST
2:30 pm CME2-3	HKBU5: “The electro-oxidative activity of cysteine on the Au electrode as evidenced by surface enhanced Raman scattering” <u>Zhaojun Liu</u> , <u>Guozhen Wu</u> . Baptist University
2:45 pm CME2-4	HKBU14: “2-photon luminescence characteristics of organic/inorganic hybrid systems” <u>W. W. Wu</u> , K. F. Li, K. W. Cheah, D. W. Pang, and Louis M. L. Leung. Baptist University
3:00 pm CME2-5	HKBU12: “Study on the ambipolar characteristics of oxadiazole-triphenylamine based compounds and their application to homojunctions OLEDs” <u>K.L.Tong</u> , S.K.So, Tik H.Lee, L.M.Leung, M.Y.Yeung, K.H.Lee, C.F.Lo. Baptist University
3:15 pm	Coffee Break
4:35 pm CME2-6	CITYU2: “Electrical properties of nitrogen incorporated in nanodiamond films” <u>K.L. Ma</u> , W.J. Zhang, Y.M. Chong, K.M. Leung, I. Bello and S.T. Lee. City University of Hong Kong
4:50 pm CME2-7	CITYU4: “Copper-doped effect on low temperature photoluminescence from Cd _{1-x} Zn _x S nanoribbons” T. Y. Lui, D.D.D. Ma, J. A. Zapien, Y. K. Liu, H. Tang and S. T. Lee. City University of Hong Kong
5:05 pm CME2-8	HKBU8:”Inorganic/organic hybrid white-light phosphor for solid state illumination” <u>K.M. Ng</u> , K.W. Cheah, Jian Xu, and M.L Gong. Baptist University
5:20pm CME2-9	HKBU9: “Sensitive elemental analysis by ArF laser induced atomic fluorescence” <u>Sut Kam Ho</u> and Nai Ho Cheung. Baptist University

Time	CMT1 (LT8) Session Chair: R Q Zhang
10:30 am CMT1-1	HKBU6: “Dynamical mode locking in the dynamics of commensurate structures with asymmetric deformable substrate potential” Bambi Hu and Jasmina Tekić. Baptist University
10:45 am CMT1-2	CITYU9: “Ca/PFO interaction in organic light-emitting device- a theoretical study” <u>S L Sun</u> and R Q Zhang. City University of Hong Kong
11:00 am	Coffee Break
11:15 am CMT1-3	CITYU8: “Temperature profile and pressure effect on the growth of silicon nanowires” <u>S W Cheng</u> and H F Cheung. City University of Hong Kong
11:30 am CMT1-4	Invited Talk HKU5: ”Spin Hall effect in quantum Hall regime” S Q Shen. University of Hong Kong

Time	CMT2 (LT8) Session Chair: S Q Shen
2:15 pm CMT2-1	UST6: “Liquid crystals alignments on heterogeneous surfaces” J T K Wan, O K C Tsui, H S Kwok and P Sheng. HKUST
2:30 pm CMT2-2	UST2: “Interface band mixing from first principles” B A Foreman. HKUST
2:45 pm CMT2-3	CITYU7:” Insight into the interaction of a lithium atom with single-walled carbon nanotubes: an ab initio study” <u>Y J Wang</u> and R Q Zhang. City University of Hong Kong
3:00 pm CMT2-4	CITYU6: “ Interaction of water clusters (H ₂ O) _n (n=1-6) with graphite surface” <u>C S Lin</u> and R Q Zhang. City University of Hong Kong
3:15 pm	Coffee Break
4:35 pm CMT2-5	UST12: “Spinless hardcore bosons on checkerboard lattice near half filling” Y Zhou. HKUST
4:50 pm	UST4: “Strong optical force induced by morphology dependent resonances”

CMT2-6	J Ng, Z Lin, C T Chan and P Sheng. HKUST
5:05 pm CMT2-7	HKBU7: “Quantum delocalization of the classical pinned state in Frenkel-Kontorova model” Jiaxiang Wang and Bambi Hu. Baptist University

Time	INT1 (LT7) Session Chair: H F Chau
10:30 am INT1-1	CU1: “ Relation of scaling behaviour of velocity and temperature fluctuations in turbulent Rayleigh-Benard convection” E C S Ching and <u>H Guo</u> . Chinese University of Hong Kong
10:45 am INT1-2	HKBU2: “ Control of heat conduction by periodicity tuning” B Hu and L Yang. Baptist Universtiy
11:00 am	Coffee Break
11:15 am INT1-3	HKBU4: “Management of Bose-Einstein Condensates by spatially periodical modulation of the atomic s-wave scattering length” G Dong and B Hu. Baptist University
11:30 am INT1-4	HKU4: “ Einstein’s question about whether a complete description of reality exists remains open” G L Li and V O K Li. University of Hong Kong
11:45 am INT1-5	HKU1: “ Search of quasisoft x-ray sources in galatic center SGR A*” <u>T Li</u> , A K H Kong, R Di Stefano and C S J Pun. University of Hong Kong

Time	INT2 (LT7) Session Chair: D Ong
2:00 pm INT2-1	Invited Talk HKBU1: “Underwater optical sensing for in situ measurement of marine phytoplankton” <u>R K Y Chan</u> , X Z Wang and A S K Cheng. Baptist University
2:30 pm INT2-2	HKBU10: “In silico simulations of e coli metabolic network” S Liang S Hui and L Tang. Baptist University
2:45 pm INT2-3	HKBU11: “Topological characteristics of yeast metabolic network” S Hui, S Liang and L Tang. Baptist University
3:00 pm	HKBU13: “Mechanism characterization of transcriptional regulation in budding

INT2-4	yeast cell cycle” C Cai, C Wang and L Tang. Baptist University
3:15 pm	Coffee Break
4:35 pm INT2-5	HKU3: “ Study of wealth inequality in the minority game” <u>K H Ho</u> F K Chow and H F Chau. University of Hong Kong
4:50 pm INT2-6	HKU2: “ The relevance of memory in minority game” K H Ho, <u>W C Man</u> , F K Chow and H F Chau. University of Hong Kong
5:05 pm INT2-7	CU2: “ Aspect-ratio dependence of heat transport by given velocity fields” E C S Ching and <u>W S Tam</u> . Chinese University of Hong Kong

Time	PC (LT5) Session Chair: K S Wong
2:15 pm PC-1	UST10: “Tuneable optical properties of 1D photonic crystals in planar silver nano-particles gelatin emulsion” <u>M H Kok</u> , R Ma, J C W Lee, W Y Tam, C T Chan and P Sheng. HKUST
2:30 pm PC-2	UST8: “Characterization of photo-cross-linkable light-emitting polymers” L Wu, J Hua, B Z Tang, and K S Wong. HKUST
2:45 pm PC-3	UST9: “Fabrication of 1D, 2D and 3D photonic crystals by single refracting prism laser holographic lithography” L Wu, Y Zhong, C T Chan, K S Wong and G Wang. HKUST
3:00 pm PC-4	UST14: “Realization of optical periodic quasi-crystals using holographic lithography” X Wang, <u>J Xu</u> , J C W Lee, Y K Pang, W Y Tam, C T Chan and P Sheng. HKUST
3:15 pm	Coffee Break
4:35 pm PC –5	UST5: “Polarization gap in spiral structure” J C W Lee and C T Chan. HKUST
4:50 pm PC-6	UST1: “Directive emission from quasi-periodic planar metamaterial substrates” H Li, <u>Z Hang</u> Y Qin L Zhou, Y Zhang H Chen and C T Chan
5:05 pm PC –7	UST7: “Thermal emission by photonic micro-textured surfaces” J T K Wan and C T Chan. HKUST

Abstracts for CME1
CME1-1 10.30am LT9
HKBU3

Concentration effect on the photoluminescence and lifetime of Eu^{3+} activated



Pui Yan Cheng, Jian Xu, Ka Man Ng, Kok Wai Cheah

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Hong Kong Baptist University,

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China

The luminescence intensity and lifetime of Eu^{3+} doped $\text{YAl}_3\text{B}_4\text{O}_{12}$ with different concentration (5% - 100%) are investigated under UV excitation. The photoluminescence (PL) spectrum and lifetime measurement of the phosphor allow us to obtain the optimum Eu^{3+} doping concentration with the highest luminescence intensity and the shortest lifetime. In our experimental result, the luminescence intensity, under 325nm excitation, increases with the doping concentration and the maximum occurs at the concentration equaled 100% (i.e. $\text{EuAl}_3\text{B}_4\text{O}_{12}$) — concentration quenching phenomenon was not observed from the PL spectrum. Different from the PL intensity, the lifetime of the phosphor decreases with the concentration. The longest lifetime is 1.4ms at 5% and the shortest lifetime is 0.6ms at 100%. Compared with the phosphors which have concentration quenching phenomenon (such as $\text{Y}_2\text{O}_3:\text{Eu}^{3+}$), the Eu^{3+} lifetime in $\text{YAl}_3\text{B}_4\text{O}_{12}$ decreases with a smaller amplitude with the doping concentration. It reflects that the energy transfer between Eu^{3+} ions in this host is not as efficient as $\text{Y}_2\text{O}_3:\text{Eu}^{3+}$.

CITYU5

Buried tungsten silicide layer in silicon on insulator substrate by Smart-Cut[®]

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In mixed-mode high frequency integrated circuits the coupling of signals through the substrate is a major problem. For operating frequencies below 10GHz SOI substrates offer better protection against cross-talk, but at higher frequencies the buried oxide becomes transparent to the signals. A high conductive layer below the buried silicon dioxide layer can be used as a ground plane to pin potential on the surface of the handle wafer. Cross-talk will therefore be suppressed since lateral potential variations are eliminated. There have been some reports about the fabrication of a metallic silicide embedded in SOI. But all of them use silicon direct wafer bonding with grind/polish back (BESOI) method. In this work, a flexible Smart-cut[®] technique is employed.

Single-crystalline Si/SiO₂/poly-WSi_x/Sub-Si structure has been successfully fabricated by a new method incorporating standard smart-cut[®] technique and high temperature reaction between tungsten and silicon. Annealing at 800-1100°C does not only strengthen the bonding of the wafers but also induces solid phase reaction of deposited tungsten and silicon. A poly-crystalline WSi_x (1<x<2) layer with tetragonal structure is formed below the buried oxide layer. Cross section images of TEM show three steep interfaces of four layers. It is found that increasing annealing temperature is in favor of decreasing sheet resistance of tungsten silicide and improving the crystal quality of the top silicon layer. But spreading resistance profile measurement shows annealing under high temperature (≥1000°C) will induce diffusion of tungsten into Si substrate which is confirmed by EDX result and the reason is presented.

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Thermal and Mechanical Properties of Cu-Zr-Al Bulk Metallic Glasses

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The thermal and mechanical properties of $(\text{Cu}_{50}\text{Zr}_{50})_{1-x}\text{Al}_x$ bulk metallic glasses (BMGs) ($4 \leq x \leq 10$ at.%) were investigated with differential scanning calorimetry and nanoindentation. Glassy rods of 3mm in diameter of these alloys were prepared by using copper mould suction-casting. The glass transition temperatures and crystallization temperatures of the specimens increased with increasing Al content. The Microvickers hardness of the BMG increased with increasing Al content. Room temperature nanoindentation was carried out on the cross section of the rods. The results showed that the nanohardness and creep rate were dependent on constant load holding time and Al content. The specimens were examined with optical and scanning electron microscopies after nanoindentation. Multi-shear bands propagating along the sides of impression were observed.

CME1-4 11:30am LT9

CITYU1

Room-temperature Electrosynthesized ZnO film with Strong (0002) Orientation

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ABSTRACT

ZnO thin film with high orientation (0002) was electrosynthesised on ITO-coated glass substrate at room temperature under pulsed voltage. Photoluminescence (PL) shows two obvious peaks: violet band and strong green band. The former is due to the free-excitonic transition and the latter is believed to arise from the single ionized oxygen vacancy (V_o^+). Raman scattering reveals that the 580 cm^{-1} mode and the shoulder peak mode at 550 cm^{-1} originate from the N-related local vibration mode (LVM) and E_1 (LO) mode, respectively. Time-resolved growth of ZnO film revealed its growth mechanism, which is helpful to understand electrodeposition process and film growth.

CME1-5 11:45am LT9

UST13

Time Evolution Study of Spinodal Dewetting

Y. J. Wang and O. K. C. Tsui

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Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

Spinodal dewetting is a phenomenon in which liquid films break up spontaneously into droplets.

Theory predicts the breakup process to be initiated by small surface ripples that grow exponentially with time at a rate $\Gamma(\lambda)$ dependent on the wavelength component, λ , of the ripples.

We used atomic force microscopy to investigate the time evolution of the dewetting of polystyrene (PS) films on oxide-coated silicon, enabling us to measure $\Gamma(\lambda)$. We found that $\Gamma(\lambda)$ deduced in the initial stage of rupturing fit well to the expression $\Gamma(\lambda) = \Gamma(\lambda_{\max})(2\lambda_{\max}^{-2} \lambda^{-2} - \lambda^{-4}) \lambda_{\max}^4$, in accordance to the theory. However, data obtained in the later stage demonstrate severe disagreements. We discuss the possible reasons.

We acknowledge financial support of the Research Grant Council of Hong Kong through the projects HKUST6070/02P and 603604.

Abstracts for CME2
CME2-1 2:00pm LT9
UST3

Substrate Patterning for Liquid Crystal Alignment by Optical Interference

Xuemin Lu,¹ Fuk Kay Lee,¹ F. C. Xie,² Ping Sheng,¹ H. S. Kwok,² W. Y. Tam,¹ and Ophelia . C.
Tsui¹

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Science and Technology, Hong Kong.

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Technology, Hong Kong.

Inhomogeneous surface patterns comprising domains preferring different liquid crystal (LC) alignment directions can produce an uniform alignment effect overall if the elastic energy of the LC, in copying the surface inhomogeneity, is comparable to the surface anchoring energy of individual domains or if the location of concern is farther than a distance equal to the dominating length scale of the inhomogeneous pattern from the surface. Recent studies show that this new approach for LC alignment can be adapted to several unique applications. However, existing methods used in producing these surfaces are time consuming and make pattern areas $< (100 \mu\text{m})^2$. Here we demonstrate a simple method, based on photo-patterning of an azo-dye film with two interfering UV beams, can produce alignment patterns within seconds with size $\sim 10 \text{ mm}^2$.

We acknowledge financial support of the Research Grant Council of Hong Kong through the project HKUST6115/03E.

CME2-2 2:15pm LT9

UST11

Autophobic Dewetting of Polystyrene Films

Xueyun Zhang and Ophelia K. C. Tsui

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Grafting or adsorbing polymers onto surfaces is often used to modify surface forces and has important technological applications in many areas. In this report, the dewetting instability of Polystyrene/Brush/SiO₂/Si system was investigated as a function of initial homopolymer thickness, annealing time, relative homopolymer molecular weight and grafting density. It was found that only the relative homopolymer molecular weight and grafting density have significant influence on the equilibrium thickness of dewetted films, i.e., the thickness of the residual film after dewetting. Our result, to our knowledge, is the first experimental result that shows good agreement with existing theories for autophobic dewetting of polymers.

We acknowledge financial support of the Research Grant Council of Hong Kong through the projects HKUST6070/02P and 603604.

CME2-3 2:30pm LT9

HKBU5

The electro-oxidative activity of cysteine on the Au electrode as evidenced by surface enhanced Raman scattering

Zhaojun Liu, Guozhen Wu*

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It is demonstrated from the surface enhanced Raman scattering that cysteine is adsorbed on the Au electrode via its carboxylate moiety. The mechanism is mainly via the charge transfer involving the π electron-rich carboxylate moiety. The adsorption of cysteine is weak that its diffusion on the Au surface is possible. The collision of two cysteine molecules may lead to the electro-oxidative formation of cystine in an irreversible way due to that the disulfide bond is not in the close vicinity of the electrode and its reduction is hampered. The physical difference as compared to its adsorption on the Ag electrode [T. Watanabe and H. Maeda, J. Phys. Chem. 1989, 93, 3258] is stressed.

CME2-4 2:45pm LT9

HKBU14

2-photon luminescence characteristics of organic/inorganic hybrid systems

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Considerable effort has been put into fabricate quantum dots (QDs) based devices. Self-assembled QDs were mainly selected because they are embedded in semiconductors. However, there tends to be strong background emission from transitions between the QDs and the substrate in such systems. This would reduce the QDs emission efficiency. In this report, a hybrid organic/inorganic device with chemically synthesized QDs embedded in strongly absorbing organic complexes was prepared. We envisaged that organic host provides excellent absorption and can transfer the energy to QDs which act as monochromatic light-emitter. CdSe/ZnS core/shell QDs with diameter of ~3 nm were embedded into N-(4-methoxyphenyl)-N-phenylnaphthalen-1-amine (MeONPA) and spun into thin films. The 2-photon luminescence characteristics of this hybrid system were studied because with 2-photon, we can selectively excite MeONPA, hence providing clean, mono-direction energy transfer from MeONPA to QDs. The 2-photon luminescence spectra and the lifetime have shown that there is strong coupling between the QDs and the organic host and efficient energy transfer happens. Hence the emission of QDs is enhanced and it implies potential high efficiency emission devices.

CME2-5 3:00pm LT9

HKBU12

STUDY ON THE AMBIPOLAR CHARACTERISTICS OF OXADIAZOLE-TRIPHENYLAMINE BASED COMPOUNDS AND THEIR APPLICATION TO HOMOJUNCTION OLEDs

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The charge transporting (CT) and electroluminescent (EL) properties of a series of aromatic ring-oxadiazole-triphenylamine (XOT) based compounds with different aromatic ring substitutes (benzene, naphthalene, anthracene, and pyrene) were studied. Time-of-flight technique has been utilized to evaluate both hole and electron mobilities of the XOT compounds. It was found that both hole and electron mobilities were within the same order of magnitude of $10^{-6}\text{cm}^2/\text{Vs}$. The CT investigation has been further extended to the examination of the frontier orbitals of the XOT compounds by *ab initio* method. It was found that the highest occupied molecular orbital (HOMO) was localized on the phenylamine moiety and was essentially fixed, whereas the lowest unoccupied molecular orbital (LUMO) was localized on the oxadiazole moiety, and shifted to the aromatic ring when the ring number increased. Organic light emitting diodes (OLEDs) were constructed with a very simple architecture ITO / CuPc / XOT / Ca. High efficiency devices with both CT and EL took place within the same layer were fabricated. The EL spectra of the XOT homojunction devices were from 440-520nm. The maximum luminance reached $7500\text{cd}/\text{m}^2$, with current efficiency $2.5\text{cd}/\text{A}$.

CME2-6 4:35pm LT9

CITYU2

Electrical properties of nitrogen incorporated in nanodiamond films

K.L. Ma*, W.J. Zhang, Y.M. Chong, K.M. Leung, I. Bello and S.T. Lee

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Nanocrystalline diamond has the properties comparable to single-/micro- crystalline diamond. In some aspects, nanodiamond is even more suitable for some specific applications, i.e., ultra-smooth coatings for micromachining tools, and emitter materials for field electron emission (FEE) devices. It has been demonstrated that nitrogen incorporation in the deposition process of nanocrystalline diamond is able to reduce dramatically the turn-on electric field for electron emission. However, the mechanism has not been well understood. In this work, nanodiamond films were synthesized by microwave plasma-enhanced chemical vapor deposition in a gas mixture of CH₂/H₂/N₂. The H₂/N₂ ratio was varied in a wide range (1:0 to 1:5) while keeping the methane concentration constant. The films were characterized by Raman spectroscopy, infrared spectroscopy, and scanning electron microscopy. The nitrogen content in the films was investigated by X-ray photoelectron spectroscopy (XPS). The effects of nitrogen content on 1) the electrical and 2) FEE characteristics of the nanodiamond films were studied. The current-voltage (I-V) measurements showed a linear-characteristic, and the dependence of the resistivity on the nitrogen content in the films was revealed. Furthermore, it was found that the nitrogen incorporation could effectively reduce the turn-on electric field for electron emission.

The influences of nitrogen incorporation on the nanodiamond surfaces and microstructures were also studied. The Raman spectra showed that the intensity of the peak at 1190cm⁻¹, which is possibly assigned to the bonding between nitrogen and carbon, increases significantly with the additional nitrogen concentration. The existence of single carbon-nitride bonding in the films was revealed.

Keywords: Diamond properties and applications, nanodiamond, nitrogen incorporation, field emission

CME2-7 4:50pm LT9

CITYU4

Copper-doped effect on low temperature photoluminescence from $\text{Cd}_{1-x}\text{Zn}_x\text{S}$ nanoribbons

T. Y. Lui, D.D.D. Ma, J. A. Zapien, Y. K. Liu, H. Tang and S. T. Lee.

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Abstract

CdZnS nanoribbons doped with copper were fabricated via thermal evaporation of CdS, ZnS mixed with CuS powder. Copper was doped into the nanoribbons during the growth process. Nanoribbons with lengths range from several tens to hundreds of micrometers and widths ranging from 500 nm to 2 μm with thickness from 30 to 60 nm were synthesized. The CdZnS ternary compound nanoribbons have the hexagonal wurzite structure. We provide evidence that the growth of the nanoribbons is by vapor-liquid-solid mechanism with the use of Au catalyst coated on the Si wafer. Low-temperature photoluminescence (LT-PL) was employed to analyze the luminescent mechanism of the nanoribbons. The results show that the PL of the products depends on the measurement temperatures. Analysis of this temperature-dependent luminescence indicates that the bluish-green emission (2.571 eV) of nanoribbons originates from the recombination of a donor-acceptor pair (DAP) at the states of the monovalent interstitial zinc (Zn_i^+) and the shallow acceptor level (Cu^+ , h), while the yellowish emission (2.06 eV) is attributed to the DAP recombination related to impurities. With lower copper and zinc content, the luminescence peak at 2.06 eV and 2.571 eV significantly weakened and disappeared, respectively. Simple evaporation method to synthesize CdZnS:Cu nanoribbons can be utilized effectively in various opto-electronic devices such as solar cells.

CME2-8 5:05pm LT9

HKBU8

**INORGANIC/ORGANIC HYBRID WHITE-LIGHT PHOSPHOR
FOR SOLID STATE ILLUMINATION**

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White-light-emitting diode was fabricated by using near UV LED ($\lambda = 390\text{-}420\text{nm}$) with a novel inorganic/organic hybrid phosphor. The white-light phosphor consist of three fluorescence phosphors; two strontium based with lanthanide oxides, $\text{Sr}_4\text{Al}_{14}\text{O}_{25}:\text{Eu}$, M (for blue (490nm) emission) and $\text{SrGa}_x\text{S}_y:\text{Eu}$ (for green (540nm) emission) and a new organic Eu organometallic complex, EuBT (for red (614nm) emission). These materials have good absorption in the 300-500nm range and have high quantum efficiencies up to 80%. The white phosphor has a CIE value of (0.335, 0.339) while the commercial white LED has a CIE value of (0.289, 0.301). Warm and cool white light, with CIE values of (0.397, 0.378) and (0.281,0.303) respectively and with color temperature ranged from 3000K to 6000K, can also be obtained by combining different ratios of the blue, green and red phosphors. A stability test was done on the white phosphor and no significant changes on the PL spectrum or the luminescent intensity were found.

CME2-9 5:20 pm LT9

HKBU9

SENSITIVE ELEMENTAL ANALYSIS BY ArF LASER INDUCED ATOMIC FLUORESCENCE

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Earlier, we reported the analysis of lead in the form of carbonate colloids using ArF laser induced atomic fluorescence spectroscopy. Detection limit of 0.24 ppb was demonstrated. More recent results showed that a wide range of elements such as Au, Cu, Mg, Bi, Si, C, B and Fe in various matrices could be detected by the same method. This universal excitation at 193 nm was puzzling. One possible mechanism was photofragmentation fluorescence (PFF), when precursor molecules with broad molecular absorption bands non-selectively absorbed the VUV photons to produce excited analyte atomic fragments. In the case of lead, Pb fluorescence emissions at 357.3 nm (upper energy level is 6.13 eV) was observed. Noting that 193-nm photon energy is only 6.4 eV, it would not be adequate for both dissociation of precursors and excitation of analyte fragments. Similar arguments applied to the observed Cu 515.3-nm line emissions (6.19 eV upper level). This ruled out PFF unless two or more photons were absorbed. In order to investigate whether it was a single or multi-photon process, we studied the dependence of the emission signal on ArF laser energy. A copper target was first ablated by a 1064-nm laser pulse to create a vapor plume, which was then intercepted by a non-ablative ArF laser pulse. We found that the Cu 515.3-nm signal varied linearly with ArF laser energy, suggesting that it was a single photon process. Accordingly, PFF could be ruled out; and the efficient and universal absorption of 193-nm photon by this wide range of analyte atoms remained intriguing. To address this issue, we took time-resolved spectra of the Mg 285-nm, Pb 357-nm and Au 267-nm atomic fluorescence induced by ArF laser irradiation. Extensive line broadening, especially near the beginning, was observed. Given the very weak ArF laser fluences used, it could not be Doppler or Stark broadening. These excessive linewidths suggested diffuse energy bands near 6.4 eV, enabling resonant absorption at 193 nm. We showed that the scrambling of energy levels was most probably caused by proximity to other species in the dense ablation plumes.

Abstracts for CMT1

CMT1-1 10.30am LT8

HKBU6

DYNAMICAL MODE LOCKING IN THE DYNAMICS OF COMMENSURATE STRUCTURES WITH ASYMETRIC DEFORMABLE SUBSTRATE POTENTIAL

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The overdamped dynamic in the commensurate structures of one-dimensional Frenkel-Kontorova model subjected to a parameterized deformable periodic substrate potential and driven by periodic force is examined. Considering an asymmetric deformable potential, where by an appropriate choice of the shape parameter one can move in a controlled manner from the simply sinusoidal (standard) potential to an asymmetric one we analyze the dynamical mode-locking in different commensurate structures. It was found that when the shape of the substrate potential starts to deviate from the standard one the new subharmonic steps appear in the response function even in the structures with integer value of average interparticle distance while the critical depinning force can even decrease for some values of system parameters. These novel phenomena could be particularly relevant for the charge density wave systems, vortex lattices and systems of Josephson-junction arrays.

Ca/PFO interaction in organic light-emitting device - a theoretical study

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The fabrication of organic light-emitting devices (OLED) involves deposition of metal cathode materials onto the organic layer. The formation of interface between cathode and organic layer is an important factor to determine device efficiency. We have conducted a systematic theoretical study on the geometric and electronic structures of the complex formed between poly(9,9-dioctylfluorene) (PFO) and Ca, a low work function material used in OLED, using Møller-Plesset Perturbation Theory. A weak interaction with little charge transfer and with a relatively long Ca-C distance (about 4.0 Å) was found when only one Ca atom was attached to a PFO unit. However, when two Ca atoms were adsorbed at a PFO unit, a strong interaction with a shorter Ca-C distance (about 2.67 Å) took place with considerable charge transfer from the Ca atom to the PFO and with significant deformation in the backbone of the PFO oligomer. In the latter case, the frontier orbitals of the PFO were modified. However, the deformed PFO and its modified frontier orbitals could be recovered when oxygen was added, in good agreement with experimental observation.

CMT1-3 11:15am LT8

CITYU8

Temperature Profile and Pressure Effect on the Growth of Silicon Nanowires

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Abstract

The temperature profile during the growth of silicon nanowire is calculated by considering the release of latent heat and heat transfer by conduction and radiation. The excess temperature at the silicon nanowire tip is found to be generally low. Therefore we conclude that the difference in adhesive property of the silicon nanowire tip and sidewall cannot be due a large excess temperature at the nanowire tip. We have also calculated the excess pressure and the corresponding lowering in melting temperature at the nanowire tip. We found that surface tension alone cannot cause sufficiently high excess pressure that drives a significant lowering in melting temperature at the nanowire tip. Based on a charge-assisted model of silicon nanowire growth proposed earlier by us, electrostatic charge accumulates at the nanowire tip, creating a strong electrostatic field. The stress originated from this electrostatic field can be viewed as a high negative pressure. Since negative pressure favors the increase of surface area, we propose that this is the key force driving the silicon nanowire to grow in only one direction.

CMT1-4 (Invited) 11:30am LT8

HKU5

Spin Hall effect in quantum Hall regime

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Remarkable phenomena have been observed in 2DEG over last two decades, most notably, the discovery of integer and fractional quantum Hall effect. The study of spin transport provides a good opportunity to explore spin physics in two-dimensional electron gas (2DEG) with spin-orbit coupling and other interaction. It is already known that the spin-orbit coupling leads to a zero-field spin splitting, and competes with the Zeeman spin splitting if the system is subjected to a magnetic field perpendicular to the plane of 2DEG. The result can be detected as beating of the Shubnikov-de Haas oscillation. Very recently the speaker and his collaborators studied transport properties of a two-dimensional electron system with Rashba spin-orbit coupling in a perpendicular magnetic field. The spin-orbit coupling competes with the Zeeman splitting to generate additional degeneracies between different Landau levels at certain magnetic fields. It is predicted theoretically that this degeneracy, if occurring at the Fermi level, gives rise to a resonant spin Hall conductance, whose height is divergent as $1/T$ and whose weight is divergent as $-\ln T$ at low temperatures. The charge Hall conductance changes by $2e^2/h$ instead of e^2/h as the magnetic field changes through the resonant point. The speaker will address the spin edge state and edge current, and establish a unified picture from both the bulk and edge state point of view. It is demonstrated that the transverse spin current are proportional to the spin polarization at a finite magnetic field, which provides an explicit way to extract the spin current experimentally.

This work was supported by the Research Grants Council of Hong Kong under Grant No.: HKU 7088/01P.

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Liquid crystals alignments on heterogeneous surfaces

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Abstract

The effects of a nonuniform surface on the director field of a nematic liquid crystal (LC) are studied by computer simulations. The nonuniform surface is made by mixing a homeotropic anchoring domain and a planar anchoring domain with different area fractions. For each area fraction, a dimensionless parameter is derived to simultaneously study the geometric and the material effects on the director field. In the limit of weak anchoring, the average pretilt angle can be expressed analytically in terms of the area fractions of the anchoring domains. When in the strong anchoring limit the average pretilt angle varies with the area fractions almost linearly and is independent of the geometric and material parameters. The results are confirmed by computer simulations.

We acknowledge financial support of the Research Grant Council of Hong Kong through the project HKUST6115/03E.

CMT2-2 2:30pm LT8

UST2

Interface band mixing from first principles

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Interface band-mixing plays an increasingly important role in the physics and technology of semiconductor heterostructures, especially given the recent interest in spin-polarization phenomena such as the Rashba effect. Such effects lie outside the scope of conventional effective-mass theory, but are often included in envelope-function Hamiltonians on the basis of symmetry arguments. The key interface parameters depend on the detailed form of the self-consistent potential energy at the interface, but to date they have only been derived from empirical models, which are incapable of predicting this potential. This presentation describes the first derivation of an interface envelope-function Hamiltonian from first-principles self-consistent pseudopotentials.

The derivation is based on Dyson's equation for quasiparticles in a lattice-matched semiconductor heterostructure. The key assumption (proved within the nonlinear Thomas-Fermi approximation) is that the heterostructure can be treated as a weak perturbation with respect to some periodic reference crystal, with the nonlinear response small in comparison to the linear response. Quadratic response theory is then used in conjunction with $\mathbf{k}\cdot\mathbf{p}$ perturbation theory to develop a multiband effective-mass Hamiltonian in which all interface effects are determined by the linear response. The interface Hamiltonian is therefore given by a set of bulk-like parameters (not requiring a supercell calculation) modulated by a structure factor that determines the distribution of atoms in the heterostructure. The same parameters determine the Hamiltonian for slowly varying and abrupt heterostructures of arbitrary shape and orientation. The method of invariants is used to determine the explicit form of the Hamiltonian for Γ_6 and Γ_8 states in semiconductors with the zinc-blende structure, and for intervalley mixing of Γ and X electrons in (001) GaAs/AlAs heterostructures. This resolves a debate in the literature over the significance of various contributions to Γ - X coupling (the value of which depends strongly on the chosen model potential in empirical pseudopotential studies).

CMT2-3 2:45pm LT8

CITYU7

Insight into the interaction of a lithium atom with single-walled carbon nanotubes: an *ab initio* study

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By first-principles calculations using density functional theory with the generalized gradient approximation (GGA), a systematic study was performed to investigate the strong interaction of lithium atom with the surface of (n, n) single walled carbon nanotubes (SWNTs) (n=5~10) and (n, 0) SWNTs (n=7~12). As a result, the binding energies (E_b) of lithium with (n, 0) SWNTs (2.00 eV ~ 2.66 eV) are always larger than those with (n, n) SWNTs (1.80 eV ~ 1.95 eV). E_b decreases with the increasing tube radius. By the analysis on the frontier molecular orbital, it is found that the existence of a “ π -bond defect” on the (n, 0) SWNTs surface offers the conjugated system effective reactivity because of the free electron on it. Compared with (n, n) SWNTs, (n, 0) SWNTs exhibit high reactivity to Li atom and will be the promising materials for hydrogen storage via lithium adsorption.

CMT2-4 3:00pm LT8

CIYU6

Interaction of water clusters $(\text{H}_2\text{O})_n$ ($n=1-6$) with graphite surface

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The interaction of small water clusters $(\text{H}_2\text{O})_n$, $n = 1-6$ with graphite surface have been studied using a density-functional tight-binding (DFTB) method complemented with empirical van der Waals force correction. It is shown that the binding energy and geometry of water clusters adsorbed on graphite surface given by DFTB compare reasonably well with the results of the MP2 method. The optimized geometry of water hexamer may change its original structure to a near iso-energy one when interacting with graphite surface in some specific orientation, while the smaller water cluster will maintain its cyclic or linear configurations (for water dimer). The binding energy of water clusters and graphite is dependent on the number of water molecules that form hydrogen bonds, but is independent of the water cluster size. These physically adsorbed water clusters show little change in their IR peak position and leave an almost perfect graphite surface. The reasonable efficiency and reliability of DFTB method which takes into account the weak force is promising for application in more complicated systems such as nanostructures assembled on a substrate.

CMT2-5 4:35pm LT8

UST12

Spinless Hardcore Bosons on Checkerboard Lattice Near Half Filling

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We study a spinless hardcore boson model on checkerboard lattice by Green function Monte Carlo method. At half filling, the ground state energy is obtained up to 28×28 lattice and extrapolated to infinite size, the pseudospin magnetization is found to vanish in the thermodynamic limit. Thus charge order is absent in this system. Away from half filling, two defects induced by each hole (particle) may act as fractional excitations. For one hole case, we study how the defect-defect correlation changes with t/J , which is the ratio between the hopping integral and cyclic exchange, equals to $V/2t$ when $V \gg t$. Moreover, we argue that these fractional excitations may propagate independently when the concentration of holes (or defects) is large enough.

CMT2-6 4:50pm LT8

UST4

Strong Optical Force Induced by Morphology Dependent Resonances

Jack Ng, Zhifang Lin, Che-Ting Chan and Ping Sheng

Hong Kong University of Science and Technology

A strong optical force can be induced on a pair of transparent dielectric microspheres (a few microns in diameter) by exciting the morphology dependent resonance (MDR). We investigate such a resonant optical force through rigorous calculations using multiple scattering theory for the electromagnetic field and the Maxwell stress tensor for the electromagnetic force. The bonding and anti-bonding modes of the electric field of the MDR's correspond to strong attractions and repulsions respectively. At resonance, the force can be enhanced by orders of magnitude as compare to the off-resonance case. With a modest incident light intensity, it is shown that the MDR-force can be stronger than thermal fluctuations and the van der Waals forces when the separation between the spheres is more than a few tens of nano-meter, thus achieving the goal of manipulation. It is shown that stable binding of the spheres is possible. The dependence of the force on separation between the spheres, and the role of absorption by the material, and the robustness against sphere size dispersions are also discussed.

CMT2-7 5:05pm LT8

HKBU7

Quantum delocalization of the classical pinned state in Frenkel-Kontorova model

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The Frenkel-Kontorova (FK) model describes the dynamics of the spring-connected particles in an external sinusoidal potential. It can be used to study many physical systems exhibiting a competition between two or more length scales, such as charge density wave, magnetic spirals, Josephson junction and adsorbed monolayers. From the viewpoint of classical physics, there have been a lot of work devoted to this model. One of the most important available results is that, for the incommensurate case in one dimension, when the external potential is strong enough, the system will go from a sliding state to a pinned state, which is often called transition of breaking analyticity (TBA). What is the influence of quantum effect upon this phenomenon has been a central point for the investigation of quantum FK model for many years. In our work, instead of accessing this problem from the path integral viewpoint, we have used the technique of density-matrix renormalization group (DMRG) method to solve the quantized FK model directly. Our numerical results have not only confirmed many former findings, such as the transition of a standard map to a saw-tooth map, but also demonstrate that, as the quantum effect is big enough, the classical pinned state will become delocalized and the whole system behaves just like a pure harmonic chain. The underlying mechanism for this new transition is still under exploration.

Abstracts for INT1

INT1-1 10.30am LT7

CU1

Relation of scaling behavior of velocity and temperature fluctuations in turbulent Rayleigh-Benard convection

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In Rayleigh-Benard convection, motion is driven by an applied temperature difference across the height of a closed box of fluid. When the motion is fast enough, it becomes turbulent. An important issue is to understand the interplay of the velocity and temperature fields, and in particular, how the scaling behavior of the velocity and temperature fluctuations would be related to one another. In our earlier work, we are able to separate the velocity fluctuations into two parts: one part that is correlated with some function of the temperature fluctuations (the correlated part) and the other part that is uncorrelated with any function of the temperature fluctuations [Phys. Rev. Lett. **93**, 124501 (2004)]. In this talk, we shall show how we can obtain relation of the scaling behavior of the correlated part of the velocity and the temperature fluctuations. This relation is tested and supported by experimental measurements.

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Heat conduction in classical systems relates macroscopic physical phenomena to their microscopic statistical properties [see [1] for a recent review]. When microscopic interactions are harmonic, the phonons propagate ballistically, this leads to the thermal “super conduction”. In recent years, many nonlinear models have been studied for the role of nonlinear microscopic interactions on heat conduction. Based on better understandings of these models, a potentially

interesting application is to control heat currents. One of intriguing cases is to design a thermal rectifier (a thermal diode) [2]. We investigate the possibility to control the thermal conductivity by the nonlinear external potential, as the interparticle potential is harmonic and the temperatures of thermostats are fixed. This study is not entirely academic, it is of immediate experimental and of technological importance. For example, to make a controlled thermal conductor has attracted much attention in engineering applications [3].

We consider the Frenkel-Kontorova (FK) model [4], which has found applications in a wide variety of physical problems. Its Hamiltonian is $H = \sum_{i=1}^N \left(\frac{p_i^2}{2m} + \frac{\lambda}{2} (q_{i+1} - q_i - l_0)^2 + \frac{\beta}{2} (1 - \cos \frac{\pi}{a} q_i) \right)$, where N is the system size, p_i the momentum of the i th particle, q_i its displacement, $2a$ the periodicity of the external potential, β the strength of the external potential, $l_0 = 2.0$ the natural length of the spring and $\lambda = 1$ the strength of the interparticle potential. The thermal conductivity κ is defined as $\kappa = J/\Delta T = jN/\Delta T$, where ΔT is the temperature difference at the two ends of a chain, j is the heat flux in the steady state and J is the total heat flux. We focus on the influence of the external potential $\frac{\beta}{2} (1 - \cos \frac{\pi}{a} q_i)$ to the thermal conductivity, particular the periodicity of the external potential $2a$. As $2a \rightarrow \infty$, the relative displacement of particle $\frac{\Delta q}{2a} = \frac{q_{i+1} - q_i}{2a}$ tends to zero. The FK model approaches its continuum limit, an integrable system, the sine-Gordon chain. Therefore its thermal conductivity is infinite. On the other hand, as $2a \rightarrow 0$, the particle’s motions are confined to the infinite potential wells, the FK model becomes a thermal insulator.

Based on the investigations including the non-equilibrium Molecular-Dynamics (MD) simulations, the phonon equation, and the frequency spectra of the particle vibration, we show that the thermal conductivity will decrease as a decreases or β increases. So one can control that the FK model changes from a thermal conductor to a thermal insulator by tuning the periodicity or strength of the external potential. We suggest a design of a controlled thermal conductor by tuning the periodicity or strength of the external potential. The efficiency of the controlled thermal conductor is defined as $e = (\kappa_1/\kappa_2)/(c_1/c_2)$, the ratio of the output to the input, where the controlling parameter c can be β or a . When tuning β , in our simulations $e_\beta = (\kappa_1/\kappa_2)/(\beta_1/\beta_2) > 5000/30 \approx 167$. When tuning a , in our simulations $e_a = (\kappa_1/\kappa_2)/(a_1/a_2) > 10000/8 = 1250$. The analysis of the finite size effect shows that e_a or e_β will increase as the system size for large a or small β . Namely, for a larger system size, e_a will be larger than 1250 and e_β will be larger than 167. Moreover, tuning the periodicity of the external potential may be a more economical way than tuning the strength of the external potential in practical applications.

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INT1-3 11:15am LT7

HKBU4

Management of Bose-Einstein condensates by spatially periodical modulation of the atomic s-wave scattering length

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Using a non-uniform optical or magnetic field, a spatial pattern of the atomic s-wave scattering length can be produced for controlling spatial evolution of a Bose-Einstein condensation (BEC). In particular, we study the propagation of a BEC within a finite regime where the atomic s-wave scattering length, tuned by a periodic magnetic or optical field, results in the Bragg scattering of the BEC. We have deduced coupled mode equations for the forward and backward propagating matter waves, analytically studied the transmittance feature, and found that the periodic modulation of the scattering length results in a matter wave optical limiting processing. Further, we show that when the external potential cannot be neglected, a matter wave bistability could be realized, depending on the length of the modulation regime.

INT1-4 11:30am LT7 HKU4

Einstein's Question about Whether a Complete Description of Reality Exists Remains Open

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Although Albert Einstein made many fundamental contributions to the development of quantum mechanics, he remained critical to the Copenhagen interpretation of this theory. Niels Bohr was the main defender against Einstein's criticism. Their celebrated debate lasted for more than a decade. Most physicists, however, consider this part of the story of Einstein's life somehow ironic. By simply taking the quantum mechanical description as reality itself, most physicists nowadays have put the issue raised by Einstein, i.e., whether the quantum mechanical description of physical reality is complete, behind them. This is largely due to the result of the experimental test of Bell's inequality. However, in contrast to commonly accepted belief, we shall show that, the quantum mechanical description (based on the Copenhagen interpretation) is neither complete nor consistent.

Unlike Einstein's criticism, which might be due to his insistence on causality, the basis of our claim above is of a technical nature. We demonstrate the inconsistency of the Copenhagen interpretation, using Heisenberg's uncertainty relation as an example. We prove that Born's probability explanation of the wave function is incorrect. We explain why the experimental result of Bell's inequality is not evidence supporting the Copenhagen interpretation. We point out that successful applications of quantum mechanics and explanation of the quantum phenomena do not necessarily rely on the Copenhagen interpretation.

INT1-5 11:45am LT7 HKU1

SEARCH OF QUASISOFT X-RAY SOURCES IN GALACTIC CENTER SGR A*

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Quasisoft X-ray sources (QSSs) are X-ray emitting objects which emit a significant amount of photons with energies higher than 1.1keV, but not at energies higher than 2keV. QSSs have been identified in external galaxies, but not yet in our own Galaxy. The physical nature of QSSs remains unknown. One possibility is that QSSs may be intermediate mass black holes (IMBHs) whose masses are hundred times solar. We examine X-ray images of the Galactic center Sgr A* taken by Chandra X-ray Observatory. By performing aperture photometry on all 2357 detected X-ray point sources in the field, we identify 73 QSSs. We also match all X-ray point sources with optical objects in catalog and find that while only about half of all X-ray sources have optical counterparts, 80% of QSSs do have optical counterparts. This implies the QSSs or the companions of QSSs in our Galactic center tend to be able to emit at optical wavelengths.

Abstracts for INT2

INT2-1 (Invited) 2:00pm LT7

HKBU1

Underwater optical sensing for *in situ* measurement of marine phytoplankton

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Marine phytoplankton plays an important role in the climate regulation and the cycling of carbon. Of particular importance to their role are their size distributions, concentration, and biomass. Using sensing techniques to make a realistic estimation of their shapes and sizes is difficult because of the diversity of the species, their highly irregular shapes and their sizes. To obtain information on size distribution and concentration one cannot rely on any single technique, not even with visual inspection, given the lengthy processing procedures and time for sample preparation and image analysis, which render the technique inefficient as a practical tool by itself. At the present stage, size measurements can give a rough indication as to the size type, or at best the species groups, of phytoplankton that is present in the water. Over the years, various attempts have been made to develop methods to measure these important phytoplankton characteristics in a dynamic way. However, most reliable methods tend to be mostly confined to the laboratory and, hence, are tedious to operate for field measurement application especially for extended periods of time. To address this problem, we are developing a novel type of flow cytometer that can work underwater. Our novel cytometer is an attempt to realize a more practical optical technique for real-time *in situ* measurements. The cytometer was put to the test in field trial measurements carried out around Hong Kong waters and results are encouraging in demonstrating its practical usage in environmental monitoring.

INT2-2 2:30pm LT7
HKBU10

***In Silico* Simulations of *E. coli* Metabolic Network**

Shenghua Liang, Sheng Hui, and Leihan Tang

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The metabolic network of *Escherichia coli* is collected. From the Flux Balance Analysis (FBA), the *in silico* model produces a set of objective compounds (with a chosen proportion) under various growth conditions. We observed unexpected high optimality of super-position of single-compound synthesizing vectors in producing multiple objective compounds. Our results reflect the flexible optimal solution space of the network. The flexibility indicates compound-synthesizing processes are largely decoupled to each other. It is possible that this independence gives the simplicity to the regulatory system without losing optimality. Our analysis also raises the question on which solution the cell chooses *in vivo* from the available optima. Besides maximizing the yield of objective compounds, simplicity of regulation may also play an important role in the organization of the metabolic network (e.g., which set of reactions to include) for a given organism.

INT2-3 2:45pm LT7

HKBU11

TOPOLOGICAL CHARACTERISTICS OF YEAST METABOLIC
NETWORK

Sheng Hui, Shenghua Liang, and Leihan Tang

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A nearly complete network of metabolic reactions in yeast *Saccharomyces cerevisiae* is collected. In this presentation we characterize the global and local topology of the network. Besides verifying the scale-free property, we also show here that the network is intrinsically hierarchical and modular. We next focus on the network motifs which are re-occurring local structural units. The 2-compound loop is found to be the most significant motif. It plays the important role of flux coupling within the network. To further elucidate this property, an *in silico* yeast model is simulated. Removal of 2-compound loops from the sub-network activated under particular growth conditions reveals the network backbone. Loops with more than 2 compounds are also enumerated and analyzed. To our surprise, every loop we identified has a conserved chemical part, which in many cases corresponds to a known biochemical compound. The nontrivial conserved part further highlights the biological significance of reaction loops as delivery and recycling systems.

INT2-4 3:00pm LT7

HKBU13

Mechanism characterization of transcriptional regulation in budding yeast cell cycle

Chun-hui Cai, Chao Wang and Lei-han Tang

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Budding yeast is one of principal model organisms of biology. Growth and division of a yeast cell follows a sequence of events known as the cell cycle, with characteristics common to all eukaryotic organisms. In each phase of the cell cycle, a specific set of proteins are present in active form to perform the designated functions. These activities are tightly regulated by the cell to ensure smooth progression of events. An important component in the regulatory machinery is the transcriptional control of genes by nine known transcription factors (TF). In this work, we investigate the regulatory mechanisms of cell cycle genes by combining the cell cycle time-course gene expression data, the TF binding data, and Gerstein's TF regulatory network. We confirm three TF_orf clusters functioning in different cell cycle stages. For a selected group of genes in each cluster, we have identified several regulatory constructs which can be used for further quantitative modeling of combinatorial control of gene expression.

INT2-5 4:35pm LT7

HKU3

Study of the Wealth Inequality in the Minority Game

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To demonstrate the usefulness of physical approaches for the study of realistic economic systems, we investigate the inequality of players' wealth in one of the most extensively studied econophysical models, namely, the minority game (MG). We gauge the wealth inequality of players in the MG by a well-known measure in economics known as the modified Gini index. From our numerical results, we find that the wealth inequality in the MG is very severe near the point of maximum cooperation among players.

[1] K. H. Ho, F. K. Chow and H. F. Chau, Phys. Rev. E 70, 066110 (2004).

INT2-6 4:50pm LT7

HKU2

The Relevance of Memory in Minority Game

K. H. Ho, W. C. Man, F. K. Chow, H. F. Chau

The Department of Physics, The University of Hong Kong, Pokfulam Road, Hong Kong and
Center of Theoretical and Computational Physics, The University of Hong Kong, Pokfulam
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The Minority Game (MG) has become a famous model in econophysics since it was introduced by Challet and Zhang in 1997; fruitful and exciting results have been revealed from this game and many of its variants. Memory, which is the historical records of past outcomes of the game and is the only public information agents rely to make their choices, has long been regarded to be relevant in the asymmetric phase of the game, but irrelevant in the symmetric phase. Here, we show by a large scale simulation that the memory is in fact also relevant in the symmetric phase. Removal of memory eliminates the periodic dynamics behavior of the game in this region and alters its properties. Our discovery shows that memory in many complex adaptive models are important and cannot be simply dumped away.

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D. Challet and Y. C. Zhang, *Physica A* **246**, 407 (1997)

K. H. Ho, W. C. Man, F. K. Chow and H. F. Chau, *cond-mat/0411554*

INT2-7 5:05am LT7

CU2

ASPECT-RATIO DEPENDENCE OF HEAT TRANSPORT BY GIVEN VELOCITY FIELDS

Emily S.C. Ching and W.S. Tam

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In order to gain insights to the problem of heat transport in turbulent convection, we study heat transport by given two-dimensional velocity fields. We choose velocity fields with the same characteristics of the mean velocity field observed in turbulent convection experiments. These velocity fields are circulating and produce a shear near the boundaries. In our numerical calculations, we apply a fixed temperature difference across the vertical direction of a two-dimensional box, keep the maximum magnitude and the shear of the velocity fields fixed and investigate the effect of the aspect ratio, which is the ratio of the width to the height of the box, on heat transport. We find that the Nusselt number, which is a dimensionless number measuring heat transport, decreases with the aspect ratio. Detailed results will be presented and discussed.

Abstracts for PC

PC-1 2:15pm LT5

UST10

**TUNEABLE OPTICAL PROPERTIES OF 1D PHOTONIC CRYSTALS IN
PLANAR SILVER NANO-PARTICLES GELATIN EMULSION**

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In this talk, we will present 1D photonic crystals with tuneable planer structure consisting of nano-scaled Ag particles embedded in gelatin fabricated on monochromatic holographic emulsion by using a holographic lithography method. Bandgaps of different orders are observed in visible and near IR regions. Furthermore, we are able to fabricate hologram with a continuous planar spacing on a single holographic plate in a single exposure, creating a colourful reflection “rainbow” pattern. Good agreement between experimental and theoretical results of optical properties is also obtained by modeling the Ag nano-particle-gelatin composite with a planar structure using an effective medium approach.

**CHARACTERIZATION OF PHOTO-CROSS-LINKABLE LIGHT-EMITTING
POLYMERS**

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Organic molecules and polymers have attracted increasing interest over the past decade due to their excellent optoelectronic properties. Rapid progress in this area already resulted in commercial organic light emitting diode (OLED) products. To optimize the electron and hole injections and enhance the stability, OLED consist of two or more different layers¹ fabricated either by vacuum deposition or spin coating. Compared to vacuum deposition, spin-coating process is cheaper and simpler and readily applicable to any organic materials with good solubility and film forming property. However, during layer-by-layer spin coating procedure, the previous layer is partially dissolved by the subsequent layer to be coated, which will degrade the device performance especially for the pixilated display device with necessary high-resolution patterning. A useful method to avoid re-dissolution is to cross-link the coated layer before applying the next one.² A number of cross-linkable materials such as hexaalkoxytriphenylamine, arylamine and fluorine-based polymers have been developed and successfully incorporated into OLED.³ However, some of these polymers such as those based on fluorene has poor color stability, especially after prolong exposure in air. Here, we characterize a group of new poly(1-phenyl-1-alkyne)s $\{-(C_6H_5)C=C(CH_2)_m-OCOCH=CH_2\}_n$; $m = 3, 9$ comprising of disubstituted polyacetylenes as backbone and vinyl pendant groups as cross-linkable units. This polymers have very high light emitting efficiency, which are comparable to that of poly(1-phenyl-1-octyne), a well-known highly luminescent disubstituted polyacetylene with high air and color stability.⁴ The cross-linked film from this type of polymer is very uniform and flat. Fluorescence and time-resolve measurement results exhibit that the quantum efficiency degradation is very small after exposing to UV even in the air, which is a very attractive property in the language of device fabrication.

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PC-3 2:45pm LT5

UST9

Fabrication of 1D, 2D and 3D Photonic Crystals by Single Refracting Prism Laser Holographic Lithography

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As being able to produce defect-free, nanometer-scale structures over large area uniform photonic crystals (PhCs) in a single step fabrication, holographic lithography has shown to be a very economical and powerful tool and might hold the key to volume production of photonic structures. In the previous demonstrations, however, multiple beams forming the interference pattern were obtained by two independent optical elements and steps: splitting the laser output into multiple beams either by a dielectric beam splitter or a grating; and then superposing them at the exposure area by another specially designed prism. This fabrication strategy can introduce alignment complexity and inaccuracies due to differences in the optical path length and angles among the interfering beams as well as vibrational instabilities in the optical setup. We now demonstrate another approach for easy fabrication of 1D, 2D and 3D photonic crystal microstructures, using a single refracting prism. This prism enables the splitting and recombining of a single incoming laser beam to form multiple-beam interference pattern simultaneously. Thus, anti-vibration equipment, polarization modulators and complicated optical alignment system to adjust the angles between the interfering beams are not required, leading to a very simple optical setup. Temporal overlap of the divided pulses will be able to be achieved without adjusting the optical path lengths if a pulsed laser to be applied in the fabrication. In the context of mass production, this method is much more practical and robust than those previous demonstrations by two independent-element setups.

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PC-4 3:00pm LT5

UST14

Realization of optical *periodic* quasicrystals using holographic lithography

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In this report, we present the use of a ten-beam visible light holographic lithography method to fabricate 3D quasicrystal, *periodic* quasicrystal (a hybrid of the icosahedral quasicrystal), in polymeric resin having quasiperiodicity of a Penrose in 2D but periodic in the normal (z) direction. Normal SEM image and diffraction pattern of the *periodic* quasicrystal confirm the quasiperiodicity of 2D Penrose structure in the x - y plane while cross-section SEM image verifies the periodicity around $0.2 \mu\text{m}$ along z -axis, in excellent agreement with simulated interference pattern. Furthermore, the *periodic* quasicrystal fabricated is very colourful exhibiting photonic bandgaps in the visible range. The bandgaps follow a simple relation with periodicities and polymeric volume fractions, in good agreement with the Bragg's diffraction relation.

PC-5 4:35pm LT5
UST5

Polarization gap in spiral structure

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We studied a dielectric structure with spirals arranged in a HCP lattice. The filling ratio of the spiral structure is 15.17% and the dielectric ratio of the material is 9. It is found that such kind of structure will produce a polarization gap with gap to middle gap frequency ratio equals to 26.40% for k vectors lie along the axis of the spirals. The eigenmode inside the polarization gap is right hand or left hand circularly polarized depending on the whether the handedness of the spirals. The transmission spectrum of the structure have been calculated with incident plane-wave being right hand or left hand circularly polarized and the results matches well with the study on the eigenmodes.

PC-6 4:50pm LT5

UST1

Directive emission from quasi-periodic planar metamaterial substrates

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We report our experimental and theoretical studies on a metamaterial substrate consisting of a quasi-periodic metallic planar pattern and a flat metal sheet, interconnected through metallic vias. We show that this structure possesses *multiple* in-phase reflection frequency regimes and spectral gaps for transverse-magnetic surface waves, whereas the transverse-electric surface waves are suppressed in *all* frequencies. In particular, an antenna put on top of this planar structure radiates with very high directivity ($D=240$) at some frequencies. This phenomenon is mainly governed by the inhomogeneity of the structure, which is a collective effect of perfect magnetic and electric conductors operating simultaneously at the frequency.

Thermal emission by photonic micro-textured surfaces

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Abstract

Ordinary metallic photonic crystals (PCs) have photonic band gaps in which the density of states is suppressed. Thermal emission of photons is suppressed in those frequencies, and is enhanced in other frequencies. We considered the thermal emission property of a photonic crystal and compared it with that of a simple micro-textured surface. The proposed micro-textured surface exhibits a similar optical thermal emission spectrum with that of a photonic crystal. In addition, the present proposed topology also suppresses emission in low frequencies. This simple and yet effective surface structure inspires new directions in fabricating thermal emitting materials.