

제 17차 통계물리 Workshop

2013년 10월 31일(목)~11월 3일(일)

충무 marina 리조트

주최 : 한국물리학회 통계물리학분과

후원 : 고등과학원

피플엑스

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워크숍 일정표

(논문발표 12분, 질의 및 응답 3분)

시간	10-30(수)	10-31(목)	11-01(금)	11-02(토)	11-03(일)
8:00			8:00 ~ 9:00 조식	8:00 ~ 9:00 조식	08:00~09:30 조식
09:00		9:00~10:45 생물물리와 복잡계 (BC) 좌장: 박혁규	9:00~10:30 통계물리일반 (SP) 좌장: 박수찬	09:00~11:00 복잡계 (CS) 좌장: 김범준	09:30~11:00 Round table
10:00		10:45~11:00 휴식	10:30~11:00 휴식		
11:00		11:00~12:45 포스터세션	11:00~12:30 생물물리 (BP) 좌장: 김판준	11:00~13:00 점심	11:00~13:00 점심
12:00		12:00~13:00 물리학회 등록 (창원 컨벤션센터)			
13:00		13:00~14:45 상전이와 임계현상 (CR) 좌장: 고헌일	12:45~14:30 점심 및 이동	12:30~14:15 점심	13:30~18:00 Excursion2
14:00		14:45~15:00 휴식	14:30~15:30 워크숍 등록 (충무 마리나 리조트)	14:15~16:00 네트워크 (NW) 좌장: 육순형	
15:00		15:00~16:45 통계역학 (SM) 좌장: 하미순	15:30~18:00 Excursion1	16:00~16:30 휴식	
16:00				16:30~18:00 경제물리 (EP) 좌장: 이재우	
17:00					
18:00		18:00~19:00 저녁	18:00~19:00 휴식	18:00~19:00 저녁	
19:00		19:00~20:00 자유토론	19:00~21:00 만찬	19:00~20:00 자유토론	

발표논문 목록

약자

물리학회	CR	상전이와 임계현상
	SM	통계역학
	BC	생물물리와 복잡계
워크숍	SP	통계물리일반
	BP	생물물리
	NW	네트워크
	EP	경제물리
	CS	복잡계

물리학회 발표

[CR1] 액체 타이타늄의 고압하에서의 액체-액체 상전이 이 근우, 이 병찬¹(한국표준과학연구원. ¹경희대학교)

[CR2] Isostructural phase transition of 1,2,4,5-tetrabromobenzene (C₆H₂Br₄) jumping crystals studied by Brillouin light scattering KO Jae-Hyeon, LEE Kwang-Sei¹, SAHOO Subash Chandra², NAUMOV Pance²(Department of Physics, Hallym University. ¹Department of Nano Systems Engineering, Center for Nano Manufacturing, Inje University. ²New York University Abu Dhabi)

[CR3] Surface Scaling with the Finite-Time and Finite-Size of the Globally-coupled Kuramoto Model LEE Mi Jin, YI Su Do, KIM Beom Jun(Department of Physics, Sungkyunkwan University)

[CR4] Exact Partition Function Zeros of the Wako-Saito-Muñoz-Eaton Protein Model LEE Julian(숭실대학교 생명정보학과)

[CR5] Statistical mechanics of the coagulation-diffusion process with a stochastic reset DURANG Xavier, HENKEL Malte¹, PARK Hyunggyu(KIAS. ¹U Nancy)

[CR6] Conductivity jump in the avoiding a spanning cluster model *KIM sungmin, CHO young sul, ARAUJO nuno¹, KAHNG Byungnam(Seoul National University. ¹ETH Zurich)*

[CR7] Ashkin-Teller Model on Scale-free Networks *JANG Siho, HWANG Sungmin, KAHNG Byungnam(Seoul National University)*

[SM1] Stochastic resonance in spin systems *BAEK Seung Ki, PARK Hye Jin¹, KIM Beom Jun¹(Department of Physics, Pukyong National University. ¹Department of Physics, Sungkyunkwan University)*

[SM2] Discrete-time statistical mechanics *김 상락(경기대)*

[SM3] Realistic Thermodynamic and Statistical-Mechanical Measures for Neural Synchronization *LIM Woochang, KIM Sang-Yoon¹(Daegu National University of Education, Department of Science Education. ¹LABASIS Corporation, Research Division)*

[SM4] Topological property of networks in the structural classification of proteins *김 경식, 민 승식¹(부경대학교, 물리학과. ¹해군사관학교)*

[SM5] Impact of Link Overlaps in Multiplex Networks *고 광일, 이 상철, 민 병준, 이 규민(고려대학교 물리학과)*

[SM6] 2D q-state Clock Models and the Stochastic Resonance *PARK Hye Jin, BAEK Seung Ki¹, KIM Beom Jun(Department of Physics, Sungkyunkwan University. ¹Department of Physics, Pukyong National University)*

[BC1] Nanoscale Self-Assemblies of Biological Molecules: Structures and Interactions of Protein Nanotubes *최 명철(Dept. of Bio and Brain Engineering, KAIST)*

[BC2] Bundling in brushes of directed and semiflexible polymers *BENETATOS Panayotis, TARENTJEV Eugene¹, ZIPPELIUS Annette²(Department of Physics, Kyungpook National University. ¹Cavendish Laboratory, University of Cambridge. ²Institute for Theoretical Physics, University of Goettingen)*

[BC3] Local and global denaturation in DNA with repetitive sequences *성 우경, 이 오철(포항공과대학교, 물리학과)*

[BC4] Stable and flexible system for glucose homeostasis 홍 현숙, 조 정효¹, 신 상진²(전북대학교, 물리학과. ¹APCTP; 포항공대, 물리학과. ²한양대학교, 물리학과)

[BC5] Backbone chromatography: the color of dynamical brain states based on dynamical motifs and network backbones SHIN Jeongkyu, KIM Seunghwan(Pohang University of Science and Technology, Department of Physics)

[BC6] Conflicts in a real network of like and dislike links YI Su Do, PARK Hye Jin, KIM Dae Joong¹, KIM Beom Jun(Department of Physics, Sungkyunkwan University. ¹Institute for Conflict Healing, Dongguk University)

워크숍 발표

[SP1] 1D sign phase transition revisited *Yongjoo Baek(KAIST), Meesoon Ha (Chosun Univ.) , Hawoong Jeong (KAIST), Hyunggyu Park(KIAS), and Marcel den Nijs(Univ. Washington)

[SP2] Fast algorithm for entries of the pseudo inverse of a sparse generator matrix of Markov chain with detailed balance *황 성민(서울대), 강 병남(서울대), 이 덕선(인하대)

[SP3] Modified saddle-point integral near singularity for the large deviation function *이 재성(KIAS), 권 철안(명지대), 박 형규(KIAS)

[SP4] Experimental Demonstration of the Fluctuation Theorem using a Colloidal Particle under Optical Trap with Strength Changing in Time *이 동윤 (부산대)

[SP5] 새로운 실험 방법을 통한 고체-액체 계면에서의 전하 상호작용 연구 *문 중균 (부산대)

[SP6] Structural properties of explosive percolations on low-dimensional systems *최 우식, 육 순형, 김 엽(경희대)

[BP1] Compaction of a confined chain by crowding particles *김 주인(KAIST)

[BP2] Global Analysis of Human Nutrition and Diet: What the Human Body Wants *김 승현(APCTP, POSTECH), Mathias Foo(APCTP), Yong-Su Jin(FSHN), 김 관준(APCTP, POSTECH)

[BP3] Population Balancing with Switching *Juyong Song(APCTP, POSTECH),
Danh-Tai Hoang(APCTP), Jongwook Kim(APCTP), Junghyo Jo(APCTP, POSTECH)

[BP4] Theoretical Approach to Spiking Variability in Star-like Clustered
Neural Network *Kim Junhyeok(POSTECH), LEE Dongmyeong(KIST), KIM
Seunghwan(POSTECH)

[BP5] Reconfiguration of Network Hub Structure after Propofol-induced
Unconsciousness *이 현수(POSTECH)

[BP6] Network dynamics of sleep stages and their characteristics
*Minkyung Kim, Jeonkyu Shin, Seunghwan Kim(POSTECH)

[NW1] Rich transition natures of heterogeneous k-core percolation on
complex network *채 희승, 옥 순형, 김 엽(경희대)

[NW2] Biased random walk을 이용한 복잡계 그물망의 탐색 문제 *박 현준, 옥 순
형, 김 엽(경희대)

[NW3] Effects of temporal and structural correlations on epidemic spreading
in temporal networks *김 혜원(KAIST)

[NW4] Phase diagram of a costly bilingualism model on hierarchical
scale-free networks *노 명균, 김 영진, 손 승우(한양대)

[NW5] A simple model for the personality aspects depending on interaction
rules *맹 성은, 이 재우, 이 덕선(인하대)

[NW6] Large fires in forest fire model *이 덕재(서울대)

[NW7] Biconnectivity of metabolic networks *김 푸른(서울대), 이 덕선(인하대), 강
병남(서울대)

[EP1] A comparative study of global index and kospi-200 index from the
year 2000-2012 *Ashadun Nobi, 이 재우(인하대)

[EP2] Measuring systemic risk through contagion effect of industry sector
*김 호용, 안 석원, 정 유, 오 갑진(조선대)

[EP3] Relationship between weather effect and stock market. *정 유, 김 호용,
안 석원, 오 갑진(조선대)

[EP4] Analyze the portfolio performance using the complex network method
*안 석원, 김 호용, 정 유, 오 갑진(조선대)

[EP5] The Impact of Heterogeneous Trading And Local Interaction Between
Traders In Artificial Double Auction Market *Kyubin Yim(POSTECH), Gabjin Oh
(Chosun Univ.), Seunghwan Kim(POSTECH)

[EP6] Competition dynamics in the International Trade Network *Matthieu
Barbier, 이 덕선(인하대)

[CS1] Effect of Social Reinforcement and Modularity on Epidemic Process
*Chung Kihong(KAIST)

[CS2] Win-lose circulations between strategies in iterated prisoners'
dilemma games with a single step memory *김 영진, 노 명균, 손 승우(한양대)

[CS3] Investigation of Road Networks in two Korean cities: Pohang and
Changwon *이 병화, 정 우성(POSTECH)

[CS4] Intra-City Bus Network Analysis on the Korean Cities for
Understanding Urban Structures *홍 인호, 정 우성(POSTECH)

[CS5] Network structure of National R&D activity in Korea in terms of
research program *안 민우, 정 우성(POSTECH)

[CS6] Understanding emergence of new scientific concepts in human society
by the words in printed publications *Jinhyuk Yun(KAIST), Pan-Jun
Kim(APCTP,POSTECH), Hawoong Jeong (KAIST)

[CS7] Exploring the trend of society by big data *Lee Byung-hwee (KAIST)

[CS8] Historical Transition of Rank Evolution in Billboard "Hot 100" Chart
*소 형준(KAIST)

발표논문 초록

물리학회 발표

[CR1] 액체 타이타늄의 고압하에서의 액체-액체 상전이 이 근우, 이 병찬¹(한국표준 과학연구원. ¹경희대학교)

A liquid-liquid phase transition (LLPT) in pure elements is a very rare event driven by pressure, e.g., P, Si, C and Ce. LLPTs discovered so far are limited to either sp-valent or f-valent rare-earth elements, and typically associated with covalently bonded, open-tetrahedral structures, allowing room to shrink to a high-density liquid under pressure. More important, LLPT in those elements have a precursor in the phase diagram, i.e. “a V-shape or a maximum in the melting curve” such that the existence of an LLPT can be expected from thermodynamics. In contrast, an LLPT has never been observed nor expected in transition metal liquids for two reasons. First, liquid Ti has a highly dense-packed local ordering at ambient pressure. Second, no elemental transition metal has been reported to show an extremum in the melting curve mentioned above. In this manuscript, we report, for the first time, an LLPT on ‘Transition Liquid metal’ Ti from ab-initio molecular dynamics calculations. The direct evidence of the pressure-induced LLPT in liquid Ti is observed from pair correlation functions and density of state. In addition, the LLPT on liquid Ti with large compressibility compared to liquid Ni provides an answer for the lower melting slope in early transition metals, which has been a long-standing question.

[CR2] Isostructural phase transition of 1,2,4,5-tetrabromobenzene (C₆H₂Br₄) jumping crystals studied by Brillouin light scattering KO Jae-Hyeon, LEE Kwang-Sei¹, SAHOO Subash Chandra², NAUMOV Pance²(Department of Physics, Hallym University. ¹Department of Nano Systems Engineering, Center for Nano Manufacturing, Inje University. ²New York University Abu Dhabi)

The isostructural phase transition of 1,2,4,5-tetrabromobenzene (C₆ H₂ Br₄;;TBB) jumping crystals was studied by Brillouin light scattering. The temperature dependence of the sound velocity and the corresponding elastic constants of three acoustic modes propagating along the [110] direction were measured as a function of temperature covering the beta gamma phase transition temperature for the first

time. All three elastic constants showed discontinuities at the jumping transition temperature with a large thermal hysteresis. While the longitudinal and one of the two transverse acoustic modes did not exhibit any appreciable changes in both the beta and the gamma phase, the lowest transverse acoustic mode showed substantial softening on approaching the jumping transition from both phases. This clearly showed that the jumping transition of this molecular crystal is driven by the elastic instability and that large intermolecular anharmonic interaction is associated with the molecular motions in the (110) plane.

[CR3] Surface Scaling with the Finite-Time and Finite-Size of the Globally-coupled Kuramoto Model *LEE Mi Jin, YI Su Do, KIM Beom Jun*(Department of Physics, Sungkyunkwan University)

We numerically investigate the short-time nonequilibrium temporal relaxation of the globally-coupled Kuramoto oscillators, and apply the finite-time-finite-size scaling (FTFSS) method which contains two scaling variables in contrast to the conventional single-variable finite-size scaling. The FTFSS method yields a smooth scaling surface, and the conventional finite-size scaling curves can be viewed as proper cross sections of the surface. The validity of our FTFSS method is confirmed by the critical exponents in agreement with previous studies: Quenched disorder gives the correlation exponent $\bar{W}_{\nu}=5/2$ and the dynamic exponent $\bar{W}_z = 2/5$ while thermal disorder leads to $\bar{W}_{\nu}=2$ and $\bar{W}_z = 1/2$, respectively. We also report our results for the Kuramoto model in the presence of both quenched and thermal disorder.

[CR4] Exact Partition Function Zeros of the Wako-Saito-Muñoz-Eaton Protein Model *LEE Julian*(숭실대학교 생명정보학과)

I compute exact partition function zeros (PFZs) of the Wako-Saito-Munoz-Eaton model for various secondary structural elements and for two proteins, 1BBL and 1I6C, using both analytic and numerical methods. Two-state and barrierless downhill folding transitions can be distinguished by a gap in the distribution of zeros at the positive real axis. The result is expected to form basis for further application of the PFZs method to finite heterogeneous systems. (Published in Physical Review Letters 110 (2013) 248101).

[CR5] Statistical mechanics of the coagulation–diffusion process with a stochastic reset *DURANG Xavier, HENKEL Malte¹, PARK Hyunggyu(KIAS. ¹U Nancy)*

The effects of a stochastic reset, to its initial configuration, is studied in the exactly solvable one-dimensional coagulation–diffusion process. A finite resetting rate leads to a modified non-equilibrium stationary state. If in addition the input of particles at a fixed given rate is admitted, a competition between the resetting and the input rates leads to a non-trivial behaviour of the particle-density in the stationary state. From the exact inter-particle probability distribution, a simple physical picture emerges: the reset mainly changes the behaviour at larger distance scales, while at smaller length scales, the non-trivial correlation of the model without a reset dominates.

[CR6] Conductivity jump in the avoiding a spanning cluster model *KIM sungmin, CHO young sul, ARAUJO nuno¹, KAHNG Byungnam(Seoul National University. ¹ETH Zurich)*

When bonds are attached randomly in two dimensional square lattices, conductivity between two opposite conductors increases continuously at the critical point, following the effective medium theory. Here, we study the conductivity in the percolation model that is designed to suppress the formation of bridge bonds between two separated clusters. When a bridge bond is occupied eventually, a spanning cluster is formed, and its occupation fraction is drastically increased. Through this discontinuous percolation, the conductivity is also increased from nonzero; however, the conductivity jump is not as large as the jump of the spanning cluster. Using the effective medium theory, we understand the numerical data for the conductivity jump in the discontinuous percolation transition.

[CR7] Ashkin-Teller Model on Scale-free Networks *JANG Siho, HWANG Sungmin, KAHNG Byungnam(Seoul National University)*

Recently, multiplex networks have been actively studied in detail, because many real-world networks are networks of networks. Nevertheless, few spin models, which incorporate interactions between nodes on inter- and intra-network, have been studied yet. Here, we studied the Ashkin-Teller (AT) model on scale-free (SF) random networks. In the AT model, spins on each site are of two types, and two spins of each type at the nearest neighbors interact with one coupling strength J_2 , and four spins of both types at the nearest neighbors interact with another coupling strength J_4 . Depending on the ratio $x=J_4/J_2$, various phases, paramagnetic phase, ferromagnetic phase, antiferromagnetic phase, the Baxter phase, and the sigma phase emerge, which was previously obtained in the mean-field level. We compare the phase diagram in the mean-field solution with that on SF networks, which we obtain. While the phase transition between paramagnetic phase and the Baxter phase is discontinuous in the mean-field solution, it can be continuous depending on the degree exponent on SF network. We discuss the implication of this difference on SF networks.

[SM1] Stochastic resonance in spin systems *BAEK Seung Ki, PARK Hye Jin¹, KIM Beom Jun¹(Department of Physics, Pukyong National University. ¹Department of Physics, Sungkyunkwan University)*

A magnetic system with a phase transition at temperature T_c may exhibit double-resonance peaks under a periodic external magnetic field because the time scale matches the external frequency at two different temperatures, one above T_c and the other below T_c . We study the double-resonance phenomena for the mean-field q -state clock model based on the heat-bath-type master equation. We find double peaks as observed in the kinetic Ising case ($q=2$) for all $q \geq 4$, but for the three-state clock model ($q=3$), the existence of double peaks is possible only above a certain external frequency since it undergoes a discontinuous phase transition. Then, we numerically study stochastic resonance in the two-dimensional q -state clock models from $q = 2$ to 7 under a weak oscillating magnetic field. As in the mean-field case, we observe double resonance peaks, but the detailed response strongly depends on the direction of the field modulation for $q \geq 5$ where the quasiliquid phase emerges. We explain this behavior in terms of free energy landscapes on the two-dimensional magnetization plane. Nonlinear responses are also discussed because they manifest themselves as the external field strength increases.

[SM2] Discrete-time statistical mechanics 김 상락(경기대)

A new formulation of statistical mechanics is proposed, based on the discrete time. Time steps of a system play an important role in characterizing the system. In this formulation, the energy levels are all discrete even in classical regime, so it is not necessary to adopt h_{3N} factor in calculating the partition functions of the system. We also discuss identical particles and coupling of the degrees of freedom.

[SM3] Realistic Thermodynamic and Statistical-Mechanical Measures for Neural Synchronization LIM Woosung, KIM Sang-Yoon¹(Daegu National University of Education, Department of Science Education. ¹LABASIS Corporation, Research Division)

Synchronized brain rhythms, associated with diverse cognitive functions, have been observed in electrical recordings of brain activity. Neural synchronization may be well described by using the population-averaged global potential V_G in computational neuroscience. The time-averaged fluctuation of V_G plays the role of a "thermodynamic" order parameter O used for describing the synchrony-asynchrony transition in neural systems. Population spike synchronization may be well visualized in the raster plot of neural spikes. The degree of neural synchronization seen in the raster plot is well measured in terms of a "statistical-mechanical" spike-based measure M_s introduced by considering the occupation and the pacing patterns of spikes. The global potential V_G is also used to give a reference global cycle for the calculation of M_s . Hence, V_G becomes an important collective quantity because it is associated with calculation of both O and M_s . However, it is practically difficult to directly get V_G in real experiments. To overcome this difficulty, instead of V_G , we employ the instantaneous population spike rate (IPSR) which can be obtained in experiments, and develop realistic thermodynamic and statistical-mechanical measures, based on IPSR, to make practical characterization of the neural synchronization in both computational and experimental neuroscience.

[SM4] Topological property of networks in the structural classification of proteins 김 경식, 민 승식¹(부경대학교, 물리학과. ¹해군사관학교)

We investigate topological properties of networks in structural classification of proteins. We model the native-state protein structure as a network made of its constituent amino-acids and their interactions. We treat four structural classes of proteins composed predominantly of α helices and β sheets and consider several proteins from each of these classes whose sizes range from amino acids of the Protein Data Bank. Particularly, we simulate and analyze the network metrics such as the mean degree, the probability distribution of degree, the clustering coefficient, the characteristic path length, the small-worldness, the local efficiency, and the cost.

[SM5] Impact of Link Overlaps in Multiplex Networks 고 광일, 이 상철, 민 병준, 이 규민(고려대학교 물리학과)

Many real-world networks such as physical, social, biological, and technological networks can be represented by multiplex networks. Link overlaps in different layers are found to be non-negligible. We study the impact of the link overlaps in multiplex networks using the generating function method. Our results show that the overlap links have important role to make MCGC (mutually connected giant component).

[SM6] 2D q-state Clock Models and the Stochastic Resonance PARK Hye Jin, BAEK Seung Ki¹, KIM Beom Jun(Department of Physics, Sungkyunkwan University. ¹Department of Physics, Pukyong National University)

We numerically study stochastic resonance in the two-dimensional q-state clock models from $q = 2$ to 7 under a weak oscillating magnetic field. As in the mean-field case, we observe double resonance peaks, but the detailed response strongly depends on the direction of the field modulation for $q \geq 5$ where the quasiliquid phase emerges. We explain this behavior in terms of free energy landscapes on the two-dimensional magnetization plane.

[BC1] Nanoscale Self-Assemblies of Biological Molecules: Structures and Interactions of Protein Nanotubes 최 명철(*Dept. of Bio and Brain Engineering, KAIST*)

The research in my group is focused on elucidating structures and interactions of supramolecular assemblies of biological molecules. Microtubules, hollow 25 nm diameter protein nanotubes, are among the major filamentous elements of the eukaryotic cytoskeleton and are involved in a range of cellular functions including cell division, the establishment of cell shape and axonal transport in neurons. This talk deals with our recent findings on interactions between microtubules and their associated molecules which leads to their distinct structures (related to their specific functions in cells) on the nanometer scale. Structures are solved by combining reciprocal space and real space data resulting from synchrotron small angle x-ray scattering, electron microscopy experiments.

[BC2] Bundling in brushes of directed and semiflexible polymers
BENETATOS Panayotis, TARENTJEV Eugene¹, ZIPPELIUS Annette²(Department of Physics, Kyungpook National University. ¹Cavendish Laboratory, University of Cambridge. ²Institute for Theoretical Physics, University of Goettingen)

We explore the effect of an attractive interaction between parallel-aligned polymers which are perpendicularly grafted on a substrate. Such an attraction could, e.g., be due to reversible cross-links. The alignment of the polymers could be due to an externally induced tension which gives rise to a tilt modulus or due to a large bending stiffness. For the sake of simplicity, first we assume that the brush consists of (flexible) directed polymers randomly grafted on a planar surface. Their preferred direction is perpendicular to the surface. We use a field-theoretic analytical approach and treat the randomness of the grafting points as quenched disorder. In the absence of any attractive interaction, and after averaging over the disorder of grafting positions, the polymer array is in-plane translationally symmetric. We show that an attractive interaction can cause an instability to a phase with modulated areal density, which has broken in-plane translational symmetry at a certain wavelength. The cause of this instability is the interplay of attraction which induces in-plane collapse of the directed polymers and the permanent grafting which resists it. We also show that this behavior is robust and persists, if instead of directed polymers we consider perpendicularly grafted weakly bending semiflexible polymers with persistence length greater than their contour length.

[BC3] Local and global denaturation in DNA with repetitive sequences 성 우
경, 이 오철(포항공과대학교, 물리학과)

A double-stranded DNA (dsDNA) is a linear array of AT and GC base pairs(bp). In vivo, the DNA has many repetitive sequence parts called satellites of the size ranging widely from 1 to 171 bp. A simulation using the Breathing DNA model[1,2] has shown that as the satellite size increases the denaturation bubbles tend to be much larger than usual. We find that for the optimal value of the satellite size, which is 6~9 bp long, the probability of large bubble formation is highest. To understand this surprising phenomenon analytically, in this work, we study the effects of this satellite size on DNA local and global melting via the Ising model.

[1] O. Lee and W. Sung, Phys. Rev. E, 85, 021902 (2012). [2] O. Lee, J. Jeon and W. Sung, Phys. Rev. E, 81, 021906 (2010).

[BC4] Stable and flexible system for glucose homeostasis 홍 현숙, 조 정효¹,
신 상진²(전북대학교, 물리학과. ¹APCTP; 포항공대, 물리학과. ²한양대학교, 물리학과)

Pancreatic islets, controlling glucose homeostasis, consist of α , β , and δ cells. It has been observed that α and β cells generate out-of-phase synchronization in the release of glucagon and insulin, counter-regulatory hormones for increasing and decreasing glucose levels, while β and δ cells produce in-phase synchronization in the release of the insulin and somatostatin. Pieces of interactions between the islet cells have been observed for a long time, although their physiological role as a whole has not been explored yet. We model the synchronized hormone pulses of islets with coupled phase oscillators that incorporate the observed cellular interactions. The integrated model shows that the interaction from β to δ cells, of which sign is a subject of controversy, should be positive to reproduce the in-phase synchronization between β and δ cells. The model also suggests that δ cells help the islet system flexibly respond to changes of glucose environment.

[BC5] Backbone chromatography: the color of dynamical brain states based on dynamical motifs and network backbones *SHIN Jeongkyu, KIM Seunghwan(Pohang University of Science and Technology, Department of Physics)*

Recently, studying brain network, an abstraction of anatomical/functional relationship in brain activity, became very popular. We propose the abstract visualization method of the dynamical state of brain signals by combining the dynamical network motifs and simplified backbone-rank diagram. We propose backbone chromatography as the mixture of colors representing the orthogonal states defined by dynamic network backbones and motif distribution. Demonstration with the cortical EEG of humans undergoing general anesthesia as well as fMRI of chronic pain patients show potential to quantify different anesthetic states. Backbone chromatography offers the intuitive and direct information about the current state and dynamics of functional brain connection, and is appropriate for the clinical application as a monitor of the brain state, not only in the brain signal level, but the relationship of them. We also test our method as a tracer of spatiotemporal evolution of multi-layered networks.

[BC6] Conflicts in a real network of like and dislike links *YI Su Do, PARK Hye Jin, KIM Dae Joong¹, KIM Beom Jun(Department of Physics, Sungkyunkwan University. ¹Institute for Conflict Healing, Dongguk University)*

We investigate a real network of social relations which contains both like- and dislike-links. By using statistical physics approach that the two types of links are considered as ferromagnetic and antiferromagnetic interactions, respectively, we study the network structure by using the q-state voter model. It is found that like- and dislike-relations exhibit very different behaviors. The resolution of conflict in time is also investigated.

워크숍 발표

[SP1] 1D sign phase transition revisited *Yongjoo Baek(KAIST), Meesoon Ha (Chosun Univ.) , Hawoong Jeong(KAIST), Hyunggyu Park(KIAS), and Marcel den Nijs(Univ. Washington)

We examine whether $1 + 1$ dimensional directed polymers in a random medium can display long-range order associated with an imaginary interaction that flips the sign of the partition function with probability p . It was claimed [1, 2] that such sign type order exists even at nonzero p , which would then be an example of one-dimensional (1D) dynamic phase transition induced by a non-equilibrium process. Reinterpreting the sign as ferromagnetic Ising spins coupled to the Kardar-Parisi-Zhang (KPZ) type surface growth, we numerically show that such dynamics does not lead to a phase transition, but does give rise to a distinct crossover anomaly observable in finite systems that mimics a phase transition. We discuss the finite-size scaling of this crossover phenomenon.

[1] B. Spivak, S. Feng, and F. Zeng, Pis'ma Zh. Eksp. Teor. Fiz. 64,

[SP2] Fast algorithm for entries of the pseudo inverse of a sparse generator matrix of Markov chain with detailed balance *황 성민(서울대), 강 병남(서울대), 이 덕선(인하대)

We propose an algorithms for solving entries of the sparse symmetric matrix using Gaussian integration and further be generalized to the some cases where the matrix becomes singular. This generalization includes the stochastic matrices with the detailed balance condition where the knowledge of pseudo-inverse is related to the correlation between states. The proposed algorithm is particularly useful if one only needs partial entries of the pseudo-inverse of the given matrix since the time complexity of the algorithm can be dramatically reduced. The performance of the proposed algorithm is highly dependent of the integration order of the multiple integration. Interestingly, finding the optimal ordering turns out to be *graph elimination game* which is widely used in the QR decomposition of the sparse matrix. Using the several known heuristics of the elimination game, we present numerical data to show the overall performance of the algorithm.

[SP3] Modified saddle-point integral near singularity for the large deviation function *이 재성(KIAS), 권 철안(명지대), 박 형규(KIAS)

Long-time-integrated quantities in stochastic processes, in or out of equilibrium, usually exhibit rare but huge fluctuations. Work or heat production is such a quantity, of which the probability distribution function displays an exponential decay characterized by the large deviation function (LDF). The LDF is often deduced from the cumulant generating function through the inverse Fourier transformation. The saddle-point integration method is a powerful technique to obtain the asymptotic results in the Fourier integral, but a special care should be taken when the saddle point is located near a singularity of the integrand. In this paper, we present a modified saddle-point method to handle such a difficulty efficiently. We investigate the dissipated and injected heat production in equilibration processes with various initial conditions, as an example, where the generating functions contain branch-cut singularities as well as power-law ones. Exploiting the new modified saddle-point integrations, we obtain the leading finite-time corrections for the LDF's, which are confirmed by numerical results.

[SP4] Experimental Demonstration of the Fluctuation Theorem using a Colloidal Particle under Optical Trap with Strength Changing in Time *이 동훈 (부산대)

Recently, there have been growing theoretical interests in non-equilibrium processes for the thermodynamic description of microsystems. Since the discovery of the fluctuation theorem in mid 1990's, a number of theoretical results have been proposed and many experiments have been done to confirm the theories. However, there was no experiment of checking the theorem in an exactly solvable system. In this work, we tested the fluctuation theorem by using a colloidal particle trapped in harmonic potential, which can be considered as a simple harmonic oscillator. Initially, the particle was trapped inside a potential with fixed trap strength and the particle is in equilibrium state. At $t=0$, in order to drive the particle away from equilibrium, the optical trap strength was increased (decreased) linearly with time for forward (backward) case. During these processes, the position of the particle was measured with the spatial resolution of nano meter with time. Each process was repeated 40000 times. Physical quantities, such as work and free energy difference, were calculated from the experimental data. The results agree with the fluctuation theorem very well.

[SP5] 새로운 실험 방법을 통한 고체-액체 계면에서의 전하 상호작용 연구 *문종균 (부산대)

고체-액체 계면은 주위에 혼하게 볼 수 있다. 하지만 고체-액체 계면의 전하 상호작용에 대한 이해는 많이 되어있지 않다. 계면의 전기적인 성질을 설명하는 제타전위는 고정된 표면 전하를 재는 대신, 유동적인 표면 전하를 측정하기 때문에 그 개념 자체가 모호하다. 최근 본 연구진이 개발한 새로운 실험 방법은 고체-액체 계면으로 이루어진 시스템에서 외부의 역학적 변조에 의해 발생하는 전기적인 신호를 분석하는 것이다. 정적인 방법으로 두개의 전극 사이에 물방울이 liquid bridge를 형성 하였을때 발생하는 전기적 신호를 통해 계면의 알짜 전하량과 극성을 측정하는 것이 있고 동적인 방법으로 두개의 전극사이에 형성된 liquid bridge를 진동시켰을때 나오는 전기적인 신호를 통해 계면 근처 전하들의 동역학적 특성을 알아낼 수 있다. 새롭고 획기적인 본 연구방법을 통해 아직 정확하게 알려져 있지 않은 고체-액체 계면에서 전하들의 상호작용에 대한 실마리를 풀 수 있는 연구결과를 제공할 수 있으리라 기대한다.

[SP6] Structural properties of explosive percolations on low-dimensional systems *최우식, 육순형, 김엽(경희대)

To understand the mechanisms of transition nature of the explosive percolation in lower dimensions, we investigate structural properties of spanning clusters. The fractal dimensions of the spanning cluster itself, of the backbones of the spanning cluster and of cutting bonds of the spanning cluster are measured. From these measurements, we infer the transition natures in low dimensions.

[BP1] Compaction of a confined chain by crowding particles *김 주인(KAIST)

DNA compaction in a bacterial cell is in part carried out by depletion forces induced by "free" proteins or crowding particles available in the cell. Indeed, recent in vitro studies [1] have shown that the depletion force alone can condense the *E. coli* chromosome to its in vivo size. Here, we study how a chain molecule can be compacted by crowding particles in a (cell-like) cylindrical space, using molecular dynamics simulations. Our simulation results confirm that the depletion interaction alone is strong enough to compact the chain and suggest that the compaction seems to be rapid but continuous. We also support our results by free energy analysis. This effort enables us to understand the competing effects of depletion and cylindrical confinement on chain conformation.

[1] J. Pelletier, K. Halvorsen, B.-Y. Ha, R. Paparcone, S. J. Sandler, C. L. Woldringh, W. P. Wong and S. Jun, *Proc. Nat. Acad. Sci.*, 2012, 14, E2649 – E2656.

[BP2] Global Analysis of Human Nutrition and Diet : What the Human Body Wants *김 승현(APCTP, POSTECH), Mathias Foo(APCTP), Yong-Su Jin(FSHN), 김 판준(APCTP, POSTECH)

Daily diet has significant effect on human health, thus numerous data about what people should eat and what nutrients are in foods has been accumulated. However, there are only few studies that systematically analyze those large-scale food data. With nutritional data of ~900 food products, we here present a way to quantitatively measure how each food is nutritionally valuable and to find which factors have effect on such valuableness. Specifically, to quantify valuableness of a given food, we calculated all possible different food combinations including the food, which satisfy daily nutritional requirement. The number of such food combinations is called herein nutritional fitness of the food (NF). We then found a set of nutrients which can act as bottlenecks for foods to have high NF. It turns out that only Individual bottleneck nutrients don't affect NF, but also their pairs affect NF in that foods with high NF tend to have unusual nutrient pairs not to be expected from majority of the other foods. To summarize, our study provides insight into how NF and nutrients are intricately related, and can be useful for planning of international food aid and personalized nutrition.

[BP3] Population Balancing with Switching *Juyong Song(*APCTP, POSTECH*),
Danh-Tai Hoang(*APCTP*), Jongwook Kim(*APCTP*), Junghyo Jo(*APCTP, POSTECH*)

We study a population balancing problem motivated from cell replication and transdifferentiation. The biological processes can be mapped onto ball addition and replacement in the urn problem. When a colored ball is drawn in an urn comprising two colors of balls, one additional ball with the same color is put into the urn in the Polya's urn, while the drawn ball is replaced by a different-colored ball in the Ehrenfest's urn. Our model is a mixture of the two urn cases where two types of cells replicate and switch into the other cell types. Dominant species have a higher chance to replicate and also switch into the other species. Therefore, the competition between the two processes determines population balance. We develop the master equation for describing the population dynamics, and find the critical condition for the population balancing. In addition, we analyze the fluctuation of population size by the Fokker-Planck equation derived from the master equation.

[BP4] Theoretical Approach to Spiking Variability in Star-like Clustered Neural Network *Kim Junhyeok(*POSTECH*), LEE Dongmyeong(*KIST*), KIM Seunghwan(*POSTECH*)

It has been known that the anatomical network in cortex is characterized by the properties of heterogeneous connection between nodes like small-world, scale-free network. We studied theoretically the effect of heterogeneous connection on the spiking dynamics of clustered network. From the star-like neural network model with clusters, we found that hub cluster exhibit the highest firing rate fluctuations and spiking time variability due to the highest degree of hub. Also, we checked the firing rate properties of neurons which are outside of the hub. In the future, we will extend this theoretical approaches to other heterogeneous neural network to understand the relationship between the underlying structure and spontaneous brain activity.

[BP5] Reconfiguration of Network Hub Structure after Propofol-induced Unconsciousness *이 현수(POSTECH)

Although network analysis has been widely used in brain study, there has been relatively little focus on graph theoretical approaches to network changes during general anesthesia. Considering dramatic changes in electroencephalographic signals during general anesthesia, we hypothesized that anesthetics have an effect on hub structure of functional brain network. From 21-channel electroencephalogram, functional brain network was defined by Phase Lag Index, for 3 states: wakefulness, loss of consciousness induced by anesthetic propofol, and recovery of consciousness. Topology rather than global connection strength of functional brain networks correlated with states of consciousness. The Average shortest path length, clustering coefficient, and modularity increased after administration of propofol indicating segregated and inefficient brain network in association with loss of consciousness. In particular, the strength of hub nodes significantly decreased. The primary hub location shifted from the parietal to frontal region. These altered primary locations of hub nodes correlated with the altered phase relationship between frontal and parietal regions. This study suggests that reconfiguration of hub structure is associated with anesthetic-induced unconsciousness. Furthermore, reconfiguration of hub structure may explain the observed loss of frontal-parietal feedback connectivity.

[BP6] Network dynamics of sleep stages and their characteristics *Minkyung Kim, Jeonkyu Shin, Seunghwan Kim(POSTECH),

Sleep is one of the most curious and undiscovered part of a human brain. There are 6 sleep stages and these stages are appeared in turn during sleep. We called this sleep dynamics or sleep cycle. There are Rapid Eye Movement(REM) sleep, wake stage and Non-REM(NREM) sleep which is divided to 4 stages such as sleep stage1,2,3 and 4. We observed characteristics of each sleep stage using electroencephalogram(EEG) signal with functional brain network analysis. We constructed the directed functional connectivity network using symbolic transfer entropy(STE) by frequency band-pass filtering and compared the network topology between sleep stages. We found that the connectivities between frontal and central(occipital) are changed for sleep stages. We suggest that the sleep stages have different functional network topology.

[NW1] Rich transition natures of heterogeneous k -core percolation on complex network *채 희승, 옥 순형, 김 엽(경희대)

We study transition natures of heterogeneous k -core percolation on a random network. Given a simple network, a heterogeneous k -core is defined as the largest subgraph where every nodes has at least k neighbors in the subgraph itself, where k_i is a quenched random variable assigned to i . We consider a framework where the nodes of a given network are randomly removed with probability $1-p$ and we ask how the fraction of nodes in the heterogeneous k -core varies as p is decreased. Using local-tree approximation, it is proved that the heterogeneous k -core shows a rich variety of critical phenomena such as bi-, tri-, quadri-, and penta-criticality. From the numerical simulations, we also confirm the variety of critical phenomena.

[NW2] Biased random walk을 이용한 복잡계 그물망의 탐색 문제 *박 현준, 옥 순형, 김 엽(경희대)

우리는 biased random walk 모형을 이용하여 복잡계 그물망을 탐색하는 문제를 연구하였다. Node i 에 위치한 walker가 이웃 node j 로 이동하기 위한 hopping rate, $w_{i \rightarrow j}$ 가 p 의 확률로 $w_{i \rightarrow j} \propto k_j^\alpha$ 이거나 $(1-p)$ 의 확률로 $w_{i \rightarrow j} \propto k_j^{-\beta}$ 를 따른다. 여기서 k_j 는 node j 의 degree이며, $\alpha > 0$, $\beta \geq 0$ 을 만족한다. 따라서 주어진 α , β 에 대하여 p 를 조정하여 walker가 hub를 방문할 확률과 degree가 작은 node를 방문할 확률을 결정할 수 있다. 이 모형의 전산 시뮬네이션을 통하여 다양한 그물망에서 first-passage time, τ 를 측정하였다. 이로부터 우리는 그물망에서 τ 를 최소로 만듦으로써 탐색에 최적화된 (p, α, β) 를 구하였다.

[NW3] Effects of temporal and structural correlations on epidemic spreading in temporal networks *김혜원(KAIST)

While most studies on epidemics have focused on static networks, it was recently shown that the time-varying structure of networks has nontrivial effects on the spreading pattern. Such effects were usually studied by a set of randomization schemes, which selectively destroy a particular type of structural and temporal correlations of the network. Although this method shows the importance of correlations, it does not give a description of their nature. To address this matter, we quantify various correlations present in the time-varying sexual contact network [1] and discuss their effects on the epidemics. Our arguments are checked by simulating the SI models on the same network.

[1] L. E. C. Rocha, F. Liljeros, and P. Holme, PLoS Comput. Biol. 7, e1001109 (2011).

[NW4] Phase diagram of a costly bilingualism model on hierarchical scale-free networks *노명균, 김영진, 손승우(한양대)

We investigate costly bilingualism model with a single zealot on self-similar hierarchical scale-free networks, so-called (u,v) flowers, where each link in n -th generation is replaced by two parallel paths consisting of u and v links to produce the $(n+1)$ -th generation. According to the method of construction, the networks have the properties of small world ($u=1$) or fractal ($u>1$). The phase diagrams of the costly bilingualism model are analytically studied on four different kinds of (u,v) flowers: $(1,2)$, $(1,3)$, $(2,2)$ and decorated $(2,2)$ flowers, then compared to those on one-dimensional ring with ℓ interaction ranges. The self-similar structure of the hierarchical networks makes possible exact analysis. All the results are compared with numerical simulations.

[NW5] A simple model for the personality aspects depending on interaction rules *맹 성은, 이 재우, 이 덕선(인하대)

Understanding the interplay between node characteristics and the network topology is a key issue in the field of social networks. Introversion and extroversion are among the major human characteristics, being related to the likelihood of creating and maintaining the relationship with other persons.. Given that the spread of information and the collective behaviors depend both on the node characteristics and the underlying network topology, the understanding of the emergence and influence of the introverts and extroverts in the context of social networks is highly desirable. We introduce simple agent-based models in which initial neutral nodes become intro-extroverts or neutral again, depending on its interaction rules. And we also examine the correlation between nodes and properties of evolving network and discuss about its meanings.

[NW6] Large fires in forest fire model *이 덕재(서울대)

The Drossel-Schwabl forest fire model is a representative non-conservative avalanche model with very simple dynamic rule. The model is basically a percolation process with random removals of clusters called fires. The frequency of fires determines the distribution of the fire size that is size of removed clusters. The model was usually studied in the large frequency limit because SOC feature was expected in the limit. The expectation, however, is considered doubtful in recent studies. In the limit the density of occupied nodes is below the percolation threshold and only finite clusters exist. In contrast, we study the model in the frequency region that giant clusters exist and burn down frequently. In scale free networks the giant clusters exist for any frequency of fires and, in regular lattice, they exist only for small frequency of fires. The probability density of large fires exhibits an unusual increasing power law. The scaling behavior is analyzed by the finite size scaling method.

[NW7] Biconnectivity of metabolic networks *김 푸른(서울대), 이 덕선(인하대), 강 병남(서울대)

The structural and functional connectivity pattern of cellular components in their transcriptional regulation, binding, metabolism, and so on are crucially affected by the evolutionary selection under fluctuating environments. The ability to maintain the overall functionality even with broken parts is essential for survival and reproduction, and therefore should be possessed by cellular networks, which can be quantified by the distribution of biconnected components. We here present our cross-species study of the biconnectivity in the cellular metabolism of 500 microorganisms. Computing the biconnected components in the bipartite networks of metabolic reactions and compounds and those in random networks, we find how the backup pathways are organized in a non-random way in the studied microorganisms. In particular, investigating the clustering coefficient, the giant biconnected component, and the module-biconnectivity, which represent the biconnectivity of a network on different scales, we get insights into how the metabolic networks have evolved to achieve functional stability against perturbation. We also present some theoretical approach to understand the biconnectivity of random networks with focus on the impact of the degree distribution.

[EP1] A comparative study of global index and kospi-200 index from the year 2000-2012 *Ashadun Nobi, 이 재우(인하대)

We apply random matrix theory to 31 global index and Kospi-200 each year from 2000-2012. We calculated eigenvalues, eigenvectors and Inverse participation ratio. We observed that during crisis the behaviors of global market and local market are almost same. We also compared network properties such as assortativity, clustering coefficient, mean degree, shortest distance for minimum spanning tree and also cophenetic correlation coefficient for both local and global market. We observed that network properties are also similar during crisis.

[EP2] Measuring systemic risk through contagion effect of industry sector

**김 호용, 안 석원, 정 유, 오 갑진(조선대)*

Systemic risk is the risk that negative feedback that is directed at one company is propagated to other companies via diverse interrelation. We establish the generalized variance decomposition method with a return and volatility time series data in Korean stock market to measure systemic risk. Here, we propose a novel method to measure systemic risk and calculate the systemic risk for the KOSPI market based on the contagion effect among industry sectors and the chaebol group. We find that systemic risk is closely related to financial crises such as the Asian currency crisis and the subprime mortgage crisis.

[EP3] Relationship between weather effect and stock market.

**정 유, 김 호용, 안 석원, 오 갑진(조선대)*

We analyze the relationship between weather variables and industry sector indices based on the bounded rationality of investor in the economy system using the monthly data from 2000 to 2010. We find that humidity and cloud cover have become highly related to the all industry sectors. We find that the weather information that might influence the psychological social phenomena should affect the investment strategies. Our findings suggests that the psychological effect of the investors in economic systems playing a much more important role in terms of the portfolio theory.

[EP4] Analyze the portfolio performance using the complex network method

**안 석원, 김 호용, 정 유, 오 갑진(조선대)*

Portfolio management is an essential problem of financial investment literature. Since Markowitz's portfolio theory introduced, the numerous methods for constructing portfolio set have been proposed in the traditional technology such as the several clustering algorithm and the random matrix theory, while there has been relatively little study of network approach. We used an individual stocks listed on the KOSPI index from 01.03 2000 to 12. 31. 2012. To make diverse portfolio sets, we constructed the stock network with the links above given threshold value. We consider Pearson correlation to check the performance of proposed method and calculated the correlation between the KOSPI and the network-based-portfolio index calculated by in-sample, out-of-sample. We find that the correlation value was high enough in overall threshold value in in-sample. However, the value was relatively low in out-of-sample, which is due to the noisy factors. To filter out the noise effect, random matrix theory was used and we find that the correlation value between real market index and artificial index was improved as the only meaningful factors were included.

[EP5] The Impact of Heterogeneous Trading And Local Interaction Between Traders In Artificial Double Auction Market

**Kyubin Yim(POSTECH), Gabjin Oh (Chosun Univ.), Seunghwan Kim(POSTECH)*

In financial market, there exists several stylized facts such as fat-tails and long memory of volatility. For the perspective of complex system, stylized facts could come from heterogeneous trading strategies and nonlinear interaction between traders. To understand intrinsic properties of financial market such as stylized facts, we propose ADAM(Artificial Double Auction Market) using agent based modelling. ADAM consists of heterogeneous traders such as fundamentalist and chartist. Fundamentalist(Chartist) has a risk averse (risk love) property and fills a role of liquidity provider (liquidity taker) in ADAM. When the ratio of chartist in market increases, the market becomes more volatile and risky. Additionally, we add local interaction between traders in ADAM. When adding local interaction and excluding global interaction between traders, stylized facts such as fat-tails and long memory of volatility disappear. This research provides microscopic understanding of stylized facts and the effect of local interaction between traders in financial market.

[EP6] Competition dynamics in the International Trade Network **Matthieu Barbier, 이 덕선(인하대)*

Patterns of international trade are often investigated as a major factor in nations' economic well-being, but they also play a large part in shaping the landscape of products, from raw materials to high technologies, which define our global material culture. Social trends, technological developments and national policies all contribute to the success or failure of various categories of goods, as reflected in the growth or decay of their popularity in trade. In this work, we choose to abstract from these multilevel interactions, and model the long-term dynamics of trade over forty years as a closed system where either products or countries are players competing with their peers to increase their share in trade. This competition takes the form of random exchanges of some fraction of their trade volume according to a symmetric biproportionality rule. These stochastic dynamics are shown to reproduce global properties such as the overall distribution of trade volumes and growth rates, and can also be simulated to follow the evolution of individual products or countries. Such forecasts are then compared to empirical data, allowing us to categorize players by their "predictability" (likelihood of the data under the null model), and demonstrating first that 80% do not deviate significantly from projected dynamics. By contrast, we can single out players whose trade dynamics are exceptional, revealing socio-historical determinants. This proves especially interesting in the case of products, as various types of deviations from our model predictions correlate with different categories of goods in the Standard International Trade Classification.

[CS1] Effect of Social Reinforcement and Modularity on Epidemic Process **Chung Kihong (KAIST)*

How things spread in our societies has been a long-asked question whose satisfactory answer is still in development. Now it is known that epidemic processes in societies involve two essential factors: social reinforcement and modular network topology. To take both features into account, we study the generalized epidemic process [1] on modular networks with adjustable modularity. We first show that, as social reinforcement becomes stronger, the nature of phase transition associated with outbreak changes from bond-percolation type continuous transition to discontinuous transition. We then analytically show that the boundary between different transition types changes as a function of modularity. Our results are also numerically verified.

[1] H.-K. Janssen, M. Muller, and O. Stenull, Phys. Rev. E 70, 026114 (2004).

[CS2] Win-lose circulations between strategies in iterated prisoners' dilemma games with a single step memory *김 영진, 노 명균, 손 승우(한양대)

We study iterated prisoners' dilemma games (IPDG) with a single step memory using replicator dynamics. Through the network analysis of the strategies in IPDG, we find the existence of win-lose circulations between strategies like the rock-paper-scissors. Focusing on the simplest cases among three strategies, we investigate the oscillating population densities in time and the two dimensional flows on the strategies plane. Fixed point and its stability are theoretically analyzed and checked by numerical simulation.

[CS3] Investigation of Road Networks in two Korean cities: Pohang and Changwon *이 병화, 정 우성(POSTECH)

We investigated the roads network of two Korean cities: Pohang and Changwon. By using several topological methods, we obtained the basic properties of networks such as the degree distribution, the average shortest path length, and clustering coefficient. All of them reflect the basic property of planar networks, i.e. planarity, which means that the links do not cross each other. The most significant result of this work is the betweenness centrality maps, obtained for both nodes and links. The result indicates that betweenness centrality maps have a broad distribution, consistent with a power-law distribution. This means that the traffic is concentrated on a small fraction of nodes. We also investigated which crossings and roads are potentially the most probable congestion sites. By comparing the betweenness centrality maps, which is the prediction result, and real traffic information, we showed that they looks very similar to each other, which means that prediction works well. The important point is that we can predict potentially congestion points by using only topological information of the road networks, without any meta information.

[CS4] Intra-City Bus Network Analysis on the Korean Cities for Understanding Urban Structures *홍 인호, 정 우성(POSTECH)

Complex network analysis on social systems has improved the understanding of social structures and phenomena closely related to our daily life. The transportation systems for inter-city or inter-country connections such as airlines, railways and inter-city buses have been deeply studied in perspective of the spatial network in recent decades. In contrast with the previous studies, this study focused on the intra-city bus system of Korean cities to understand the urban structures by network analysis. A few Korean cities which are not metropolitan and not in capital area are chosen as the target cities to reduce the complexity caused by alternative public transportations such as subway and metropolitan bus system. The basic network properties including degree distribution, betweenness centrality and assortativity are analyzed with the bus schedule data. The urban structure of the target cities will be discussed by comparing the network topologies in consideration of the regional characteristics.

[CS5] Network structure of National R&D activity in Korea in terms of research program *안 민우, 정 우성(POSTECH)

Technology is essential for our life, so R&D activity is crucial for the improvement of our quality of life. Therefore, many agency support R&D activity, and the amount of investment is gradually increased. We confirm the structure of the R&D activity focused on research program. We employ network analysis to see the relation between research programs. To construct network, we use the data from NTIS (National Science & Technology Information Service), which provides various data about research projects such as title, technological category, keywords, and so on. First, we construct research project network. Node is research project, and we connect two nodes if they have common keywords. From this network, research program network is created. Node is research program, and we connect two programs when connection exists between two programs in research project network. We will observe the structure of research program network and discuss about the meaning of observed results.

[CS6] Understanding emergence of new scientific concepts in human society by the words in printed publications *Jinhyuk Yun(KAIST), Pan-Jun Kim(APCTP,POSTECH), Hawoong Jeong(KAIST)

Throughout mankind's history, forecasting and predicting future has been a long-lasting interest to our society. Many fortune-tellers have tried to forecast the future by astrology, crystal ball, and other 'divine' items. Sci-fi writers have also imagined what the future would look like through their writings. However most of them have been illogical and unscientific. Meanwhile, scientists have also attempted to discover future trend of science. Many researchers have used quantitative models to study how new ideas are used and spread. W. Goffman developed some mathematical models explaining spread of scientific idea S. Bornholdt examined the changes of 2D lattice model during emergence of a new idea, which grows fast and declines slowly. Besides the modeling works, in the early 21st century, the rise of data science has provided another prospect of forecasting future. Y. Kajikawa et al tried to track emerging research areas in energy research field. Lee also tried to identify emerging research fields using scientometrics . Several researches tried to identify emerging science trends using burst detect algorithms . However many studies have focused on very limited set of period or age, due to the limitations of dataset. Hence, many questions still remained unanswered. Fortunately, at present, Google released a new dataset named "Google N-Gram Dataset" . This dataset provides us with 5 million words worth of literature dating from 1520 to 2008, and this is nearly 4% of publications-about 5 million books-ever printed. With this new time-varying dataset, we studied the spread and development of technologies by searching 'Science and Technology' related words from 1800 to 2000. By statistical analysis we determined factors that strongly affect the lifecycle of a word. Beside statistical analysis, we also determine underline dynamics of spreading scientific idea to society by using of model.

[CS7] Exploring the trend of society by big data *Lee Byung-hwee (KAIST)

Capturing the trend of society reflecting the popularity of market is a ceaseless topic of the business, economic, and financial world because public interest affects the existence of companies. To investigate social trend required much effort in the past, but information revolution makes it easy in this day. In this work, we introduce new methods of analysis of relationships between trendy words with the help of Google Trends. As illustrative examples, we analyze the fashion brands and clothes categories, the members of the 111th United States Senates, major league baseball players, and etc. We conclude that our method can be a useful tool for mining social trend.

[CS8] Historical Transition of Rank Evolution in Billboard "Hot 100" Chart

*소 형준(KAIST)

Since popularity is an important indicator of success in human society, there has been a growing interest in the description and prediction of popularity dynamics. In this work, we study the popularity dynamics of Billboard “Hot 100” chart ranking, which provides a very rich dataset reflecting the time evolution of music popularity over five decades (1958 ~ 2012). Dividing the time span of data into various subintervals, we find a noteworthy difference in trend between the periods before and after the year 1990. The rank dynamics before 1990 is well-described by a Markovian model, whereas the model becomes inaccurate afterwards. This reveals that the nature of population dynamics essentially changed in the year 1990.

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