The 13th Japan-Korea Workshop on Algebra and Combinatorics

Local organizers:
Hirotake Kurihara (Kitakyushu National College of Technology)
Akihiro Munemasa (Tohoku University)
Makoto Tagami (Kyushu Institute of Technology)

Date: January 29(Thu) – 31(Sat)
Venue: Tobata Campus, Kyushu Institute of Technology
    January 29 and 31, Multipurpose Hall in Nakamura Centenary Memorial Hall.
    January 30, Lecture Room 4-1B in Education & Research 4.

Program

January 29th (Thu) at Multipurpose Hall in Nakamura Centenary Memorial Hall

Opening Speech Makoto Tagami

10:00 – 10:45 Sejeong Bang (Yeungnam University)
Distance-regular graphs without 4-claws

11:00 – 11:45 Jae-Ho Lee (Tohoku University)
Nonsymmetric Askey-Wilson polynomials and Q-polynomial distance-regular graphs

13:30 – 14:15 Gary Greaves (Tohoku University)
Eigenvalues of symmetric matrices and tridiagonal matrices

14:30 – 15:15 Hiroshi Nozaki (Aichi University of Education)
Large regular graphs for given second-largest eigenvalue

15:45 – 16:30 Ilkyoo Choi (KAIST)
Improper coloring of planar graphs

16:45 – 17:30 Takao Komatsu (Wuhan University)
On computation of arbitrary integer powers for certain type of band matrices with Fibonacci numbers

January 30th (Fri) at Lecture Room 4-1B in Education & Research 4

10:00 – 10:45 Sho Suda (Aichi University of Education)
Mutually unbiased Bush-type Hadamard matrices and association schemes

11:00 – 11:45 Hyonju Yu (Pohang University of Science and Technology)
Isomorphism classes of association schemes induced by Hadamard matrices
13:30 – 14:15  Tao Feng (Zhejiang University)  
Some algebraic aspects of designs, codes and finite geometry

14:30 – 15:15  Takayuki Okuda (Hiroshima University)  
A new relative upper bound for equiangular lines and nonexistence of tight spherical designs of harmonic index 4

15:45 – 16:30  Masanori Sawa (Kobe University)  
On a system of Diophantine equations and quadrature on the real line

16:45 – 17:30  Keisuke Shiromoto (Kumamoto University)  
On the critical exponent of a linear code and a matroid

18:30 –  Banquet

January 31st (Sat) at Multipurpose Hall in Nakamura Centenary Memorial Hall

9:30 – 10:15  Younjin Kim (KAIST)  
On extremal combinatorial problems of Noga Alon

10:30 – 11:15  Hirotaka Ono (Kyushu University)  
Degree-constrained graph orientation: maximum satisfaction and minimum violation

11:30 – 12:15  Seung Jin Lee (KIAS)  
Affine Schubert calculus and Pieri rule for the affine flag variety

Closing Speech  Hirotake Kurihara

Banquet:  
You are welcome to attend the banquet. The banquet costs about 5,000JPY per person. A Banquet will be held from 6:30 p.m. on January 30th at Yagumotei.
Sejeong Bang (Yeungnam University)
Title: Distance-regular graphs without 4-claws
Abstract: An $n$-claw is an induced subgraph on $n + 1$ vertices which consists of one vertex with valency $n$ and $n$ vertices with valency 1. A distance-regular graph without 2-claws is a complete graph. Blokhuis and Brouwer determined the distance-regular graphs without 3-claws in 1997. Except for distance-regular line graphs they found only the icosahedron. In this talk, we consider distance-regular graphs with 3-claws but without 4-claws. This is a joint work with Alexander Gavrilyuk and Jack Koolen.

Jae-Ho Lee (Tohoku University)
Title: Nonsymmetric Askey-Wilson polynomials and $Q$-polynomial distance-regular graphs.
Abstract: Nonsymmetric Askey-Wilson polynomials were defined by Sahi in 1999. Roughly speaking, they are the eigenfunctions of the Cherednik-Dunkl operator and form a linear basis of the space of the Laurent polynomials in one variable. In my thesis (2013), we found a relationship between $Q$-polynomial distance-regular graphs and a double affine Hecke algebra of rank one. In this talk, using this relationship we will define the nonsymmetric Askey-Wilson polynomials in a different way and discuss how these polynomials are related with Sahi’s nonsymmetric Askey-Wilson polynomials.

Gary Greaves (Tohoku University)
Title: Eigenvalues of symmetric matrices and tridiagonal matrices
Abstract: It is well-known that the set of adjacency-eigenvalues of graphs is precisely the set of totally-real algebraic integers. Recently it was shown that one needs only to focus on trees, that is, the set of adjacency-eigenvalues of trees is precisely the set of totally-real algebraic integers. In this talk we describe these classical results for symmetric matrices and we will address the same questions for tridiagonal matrices.

Hiroshi Nozaki (Aichi University of Education)
Title: Large regular graphs for given second-largest eigenvalue
Abstract: The spectral gap of a regular graph is the difference of the largest and second-largest eigenvalues. A regular graph with large spectral gap has good connectivity in some sense. Let $v(k, r)$ be the largest possible order of a $k$-regular graph whose second largest eigenvalue is at most $r$. In this talk, we determine $v(k, r)$ for several $k$ and $r$. This is the joint work with Sebastian Cioaba, Jack Koolen and Jason Vermette.

Ilkyoo Choi (KAIST)
Title: Improper coloring of planar graphs
Abstract: A graph is $(d_1, \ldots, d_r)$-colorable if its vertex set can be partitioned into $r$ sets $V_1, \ldots, V_r$ where the maximum degree of the graph induced by $V_i$ is at most $d_i$ for each $i \in \{1, \ldots, r\}$. For improper coloring of planar graphs with two parts, given $g$ and $d_1$, the question of determining the minimum $d_2 = d_2(g, d_1)$ such that planar graphs with girth $g$ are $(d_1, d_2)$-colorable has attracted much interest. The finiteness of $d_2(g, d_1)$ is known for all cases except when $(g, d_1) = (5, 1)$. Montassier and Ochem, as well as Rapaud, asked if $d_2(5, 1)$ is finite. We answer this question in the affirmative with $d_2(5, 1) \leq 10$; namely, we prove that all planar graphs with girth at least 5 are $(1, 10)$-colorable. Moreover, we prove that for any Euler genus $\gamma$, there exists a $K = K(\gamma)$ where graphs with girth 5 that are embeddable on a surface of Euler genus $\gamma$ are $(1, K)$-colorable. This is joint work with H. Choi, J. Jeong, and G. Suh.
Takao Komatsu (Wuhan University)
Title: On computation of arbitrary integer powers for certain type of band matrices with Fibonacci numbers
Abstract: We give certain family of $4k$-square ($k = 1, 2, \ldots$) band matrices whose band width is $2k + 1$, and the entries in their arbitrary powers for matrices are expressed by the generalized Fibonacci numbers $G_n$ only. Here, the numbers $G_n$ satisfy the recurrence relation $G_n = bG_{n-1} + cG_{n-2} \ (n \geq 2)$ with $G_0 = 0$ and $G_1 = 1$. If $b = c = 1$, then $G_n = F_n$ are Fibonacci numbers. (This is a joint work with Mitsugu Hirasaka)

Sho Suda (Aichi University of Education)
Title: Mutually unbiased Bush-type Hadamard matrices and association schemes
Abstract: The equivalence of mutually unbiased bases and some association schemes was proved by Martin et al. in 2008. The concept of mutually unbiased bases is equivalent to mutually unbiased Hadamard matrices. In this talk, Hadamard matrices are restricted to so called Bush-type and then we give an equivalence of mutually unbiased Bush-type Hadamard matrices and some association schemes of class 5. This is joint work with Hadi Kharaghani.

Hyonju Yu (Pohang University of Science and Technology)
Title: Isomorphism classes of association schemes induced by Hadamard matrices
Abstract: Every Hadamard matrix $H$ of order $n > 1$ induces a graph with $4n$ vertices, called the Hadamard graph $\Gamma(H)$ of $H$. Since $\Gamma(H)$ is a distance-regular graph with diameter 4, it induces a 4-class association scheme $(\Omega, S)$ of order $4n$. In this talk we deal with fission schemes of $(\Omega, S)$ under certain conditions, and for such a fission scheme we estimate the number of isomorphism classes with the same intersection numbers as the fission scheme.

Tao Feng (Zhejiang University)
Title: Some algebraic aspects of designs, codes and finite geometry
Abstract: In this talk, I will give an overview of recent results on the application of exponential sums and cyclotomy to some problems in design theory, coding theory and finite geometry. This includes the cyclotomic constructions of difference sets and strongly regular graphs with new parameters, the study of some conjectures on cyclic codes, and the construction of new Cameron-Libler line classes. My collaborators include Koji Momihara and Qing Xiang.

Takayuki Okuda (Hiroshima University)
Title: A new relative upper bound for equiangular lines and nonexistence of tight spherical designs of harmonic index 4
Abstract: This talk is based on joint work with Wei-Hsuan Yu (Michigan State University). We give a new upper bound of the cardinality of a set of equiangular lines in $\mathbb{R}^n$ with a fixed angle satisfying certain conditions. Our techniques are based on semi-definite programming methods for spherical codes introduced by Bachoc–Vallentin [J. Amer. Math. Soc. 2008]. The concept of tight spherical designs of harmonic index 4 were introduced by Bannai–Okuda–Tagami [to appear in J. Approx Theory]. As a corollary to our bound, we show the nonexistence of spherical tight designs of harmonic index 4 on $S^{n-1}$ with $n > 2$.

Masanori Sawa (Kobe University)
Title: On a system of Diophantine equations and quadrature on the real line
Abstract: We consider a certain system of Diophantine equations, designed as a generalization of a famous result by Hausdorff (1909) on the construction of rational Hilbert identities as well as a classical theorem by Schur (1929) on the rationality of the zeros of Hermite orthogonal polynomials.
Keisuke Shiromoto (Kumamoto University)
Title: On the critical exponent of a linear code and a matroid
Abstract: A linear code is a subspace of a vector space over a finite field. A matroid is a combinatorial structure based on the notation of lineally independence in a vector space. So a matroid can be viewed as a generalization of a linear code over a finite field. On the other hand, a matroid is also a generalization of graph theory. Indeed, a lot of results and terminology in matroid theory are derived from graph theory. In this talk, we discuss the relationship between linear codes and matroids. This talk consists of two part. We first give a short introduction of matroid theory and show some recent results based on coding theory. Next we present a problem in coding theory which is strongly related to the critical problem in matroid theory. The critical problem is originally the problem in a vector space of finding the largest dimension of a subspace having no intersection with a given set of vectors. We focus on bounds on a parameter for linear codes and constructions of a special class of linear codes related to the problem. No knowledge of matroids will be assumed in this talk.

Younjin Kim (KAIST)
Title: On extremal combinatorial problems of Noga Alon
Abstract: Extremal combinatorics is a field of combinatorics, which aims to determine or estimate the maximum or minimum possible cardinality of a collection of finite objects (numbers, graphs, vectors, sets, etc.) that satisfy certain requirements.

In 1991, Alon, Babai and Suzuki conjectured that if $n \geq s + \max_{1 \leq i \leq r} k_i$, then $|F| \leq \binom{n}{s} + \binom{n-1}{s-1} + \cdots + \binom{n-r+1}{s-r+1}$ when $F$ is a family of subsets of $[n]$ such that $|F_i| \pmod{p} \in K = \{k_1, k_2, \ldots, k_r\}$ for all $F_i \in F$ and $|F_i \cap F_j| \pmod{p} \in L = \{l_1, l_2, \ldots, l_s\}$ for $i \neq j$, where $K$ and $L$ are disjoint subsets of $\{0, 1, \ldots, p-1\}$ and $p$ is a prime. In this talk, we prove this conjecture by using the algebraic method.

A family $F$ is $t$-intersecting if any two members have at least $t$ common elements. In 1961, Erdős, Ko, and Rado proved that the maximum size of a $t$-intersecting family of subsets of size $k$ is equal to $\binom{n}{k-t}$ if $n \geq n_0(k, t)$. In 2014, Alon, Aydinian, and Huang considered families generalizing intersecting families, and proved the same bound. In this talk, we give a strengthening of their result by considering families generalizing $t$-intersecting families for all $t \geq 1$.

Hirotaka Ono (Kyushu University)
Title: Degree-constrained graph orientation: maximum satisfaction and minimum violation
Abstract: A degree-constrained graph orientation of an undirected graph $G$ is an assignment of a direction to each edge in $G$ such that the outdegree of every vertex in the resulting directed graph satisfies a specified lower and/or upper bound. Such graph orientations have been studied for a long time and various characterizations of their existence are known. In this talk, we consider four related optimization problems: For any fixed non-negative integer $W$, the problems MAX $W$-LIGHT, MIN $W$-LIGHT, MAX $W$-HEAVY, and MIN $W$-HEAVY take as input an undirected graph $G$ and ask for an orientation of $G$ that maximizes or minimizes the number of vertices with outdegree at most $W$ or at least $W$. The problems’ computational complexities vary with $W$. Here, we resolve several open questions related to their polynomial-time approximability and present a number of positive and negative results. This is a joint work with Yuichi Asahiro, Jesper Jansson, Eiji Miyano.
Seung Jin Lee (KIAS)
Title: Affine Schubert calculus and Pieri rule for the affine flag variety
Abstract: Affine Schubert calculus is an extension of Schubert calculus to affine Grassmannians and affine flag varieties. The new approach to affine Schubert calculus is made possible by the discovery of certain explicitly defined symmetric functions called $k$-Schur functions. The $k$-Schur functions, which arose in the study of the seemingly unrelated Macdonald theory, were shown to be connected to the geometry and topology of the affine Grassmannian. In this talk, we will define $k$-Schur functions and strong Schur functions as symmetric functions and as elements in affine Nilcoxeter algebra. After digesting their combinatorics, I will connect some of their combinatorial properties with algebraic/geometric properties of affine Grassmannians and affine flag varieties. It was shown by Kumar and Kostant that the structure coefficients of the cohomology of affine flag varieties is the same as the structure coefficients of the coproduct of Nilcoxeter algebra. We will briefly review this theory and make a connection between the theory and combinatorics. This will produce the Pieri rule for the affine flag variety.