The 35th KIAS Combinatorics Workshop

Shilla Stay Haeundae
Busan, Korea
December 22–24, 2025

Contents

1 General Information

Title The 35th KIAS Combinatorics Workshop

Date December 22–24, 2025

Venue Ballroom (3F), Shilla Stay Haeundae, Busan, Korea

Homepage `http://events.kias.re.kr/h/combinatorics/`

Invited Speakers

Jungho Ahn (Inha University)

Minho Cho (KIAS)

Hojin Chu (KIAS)

Donggyu Kim (Georgia Tech)

Donghyun Kim (Seoul National University)

Minseo Kim (KAIST)

Jack Koolen (University of Science and Technology of China)

Boram Park (Seoul National University)

Zixiang Xu (IBS ECOPRO)

Organizers

Jaehoon Kim (KAIST)

Jang Soo Kim (Sungkyunkwan University)

Jeong Han Kim (KIAS)

Seog-Jin Kim (Konkuk University)

Sang June Lee (Kyung Hee University)

Jongyook Park (Kyungpook National University)

Seunghyun Seo (Kangwon National University)

2 Schedule and Abstracts

1st Day: December 22 (Monday)

14:30–15:00 Registration and Opening

——— **Session A** ——— Chair: Jongyook Park

15:00–15:40 **Jack Koolen**. *An improved bound for strongly regular graphs*

15:40–16:00 Coffee break

16:00–16:40 **Donggyu Kim**. *Representation theory for polymatroids*

16:50–17:30 **Hojin Chu**. *Connectivity-keeping subgraph deletion problem*

18:00–20:00 Dinner

2nd Day: December 23 (Tuesday)

——— **Session B** ——— Chair: Seog-Jin Kim

09:20–10:00 **Donghyun Kim**. *Symmetric function theory in* (m, n)*-worlds*

10:00–10:20 Coffee break / Group photo

10:20–11:00 **Boram Park**. *On* 2*-limited broadcast domination problem*

11:10–11:50 **Minseo Kim**. *On universal graphs for trees and tree-like graphs*

12:00–14:00 Lunch

14:00–17:30 Free discussion

18:00–20:00 Banquet

3rd Day: December 24 (Wednesday)

——— **Session C** ——— Chair: Young Soo Kwon

09:20–10:00 **Zixiang Xu**. *Uniform set systems with small VC-dimension*

10:00–10:30 Coffee break

10:30–11:10 **Minho Cho**. *Colorful circuits and colorful topes in oriented matroids*

11:20–12:00 **Jungho Ahn**. *A coarse Erdős-Pósa theorem*

12:00–13:00 Closing / Lunch

Speaker: Jack Koolen

Affiliation: University of Science and Technology of China

Title: An improved bound for strongly regular graphs

Abstract

Sims showed that there are for primitive strongly regular graphs with fixed smallest eigenvalue $-m$ except for a finite number of them they belong two families of graphs. Later in 1979 Neumaier made this bound explicit. In this talk we will improve this bound by Neumaier. This is based on joint work with Chenhui Lv, Greg Markowsky and Jongyook Park.

Speaker: Donggyu Kim

Affiliation: Georgia Tech

Title: Representation theory for polymatroids

Abstract

We develop a theory of representation of (discrete) polymatroids over tracts in terms of Plücker coordinates and suitable Plücker relations. As special cases, we recover polymatroids themselves as polymatroid representations over the Krasner hyperfield $\mathbb{K}$ and M-convex functions as polymatroid representations over the tropical hyperfield $\mathbb{T}_0$.

The space of all representations of a polymatroid J, which we call the *thin Schubert cell* of J, is represented by an algebraic object called the *universal tract* of J. When we restrict to just the 3-term Plücker relations, we obtain the *weak thin Schubert cell*, and passing to torus orbits yields the *realization space*. These are represented by the *universal pasture* and the *foundation* of J, respectively. We exhibit a canonical bijection between the universal tract and the universal pasture and prove that the thin Schubert cell and the weak thin Schubert cell coincide if the given tract is "perfect". We also show that the foundation of a polymatroid is generated by "cross ratios" and describe a complete list of multiplicative relations between cross ratios. This is joint work with Matt Baker, June Huh, Mario Kummer, and Oliver Lorscheid.

Speaker: Hojin Chu

Affiliation: KIAS

Title: Connectivity-keeping subgraph deletion problem

Abstract

The connectivity-keeping problem concerns the minimum degree conditions under which a k-connected graph remains k-connected after the deletion of a specified subgraph. Since the foundational result of Chartrand, Kaugars, and Lick in 1972, a substantial body of work has investigated when vertices, edges, paths, or more general structures can be removed without compromising connectivity. In particular, a conjecture proposed by Mader in 2012 significantly broadened the scope of this problem and continues to inspire ongoing research. In this talk, we present an overview of this problem and present some recent results we have obtained. This is a joint work with Boram Park and Homoon Ryu.

Speaker: Donghyun Kim

Affiliation: Seoul National University

Title: Symmetric function theory in (m, n)-worlds

Abstract

We introduce a combinatorial framework for studying expressions of the form $f[-MX^{m,n}]$, where f is a symmetric function. Motivated by Wilson's conjecture, which suggests a symmetric function lift of torus link homology, we discuss an (m, n)-generalization of P-tableaux and the associated combinatorics. This talk is based on ongoing joint work with Jaeseong Oh.

Speaker: Boram Park

Affiliation: Seoul National University

Title: On 2-limited broadcast domination problem

Abstract

For a graph G, a function $f : V(G) \to \{0, 1, 2\}$ is called a 2-limited dominating broadcast on G if for every vertex u, there exists a vertex v such that $f(v) > 0$ and the distance between u and v in G is at most $f(v)$. The *cost* of f means the value $\sum_{v \in V(G)} f(v)$, and the 2-*limited broadcast domination number* $\gamma_{b,2}(G)$ of G is the cost of a 2-limited dominating broadcast on G with minimum cost. Henning, MacGillivray and Yang (2020) conjectured that $\gamma_{b,2}(G) \leq \frac{|V(G)|}{3}$ for every cubic graph G and then confirmed it for a cubic graph G having neither C_4 nor C_6 as an induced subgraph. We prove that the conjecture holds. This is based on joint work with Myungho Choi.

Speaker: Minseo Kim

Affiliation: KAIST

Title: On universal graphs for trees and tree-Like graphs

Abstract

Chung and Graham [*J. London Math. Soc.* 1983] claimed to prove that there exists an n-vertex graph G with $\frac{5}{2}n\log_2 n + O(n)$ edges that contains every n-vertex tree as a subgraph. Frati, Hoffmann and Tóth [*Combin. Probab. Comput.* 2023] discovered an error in the proof. By adding more edges to G the error can be corrected, bringing the number of edges in G to $\frac{7}{2}n\log_2 n + O(n)$.

We make the first improvement to Chung and Graham's bound in over four decades by showing that there exists an n-vertex graph with $\frac{14}{5}n\log_2 n + O(n)$ edges that contains every n-vertex tree as a subgraph.

Furthermore, we generalise this bound for treewidth-k graphs by showing that there exists a graph with $O(kn\log n)$ edges that contains every n-vertex treewidth-k graph as a subgraph. This is best possible in the sense that $\Omega(kn\log n)$ edges are required. This is based on joint work with Neel Kaul, Jaehoon Kim, and David Wood.

Speaker: Zixiang Xu

Affiliation: IBS ECOPRO

Title: Uniform set systems with small VC-dimension

Abstract

The Vapnik–Chervonenkis (VC) dimension is a central concept in statistical learning theory that has also played a growing role in extremal combinatorics. A classical result in this area, the Sauer–Shelah Lemma, precisely determines the maximum size of non-uniform set systems with bounded VC-dimension. In contrast, the uniform setting, where each set has the same size, remains far less understood, and determining tight bounds in this case is a longstanding open problem. In this talk, I will discuss recent progress on this question, including improved upper bounds and structural insights. The results are based on joint work with Ting-Wei Chao, Gennian Ge, Jian Wang, Chi Hoi Yip, Shengtong Zhang, and Xiaochen Zhao.

Speaker: Minho Cho

Affiliation: KIAS

Title: Colorful circuits and colorful topes in oriented matroids

Abstract

We list some rainbow problems on oriented matroids and other related objects, such as words with bounded alternation numbers or point configurations. As a partial result, we obtain a "rainbow tope" result which implies a rainbow problem on words. The key lemma is a common generalization of Sperner's theorem and Meshulam's lemma, each of which guarantees the existence of rainbow simplexes in vertex-colored simplicial complexes under different assumptions. We follow the same approach to analyze structures of rainbow (co)circuits of oriented matroids. Using a similar proof technique, we provide an oriented matroid version of Bárány's colorful conic Carathéodory theorem. This is joint work with Frédéric Meunier and Seunghun Lee.

Speaker: Jungho Ahn

Affiliation: Inha University

Title: A coarse Erdős-Pósa theorem

Abstract

An induced packing of cycles in a graph G is a set of vertex-disjoint cycles such that G has no edge between distinct cycles of the set. The classic Erdős-Pósa theorem asserts that for every positive integer k, every graph contains k vertex-disjoint cycles or a set of $O(k \cdot \log k)$ vertices intersecting every cycle of G. We generalise the classic Erdős-Pósa theorem to the induced packings of cycles of length at least ℓ for any integer ℓ. We show that there exists a function $f(k, \ell) = O(\ell \cdot k \cdot \log k)$ such that for all positive integers k and $\ell \geq 3$, every graph G contains an induced packing of k cycles of length at least ℓ or a set X of at most $f(k, \ell)$ vertices such that the closed neighbourhood of X intersects every cycle of length at least ℓ in G. We also extend the theorem to cycles containing prescribed vertices. For a graph G and a subset S of $V(G)$, an S-cycle in G is a cycle containing a vertex in S. We show that for every positive integer k, every graph G, and every subset S of $V(G)$, G contains an induced packing of k S-cycles or a set X of at most $O(k^5)$ vertices such that the closed neighbourhood of X intersects every S-cycle in G. Our proofs are constructive and yield polynomial-time algorithms finding either the induced packing or the set X in both cases. This is based on joint works with Pascal Gollin, Tony Huynh, and O-joung Kwon.

3 List of Participants

1. Ahn, Jungho (Inha University)
2. Baek, Ingyu (Yonsei University)
3. Chae, Jihyo (Yonsei University)
4. Chang, Yeonsu (Hanyang University)
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7. Choi, Mujin (KAIST & IBS DIMAG)
8. Chu, Hojin (KIAS)
9. Eom, Taehyun (GIST)
10. GENG, ZIHAO (East China University of Science and Technology)
11. Heo, Cheolwon (SUNY Korea)
12. Hng, Eng Keat (IBS ECOPRO)
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22. Kim, Jeewon (KAIST)
23. Kim, Jeong Han (KIAS)
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25. Kim, Sangwook (Chonnam National University)
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54. Seo, Jaehyeon (Yonsei University)
55. Seo, Seunghyun (Kangwon National University)

56. Shin, Heesung (Inha University)
57. Sohn, Jaebum (Yonsei University)
58. Wang, Juwon (Sungkyunkwan University)
59. Wang, Yaling (Shanxi Normal University)
60. Xu, Zixiang (IBS ECOPRO)
61. Yoon, Mary (Korea University)
62. Zhang, Yanting (Northwestern Polytechnical University)