제6회

2009 Combinatorics Workshop
2009 조합론 학술대회

August 20–21, 2009

Bldg# E6-1, Room 1501

KAIST 수리과학과 (Dept. of Mathematical Sciences)

http://mathsci.kaist.ac.kr/workshop/combinatorics2009/

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- Dongsu Kim (김동수), KAIST
- Jaeun Lee (이재운), Yeongnam University

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KAIST 수리과학과

Time	Aug 20, Thu	Aug 21, Fri
9:00AM		**Jeong-Han Kim (김정한)**
10:00AM		Break
10:25AM		Kyomin Jung (정교민)
10:50AM		Sejeong Bang (방세정)
11:15AM		Ebrahim Ghorbani
11:30AM	**Suh-Ryung Kim (김서령)**	
11:40AM		Sho Suda
12:05PM		Joonkyung Lee (이준경)
12:30PM	Lunch	Lunch
1:30PM	**Andreas Holmsen**	**Seunghyun Seo (서승현)**
2:30PM	Break	Break
2:55PM	Young Soo Kwon (권영수)	Heesung Shin (신희성)
3:20PM	Jacobus H. Koolen	Myeong-Ju Jeong (정명주)
3:45PM	Jongyook Park (박종육)	Hana Kim (김하나)
4:10PM	Boram Park (박보람)	Uijin Jung (정의진)
4:35PM	Joon Yop Lee (이준엽)	Seok-Zun Song (송석준)
5:00PM	Break	Break
5:30PM	**Tommy Jensen**	**Mark Siggers**
6:30PM	Banquet	

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Abstracts

Invited Talk (초청강연) 1: Aug 20, 11:30AM–12:30PM

Competition graph and its variants

Suh-Ryung Kim (김서령)
Seoul National University

Given a digraph $D = (V, A)$, the *competition graph* $G = C(D)$ of D has the same vertex set and has an edge xy if for some vertex $u \in V$, the arcs (x, u) and (y, u) are in D. Competition graphs arose in connection with an application in ecology and also have applications in coding, radio transmission, and modelling of complex economic systems, and there has been a vast literature of competition graphs. There have also been introduced a variety of generalizations of the notion of competition graph, including the common enemy graph (sometimes called the resource graph), the competition-common enemy graph (sometimes called the competition-resource graph), the niche graph, the p-competition graph, and m-step competition graph.

In this talk, we survey recent results on competition graph and its variants.

Invited Talk (초청강연) 2: Aug 20, 1:30PM–2:30PM

Combinatorial geometry and geometric transversals

Andreas Holmsen
KAIST

In this talk I will survey some of the different directions in which the classical theorem of Helly on intersections of convex sets has been generalized and applied. This includes such topics as centerpoint theorems and weak-epsilon nets for convex sets, colorful Helly theorems, and higher-dimensional transversals.

Contributed Talks (일반강연) 1: Aug 20, 2:55PM–5:00PM

Classification of regular embeddings of a cartesian power of a graph

Young Soo Kwon (권영수)

Yeungnam University

A map is a 2-cell embedding of a graph into a closed surface and a regular map or a regular embeddings of a graph is a highly symmetric map like five Platonic solids. A map is not merely a topological object. It is also a sequence of permutations, which provides a relation to group theory, and a ramified covering of the Riemann sphere, which gives a relation to Riemann surface. Furthermore, it can be realized by a complex algebraic curve called Belyi function.

In this talk, we deal with regular embeddings of a cartesian power of a graph. Recently, we realized that a regular embedding of a catesian power of G^d of a graph G is related to regular embeddings of G and Q_d. As a bi-product, we classify regular embeddings of Hamming graphs $H(d, n)$ and C_n^d with odd n. In this talk, we briefly introduce recent results related to regular embeddings of a cartesian power of a graph.

Blobs, blocks and other cyclic elements

Jacobus H. Koolen

(joint work with A. Dress, K. T. Huber, V. Moulton and A. Spillner)

POSTECH

Recently, there has been a great deal of interest in decomposing phylogenetic networks (into blobs) and optimal realisations of metrics (into blocks). Intriguingly, these decompositions are all closely related to a canonical way to decompose tight-spans which, in turn, provides an example of a general way to decompose topological spaces (into cyclic elements) that was introduced by G. T. Whyburn in the 1920's. In this talk, we shall explore these interrelationships and present some new results that lead to, for example, a new algorithm for computing the blocks of an optimal realisation.

A characterization of Taylor graphs

Jongyook Park (박종욱)
(joint work with Jacobus H. Koolen)
POSTECH

Distance-regular graphs were introduced by Biggs in the late 1960's, as a combinatorial generalization of distance-transitive graphs. In 1973, Delsarte introduced metric association schemes for the study of codes and later it was discovered that these two notions are equivalent.

In this talk we study distance-regular graphs of diameter at least three. We will give some characterizations for the Taylor graphs among distance-regular graph with diameter at least three.

This is work in progress.

Fiver Games on Toruses

Boram Park (박보람)
Seoul National University

We locate $\alpha_1\alpha_2$ n-dice in an α_1 by α_2 rectangular array, and glue the lower and upper together and also the left and right edges. Then we have $\alpha_1\alpha_2$ n-dice on a torus. We denote by $\mathcal{D}((\alpha_1, \alpha_2), n)$ the set of toruses on each of which $\alpha_1\alpha_2$ n-dice are located described as above. We roll all of the n-dice located in a β_1 by β_2 subarray of a torus in $\mathcal{D}((\alpha_1, \alpha_2), n)$ so that we increase the number on each top face of them by 1. We call this action a "(β, β_2)-rolling procedure". Then we may ask "Given a torus in $\mathcal{D}((\alpha_1, \alpha_2), n)$, is it possible to have 0 appear on the top face of each of $\alpha_1\alpha_2$ n-dice on the torus by repeatedly applying (β_1, β_2)-rolling procedures?" In this paper, we characterize the toruses in $\mathcal{D}((\alpha_1, \alpha_2), n)$ for which the answer is yes. We also study Fiver games on circles.

On calculations of the number of lonesum matrices

Joon Yop Lee (이준엽)
POSTECH

A binary matrix is called lonesum if it can be uniquely reconstructed from its row and column sums. For example

$$\begin{array}{c} \begin{pmatrix} * & * & * \\ * & * & * \\ * & * & * \end{pmatrix} \begin{matrix} 2 \\ 1 \\ 3 \end{matrix} \\ \begin{matrix} 3 & 2 & 1 \end{matrix} \end{array} \rightarrow \begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix}.$$

For ternary matrices we can define similar things. In this talk, we will calculate the number of $n \times k$ binary and ternary lonesum matrices.

Invited Talk (초청강연) 3: Aug 20, 5:30PM–6:30PM

Some open problems on critical graphs

Tommy Jensen

Kyungpook National University

A graph G is called critical (respectively vertex-critical) if every proper subgraph (respectively induced subgraph) is vertex colorable with fewer colors than G itself. We survey the progress on some classical problems on critical graphs, posed by Gabriel Dirac, Paul Erdos, among others.

Invited Talk (초청강연) 4: Aug 21, 9:00AM–10:00AM

Complete description of early giant components in random graph $G(n, p)$

Jeong-Han Kim (김정한)

NIMS

In this talk, we will completely describe the structures of giant components in random graphs $G(n, p)$ with $n^{-1/3} \ll pn-1 \ll n^{-1/4}$. The description can be made using random 3-regular graphs and Galton–Watson Poisson branching processes. The proof, which uses the Poisson cloning model and interesting computation arguments, will be sketched too.

Contributed Talks (일반강연) 2: Aug 21, 10:25AM–12:30PM

Transitive-Closure Spanner of Directed Graphs

Kyomin Jung (정교민)

(joint work with Arnab Bhattacharyya, Elena Grigorescu, Sofya Raskhodnikova and David Woodruff)

KAIST

Given a directed graph $G = (V, E)$ and an integer $k \geq 1$, a k-transitive-closure-spanner (k-TC-spanner) of G is a directed graph $H = (V, E_H)$ that has (1) the same transitive-closure as G and (2) diameter at most k. These spanners were studied implicitly in access control, property testing, and data structures, and properties of these spanners have been rediscovered over the span of 20 years. We bring these areas under the unifying framework of TC-spanners.

In this talk, I will present our work on the approximability of the size of the sparsest k-TC-spanner for a given digraph. First, I'll present two efficient deterministic algorithms that find k-TC-spanners of size approximating the optimum. The first algorithm gives an $\tilde{O}(n^{1-1/k})$-approximation for k>2, and the second algorithm gives an $\tilde{O}(n/k^2)$-approximation.

Then I'll present the inapproximability of sparsest k-TC-spanners. For k=2, we show that it is $\Theta(\log n)$ unless $P = NP$. For constant $k > 2$, we prove that it is hard to approximate within $2^{\log^{1-\epsilon} n}$, for any $\epsilon > 0$, unless $NP \subseteq DTIME(n^{\text{polylog}\, n})$. Our proof uses an involved application of generalized butterfly and broom graphs, as well as noise-resilient transformations of hard problems, which may be of independent interest.

This work appeared in SODA 2009.

Geometric Distance-Regular Graphs with Smallest Eigenvalue -3

Sejeong Bang (방세정)
Pusan National University

A geometric distance-regular graph is the point graph of a linear space in which the set of lines are a set of Delsarte cliques. Geometric strongly regular graphs were introduced by R.C.Bose ([1]), and C.Godsil ([2]) generalized it to distance-regular graphs.

Definition: ([2]) A distance-regular graph Γ with valency $k \geq 3$, diameter $D \geq 2$ and smallest eigenvalue θ_D is called *geometric* if there exists a set of cliques $\mathcal{C}$ satisfying the following:
(i) Each edge lies in exactly one clique in $\mathcal{C}$;
(ii) Each clique in $\mathcal{C}$ has size $1 - \frac{k}{\theta_D}$.

Examples of geometric distance-regular graphs are the Hamming graphs (and more general the regular $2D$-gons), the Johnson graphs, the Grassmann graphs and the bilinear forms graphs.

In this talk, we classify geometric distance-regular graphs with smallest eigenvalue -3 and intersection number $c_2 \geq 2$.

References

[1] R. C. Bose, Strongly regular graphs, partial geometries and partially balanced designs, *Pacific J. Math.* **13** 389-419, 1963.

[2] C. D. Godsil, Geometric distance-regular covers, *New Zealand J. Math.* **22** 31–38, 1993.

Graphs with many ± 1 or $\pm\sqrt{2}$ eigenvalues

Ebrahim Ghorbani

Sharif University of Technology, Tehran & POSTECH

A pseudo (v, k, λ)-design is a pair $(X, \mathcal{B})$ where X is a v-set and $\mathcal{B} = \{B_1, \ldots, B_{v-1}\}$ is a collection of k-subsets (blocks) of X such that each two distinct B_i, B_j intersect in λ elements; and $0 < \lambda < k < v - 1$. We use the notion of pseudo designs to characterize graphs of order n whose spectrum contains either ± 1 or $\pm\sqrt{2}$ with multiplicity $(n-2)/2$ or $(n-3)/2$. It turns out that the subdivision of the star $K_{1,k}$ is determined by its spectrum if $k \notin \{\ell^2 - 1 \mid \ell \in \mathbb{N}\} \cup \{\ell^2 - \ell \mid \ell \in \mathbb{N}\}$. Meanwhile, partial results confirming a conjecture of O. Marrero on characterization of pseudo (v, k, λ)-designs are obtained.

On spherical dual width

Sho Suda

POSTECH

Brouwer, Godsil, Koolen and Martin defined and studied width and dual width of the subset in polynomial association schemes. In the view of Q-polynomial association schemes, dual width is a important parameter and they give a sufficient condition that the subset having good property, which is called dual narrow, is to be a Q-polynomial subscheme of an original association scheme. In this talk, we consider an analogue of dual width on sphere and give a sufficient condition that the spherical code having good property is to be a Q-polynomial association scheme.

The Rank of Skew-Symmetric Random Matrices Over Finite Fields

Joonkyung Lee (이준경)

(joint work with Sang-il Oum)

KAIST

Let a_n be the probability an $2n \times 2n$ random skew-symmetric matrix over the finite field $GF(q)$ is nonsingular, in which each entry is chosen uniformly at random from $GF(q)$. Carlitz (1954) proved that a_n converges to $(1-q^{-1})(1-q^{-3})(1-q^{-5})\cdots$ as n goes to infinity. This theorem has several consequences; for instance, a random graph with an even number of vertices would have an odd number of perfect matchings with the probability converging to about 42%. We present two additional proofs for the above theorem. One proof is based on combinatorial arguments, and the other proof is based on Markov chains and its stationary distributions. Our new method provides further nontrivial generalizations.

Invited Talk (초청강연) 5: Aug 21, 1:30PM–2:30PM

Counting derangements with ascents and descents in given positions

Seunghyun Seo (서승현)
(joint work with Dongsu Kim)
Kangwon National University

A derangement is a permutation without any fixed points. There are several generalizations of derangements in the literature. Eriksen, Freij and Wästlund recently have studied derangements with descents in given positions and ask what can be said for derangements with ascents, instead of descents, in given positions. This presentation deals with derangements which have ascents in predetermined positions. Moreover, we can prescribe the positions of ascents and descents.

Contributed Talks (일반강연) 3: Aug 21, 2:55PM–5:00PM

Symmetry and super-symmetry distribution for partitions

Heesung Shin (신희성)
(joint work with Jiang Zeng)
Université Lyon 1

Given a partition λ and a cell v in its Ferrers diagram, we define the arm, leg, coarm, coleg, hook and rim hook of v in λ. It is known that the two statistics "hook length" and "part length" are equidistributied and symmetric over all partitions of n. We construct an involution φ exchanging "hook length" and "part length" of all partitions of n, which yields two statistics are symmetric for all partitions of n. For nonnegative integers α, α', β and β' satisfying $\alpha+\alpha' = \beta+\beta'$, this involution φ makes a new bijection changing arm length α to α' and leg length β to β' over all partitions of n. It follows bijectively that arm length and leg length are super-symmetric.

Finite type invariants and n-equivalence of graphs

Myeong-Ju Jeong (정명주)
Korea Science Academy

Gussarov introduced n-equivalence of knots and showed that any pair of n-equivalent knots have the same value for all finite type invariants of degree less than n. Since we may get many finite type invariants from quantum invariants of knots, quantum invariants are used to verify whether two given knots are n-equivalent or not. We extend the n-equivalence to graphs and give necessary conditions for two graphs are n-equivalent or not by using finite type invariants of graphs.

m-pseudo involutions

Hana Kim (김하나)

Sungkyunkwan University

Let $\Omega_m = \text{diag}(1, \omega, \omega^2, \ldots)$ where $\omega = \cos\frac{(2k+1)\pi}{m} + i\sin\frac{(2k+1)\pi}{m}$ $(k = 0, 1, \ldots, m-1)$ is a root of $z^m = -1$. If $A^{-1} = \Omega_m A \Omega_m^{-1}$ for an invertible complex matrix A then we call A the m-pseudo involution. In this paper, we characterize all m-pseudo involutions in the Riordan group and m-pseudo involutions related to the commutators are explored.

Bi-resolving graph homomorphisms and application to symbolic dynamics

Uijin Jung (정의진)

(joint work with In-je Lee)

KAIST

The theory of resolving graph homomorphisms intertwines graph theory and symbolic dynamics. We show that given two graphs G and H, there is a bi-resolving (resp. bi-covering) graph homomorphism from G to H if and only if there is a subamalgamation matrix S such that $\mathsf{A}_G S \leq S\mathsf{A}_H$ and $S^\mathsf{T}\mathsf{A}_G \leq \mathsf{A}_H S^\mathsf{T}$ (resp. $\mathsf{A}_G S = S\mathsf{A}_H$ and $S^\mathsf{T}\mathsf{A}_G = \mathsf{A}_H S^\mathsf{T}$), where A_G and A_H are the adjacency matrices of G and H, respectively. We investigate the bi-covering extensions of bi-resolving homomorphisms and give several sufficient conditions for a bi-resolving homomorphism to have a bi-covering extension with an irreducible domain. Using these results, we present the extension property in symbolic dynamics.

Regular matrices and their preservers over semirings

Seok-Zun Song (송석준)

Jeju National University

Let S be a semiring. An $m \times n$ matrix A over a semiring S is called *regular* if there is an $n \times m$ matrix G over S such that $AGA = A$. We study the problem of characterizing those linear operators T on the matrices over a semiring such that $T(X)$ is regular if and only if X is. Complete characterizations are obtained for many semirings including: the nonnegative reals, the nonnegative integers and the fuzzy scalars.

Invited Talk (초청강연) 6: Aug 21, 5:30PM–6:30PM

Reflexive graphs admitting semilattice polymorphisms — a characterisation generalising chordal graphs

Mark Siggers

(joint work with Pavol Hell)

Kyungpook National University

Recent advances tell us that weak near unanimity (WNU) polymorphisms have an important relationship to the CSP Dichotomoy Conjecture. In the test case of reflexive graphs, we look the particular WNU polymorphisms known as semi-lattice (SL) polymorphisms- these have the convenient property that they can easily be represented graphically. We look at a hierarchy of restrictions on SL polymophisms that arises naturally as a byproduct of their graphical representation. When we consider the classes of graphs that admit these restricted SL polymorphisms, we find that they coincide with such well known graph classes as 'interval' and 'chordal'.

Registered participants

Students are denoted by $^{\varepsilon}$.

(1) Firouzeh Ashraf$^{\varepsilon}$
University of Isfahan, Iran
firouzeh_ashraf@yahoo.com

(2) Ralph Bottesch$^{\varepsilon}$
KAIST
ralph.bottesch@gmail.com

(3) Dan Drake
KAIST
drake@kaist.edu

(4) Ebrahim Ghorbani$^{\varepsilon}$
Sharif University of Technology, Tehran / POSTECH
ghorbani1002@yahoo.com

(5) Andreas Holmsen
KAIST
andreash@jupiter.kaist.ac.kr

(6) Tommy Jensen
Kyungpook National University
tjensen@knu.ac.kr

(7) Jacobus H. Koolen
POSTECH
koolen@postech.ac.kr

(8) Reza Sharafdini$^{\varepsilon}$
Pusan National university
sharafdini@pusan.ac.kr

(9) Mark Siggers
Kyungpook National University
mhsiggers@gmail.com

(10) Sho Suda$^{\varepsilon}$
Tohoku University / POSTECH
suda@ims.is.tohoku.ac.jp

(11) Soon-Yi Kang (강순이)
KAIST
sy2kang@kaist.ac.kr

(12) Youngmee Koh (고영미)
University of Suwon
ymkoh@suwon.ac.kr

(13) Young Soo Kwon (권영수)
Yeungnam University
ysookwon@ynu.ac.kr

(14) Kang Lin Kim (김강린)$^{\varepsilon}$
NIMS
kichi1@hanmail.net

(15) Dongsu Kim (김동수)
KAIST
dongsu.kim@kaist.edu

(16) Bo Young Kim (김보영)$^{\varepsilon}$
NIMS
boyoungkim1218@gmail.com

(17) Sang-Sub Kim (김상섭)$^{\varepsilon}$
POSTECH
helmet1981@postech.ac.kr

(18) Sang Yun Kim (김상윤)$^{\varepsilon}$
KAIST
lordsteve@kaist.ac.kr

(19) Suh-Ryung Kim (김서령)
Seoul National University
srkim@snu.ac.kr

(20) Seog-Jin Kim (김석진)
Konkuk University
skim12@konkuk.ac.kr

(21) Sun Ah Kim (김선아)[ε]
Seoul National University
sunnyeesl@lycos.co.kr

(22) Youngdo Kim (김영도)[ε]
KAIST
kyd1225@kaist.ac.kr

(23) Daniel Kim (김영호)[ε]
KAIST
classical_day@Hotmail.com

(24) Yonggu Kim (김용구)
Chonnam National University
kimm@chonnam.ac.kr

(25) Jeong-Han Kim (김정한)
NIMS
jehkim@nims.re.kr

(26) Juin Kim (김주인)[ε]
KAIST
juinkim75@gmail.com

(27) Hana Kim (김하나)[ε]
Sungkyunkwan University
hakkai14@skku.edu

(28) Sook Min (민숙)
Yonsei University
sookmin@yonsei.ac.kr

(29) Kyoung Suk Park (박경숙)[ε]
Ajou University
bluemk00@ajou.ac.kr

(30) Boram Park (박보람)[ε]
Seoul National University
kawa22@snu.ac.kr

(31) Wonjin Park (박원진)[ε]
Seoul National University
wjpark11@gmail.com

(32) Jeonghyeon Park (박정현)[ε]
KAIST
parkjh@jupiter.kaist.ac.kr

(33) Jongyook Park (박종육)[ε]
POSTECH
jongyook@postech.ac.kr

(34) Juho Park (박주호)[ε]
KAIST
jhp@kaist.ac.kr

(35) Choonkil Park (박춘길)
Hanyang University
baak@hanyang.ac.kr

(36) Sejeong Bang (방세정)
Pusan National University
sjbang3@pusan.ac.kr

(37) Yongjoo Baek (백용주)[ε]
KAIST
yongjoobaek@gmail.com

(38) Yoshio Sano (사노 요시오)[ε]
Kyoto University
sano@kurims.kyoto-u.ac.jp

(39) Soo-jeong Seo (서수정)[ε]
Chonnam National University
80crystal@daum.net

(40) Seunghyun Seo (서승현)
Kangwon National University
shyunseo@kangwon.ac.kr

(41) Seung-Woo Son (손승우)
KAIST
sonswoo@kaist.ac.kr

(42) Wanbin Son (손완빈)[ε]
POSTECH
mnbiny@postech.ac.kr

(43) Seok-Zun Song (송석준)
Jeju National University
szsong@cheju.ac.kr

(44) Heesung Shin (신희성)
Université Lyon 1
ensual@gmail.com

(45) Sang-il Oum (엄상일)
KAIST
sangil@kaist.edu

(46) Seonghun Yeom (염성훈)[ε]
Chonnam National University
chopin0@hammail.net

(47) Hyonju Yu (유현주)[ε]
POSTECH
lojs4110@postech.ac.kr

(48) Taedong Yun (윤태동)[ε]
Massachusetts Institute of Technology
tedyun@math.mit.edu

(49) Moon Sung Lee (이문성)
NIMS
mslee@nims.re.kr

(50) Sangwook Ree (이상욱)
University of Suwon
swree@suwon.ac.kr

(51) Sanghyeon Lee (이상현)[ε]
Seoul National University
tlrehrdl@empal.com

(52) Sang Hoon Lee (이상훈)[ε]
KAIST
lshlj82@gmail.com

(53) Woosun Lee (이우순)[ε]
POSTECH
lws82@postech.ac.kr

(54) Yuni Lee (이윤이)[ε]
KAIST
yunilee@kaist.ac.kr

(55) Jaeun Lee (이재운)
Yeungnam University
julee@yu.ac.kr

(56) Joonkyung Lee (이준경)[ε]
KAIST
jk87@kaist.ac.kr

(57) Junse Lee (이준세)[ε]
KAIST
junselee@kaist.ac.kr

(58) Joon Yop Lee (이준엽)[ε]
POSTECH
flutelee@postech.ac.kr

(59) Yongsub Lim (임용섭)$^{\varepsilon}$
KAIST
86ddiyong@gmail.com

(60) Heyjin Jang (장혜진)$^{\varepsilon}$
POSTECH
laluz@postech.ac.kr

(61) Gyeong A Jeong (정경아)$^{\varepsilon}$
Yonsei University
provethat@yonsei.ac.kr

(62) Kyomin Jung (정교민)
KAIST
kyomin@kaist.edu

(63) Myeong-Ju Jeong (정명주)
Korea Science Academy
determiner@hanmail.net

(64) Uijin Jung (정의진)
KAIST
uijin@kaist.ac.kr

(65) Jisu Jeong (정지수)$^{\varepsilon}$
KAIST
math0329@hanmail.net

(66) Ji-Hwan Jung (정지환)$^{\varepsilon}$
Sungkyunkwan University
jh56k@skku.edu

(67) Taeyoung Chung (정태영)$^{\varepsilon}$
POSTECH
tae7837@postech.ac.kr

(68) Soojin Cho (조수진)
Ajou University
chosj@ajou.ac.kr

(69) Juhyun Cho (조주현)$^{\varepsilon}$
KAIST
majuri@kaist.ac.kr

(70) Hee Je Cho (조희제)$^{\varepsilon}$
Konkuk University
heejecho@konkuk.ac.kr

(71) Hyeong-Kwan Ju (주형관)
Chonnam National University
chonnam@gmail.com

(72) Gi-Sang Cheon (천기상)
Sungkyunkwan University
gscheon@skku.edu

(73) Yutae Choi (최유태)$^{\varepsilon}$
POSTECH
epssilon@postech.ac.kr

(74) Jeong-Ok Choi (최정옥)
Trinity College
Jeong.Choi@trincoll.edu

(75) Meesoon Ha (하미순)
KAIST
msha@kaist.ac.kr

(76) Sang-Eon Han (한상언)
Chonbuk National University
sehan@chonbuk.ac.kr

(77) Ji-Sun Huh (허지선)$^{\varepsilon}$
Yonsei University
hyunyjia@yonsei.ac.kr

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KAIST campus map

E6-1: Dept. of Mathematical Sciences.
Workshop: Room E6-1.

E5: Dining Hall (Breakfast/Lunch/Dinner), 2nd floor.

E9: Main Library, Coffee Shop, Internet Cafe, Bookstore

W5: International Village (Guest house for some participants)

W2: DDDN Pizza, KAIST shop, Woori Bank, Travel Agency (Train tickets), Dining Hall

N12: Burger King, Snack bars (KAIST 편의점), Post Office

Taxi: 042-524-9333(찬양콜택시) 042-672–5858 (KTX콜택시)

ASARC Office: 042-350-8111

Department Office: 042-350-2702∼4

Bus from Daedeok Innopolis Guest House (대덕특구게스트하우스) to KAIST: Bus No. 121 (대덕대학행) (3km)