International Workshop on Algebraic Combinatorics

PROGRAM

Anhui University, Hefei, China

November 21st-25th, 2018

Registration: 10:00-22:00, November 21st, 2018,
Qingyuan Hotel, Anhui University.

Lecture Room: Room H117, Mathematical Building,
Anhui University (Qingyuan Campus), Hefei, China.

Accommodation: Qingyuan Hotel, Anhui University.

Dining Hall: 2nd Floor of the auxiliary building, Qingyuan Hotel.

Website: http://ahumath.ahu.cn

Contacts: Shuangdong Li: 13966670267 for pick up, accommodation.
Jing Xu: 13721058017 for registration and others.

Sponsors : School of Mathematical Sciences, Anhui University
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National Natural Science Foundation of China

International Workshop on Algebraic Combinatorics at Anhui University, November 21st-25th, 2018

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Plenary speakers

E. Bannai	Kyushu University and TGMRC
S. Cioabă	Delaware Uinversity, USA
Shaofei Du	Capital Normal University
J. Koolen	University of Science and Technology of China
Caiheng Li	Southern University of Science and Technology
A. Munemasa	Tohoku University, Japan
N. Obata	Tohoku University, Japan
M. Tagami	Kyushu Institute of Technology, Japan
H. Tanaka	Tohoku Universtiy, Japan
P. Terwilliger	University of Wisconsin at Madison, USA
L. Vinet	University of Montreal, Canada
Wei Wang	Xi'an Jiaotong University
A. Zhedanov	Renmin University

Daily Schedule

November 22, 2018	
8:45–9:30	Opening ceremony and photo
9:30–10:20	Eiichi Bannai
10:20–10:50	Coffee Break
10:50–11:20	Yan Zhu
11:25–11:55	Sergey Goryainov
12:00–14:00	Lunch break
14:00–14:50	Akihiro Munemasa
15:00–15:30	Masood Ur Rehman
15:35–16:05	Denis Krotov
16:05–16:30	Coffee Break
16:30–17:00	Semin Oh
17:05–17:55	Jack Koolen
18:00–	Dinner

November 23, 2018	
9:00–9:50	Paul Terwilliger
9:50–10:20	Coffee Break
10:20–10:50	Bo Hou
10:55–11:25	Shuangdong Li
11:30–12:00	Xueyi Huang
12:00–14:00	Lunch Break
14:00–14:50	Sebastian Cioabă
15:00–15:50	Alexei Zhedanov
15:50–16:20	Coffee Break
16:20–16:50	Suogang Gao
17:00–17:50	Caiheng Li
18:00–	Dinner

November 24, 2018	
9:00–9:50	Wei Wang
9:50–10:20	Coffee Break
10:20–10:50	Xiaoye Liang
10:55–11:25	Makoto Tagami
11:30–12:00	Alexander Gavrilyuk
12:00–14:00	Lunch Break
14:00–14:50	Nobuaki Obata
15:00–15:50	Luc Vinet
15:50–16:20	Coffee Break
16:20–17:10	Hajime Tanaka
17:20–17:50	Tatsuro Ito
18:00–	Banquet

November 25, 2018	
9:00–9:50	Shaofei Du
9:50–10:20	Coffee Break
10:20–10:50	Weicong Li
10:55–11:25	Yuefeng Yang
11:30–12:00	Dongdong Jia
12:00–12:30	Closing
12:30–14:00	Lunch

Detailed Schedule

November 22, 2018/ Math Bldg 117		
8:45–9:30	**Opening ceremony and photo**	
Chair	Yizheng Fan	
9:30–10:20	Eiichi Bannai	Unitary t-designs and unitary t-groups
10:20–10:50	**Coffee Break**	
Chair	Paul Terwilliger	
10:50–11:20	Yan Zhu	Tight complex spherical $\mathcal{T}$-designs
11:25–11:55	Sergey Goryainov	On strictly Neumaier graphs
12:00–14:00	**Lunch Break**	
Chair	Alexander Gavrilyuk	
14:00–14:50	Akihiro Munemasa	A variation of Godsil–McKay switching
15:00–15:30	Masood Ur Rehman	On the integrability of strongly regular graphs
15:35–16:05	Denis Krotov	On the number of latin trades of order 3
16:05–16:30	**Coffee Break**	
Chair	Akihiro Munemasa	
16:30–17:00	Semin Oh	On Unique Maximal Fixed Point Automorphisms of Graphs
17:05–17:55	Jack Koolen	On a generalization of a theorem of Neumaier
18:00–	**Dinner**	

November 23, 2018/ Math Bldg 117		
Chair	Hajime Tanaka	
9:00–9:50	Paul Terwilliger	An infinite-dimensional BOX_q module obtained from the q-shuffle algebra for affine sl_2
9:50–10:20	**Coffee Break**	
Chair	Suogang Gao	
10:20–10:50	Bo Hou	Leonard pairs and quantum algebra $U_q(sl_2)$
10:55–11:25	Shuangdong Li	The Terwilliger algebra of a tree
11:30–12:00	Xueyi Huang	The spectrum and automorphism group of the set-inclusion graph
12:00–14:00	**Lunch Break**	
Chair	Tatsuro Ito	
14:00–14:50	Sebastian Cioabă	The smallest eigenvalues of Hamming, Johnson and other graphs
15:00–15:50	Alexei Zhedanov	Algebraic Heun operator of Bannai-Ito type
15:50–16:20	**Coffee Break**	
Chair	Rongquan Feng	
16:20–16:50	Suogang Gao	Uniform posets and Leonard pairs based on symplectic s-paces over finite fields
17:00–17:50	Caiheng Li	Arc-transitive embeddings of graphs
18:00–	**Dinner**	

November 24, 2018/ Math Bldg 117		
Chair	Sebastian Cioabă	
9:00–9:50	Wei Wang	Are almost all regular graphs determined by their spectrum?
9:50–10:20	**Coffee Break**	
Chair	Eiichi Bannai	
10:20–10:50	Xiaoye Liang	T-modules for the Grassmann graph $J_q(N, D)$
10:55–11:25	Makoto Tagami	Harmonic Index t-design in Hamming Schemes
11:30–12:00	Alexander Gavrilyuk	On triple intersection numbers of association schemes
12:00–14:00	**Lunch Break**	
Chair	Alexei Zhedanov	
14:00–14:50	Nobuaki Obata	Quadratic embedding constants of graphs
15:00–15:50	Luc Vinet	Quantum State Revivals, Graphs and Orthogonal Polynomials
15:50–16:20	**Coffee Break**	
Chair	Keqin Feng	
16:20–17:10	Hajime Tanaka	Current progress in the Delsarte theory
17:20–17:50	Tatsuro Ito	TD-pairs at $q = -1$
18:00–	**Banquet**	

November 25, 2018/ Math Bldg 117		
Chair	Caiheng Li	
9:00–9:50	Shaofei Du	Hamilton cycles in vertex-transitive graphs of order a product of two primes
9:50–10:20	**Coffee Break**	
Chair	Tao Feng	
10:20–10:50	Weicong Li	On the existence of O'Nan configurations in Buekenhout unials in $PG(2, q^2)$
10:55–11:25	Yuefeng Yang	Thick weakly distance-regular digraphs
11:30–12:00	Dongdong Jia	Erasure combinatorial batch codes based on nonadaptive group testing
12:00–12:30	**Closing**	
12:30–14:00	**Lunch**	

Abstracts

Unitary t-designs and unitary t-groups

Eiichi Bannai (Professor Emeritus)
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Abstract: Unitary t-designs are finite subsets of the unitary group $U(d)$ that approximate the whole $U(d)$ well. The positive integer t measures how well they approximate. If a unitary t-design itself is a group, then it is called a unitary t-group. These concepts were first introduced in physics (quantum information theory). In this talk we first give a quick survey on unitary t-designs and unitary t-groups. Then we point out that the problem of classifying unitary t-groups were studied in the context of finite group theory. We point out that the main parts of the classification that (i) there are no unitary 4-groups for $U(d)$ for $d \geq 5$ and (ii) the unitary 2-groups are essentially classified for $d \geq 5$, were done by Guralnick and Tiep (J. of Algebra, 2005), by using the classification of finite simple groups and other deep techniques of finite group theory. Here we give the complete classification of unitary t-groups in $U(d)$ for all $t \geq 2$ and $d \geq 2$. It is interesting to note that the classifications for small d, say $2 \leq d \leq 4$, are closely related to the classification of finite unitary (complex) reflection groups in the sense of Shephard and Todd. This talk is based on the preprint: Unitary t-groups, by Eiichi Bannai, Gabriel Navarro, Noelia Rizo and Pham Huu Tiep, arXiv:1810.02507.

The smallest eigenvalues of Hamming, Johnson and other graphs

Sebastian Cioabă
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Abstract: The smallest eigenvalue of graphs is closely related to other graph parameters such as the independence number, the chromatic number or the max-cut. In this talk, I will describe the well known connections between the smallest eigenvalue and the max-cut of a graph that have motivated various researchers such as Karloff, Alon, Sudakov, Van Dam, Sotirov to investigate the smallest eigenvalue of Hamming and Johnson graphs. I will describe our proofs of a conjecture by Van Dam and Sotirov on the smallest eigenvalue of (distance-j) Hamming graphs and a conjecture by Karloff on the smallest eigenvalue of (distance-j) Johnson graphs and mention some open problems. This is joint work with Andries Brouwer, Ferdinand Ihringer and Matt McGinnis.

Hamilton cycles in vertex-transitive graphs of order a product of two primes

Shaofei Du
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Abstract: A step forward is made in a long standing Lovász's problem regarding the hamiltonicity of vertex-transitive graphs, by showing that every connected vertex-transitive graph of order a product of two primes, other than the Petersen graph, contains a Hamilton cycle. Essential tools used in the proof range from classical results on existence of Hamilton cycles, such as Chvátal's theorem and Jackson's theorem, to certain results on polynomial representations of quadratic residues at primitive roots in finite fields.

Uniform posets and Leonard pairs based on symplectic spaces over finite fields

Suogang Gao
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Abstract: Let $\mathbb{F}_q^{(2\nu)}$ be the 2ν-dimensional symplectic space over finite field $\mathbb{F}_q$ and let $\mathcal{M}(m,s;2\nu)$ denote the orbit of subspaces of $\mathbb{F}_q^{(2\nu)}$ under the symplectic group. Denote by $\mathcal{L}(m,s;2\nu)$ the set of subspaces generated by $\mathcal{M}(m,s;2\nu)$. By ordering $\mathcal{L}(m,s;2\nu)$ by ordinary inclusion, then the poset denoted $\mathcal{L}_O(m,s;2\nu)$ is obtained. In this talk, we first construct the subposet of $\mathcal{L}_O(m,s;2\nu)$. Then we show that this subposet is strongly uniform and construct Leonard pairs from it. This is joint work with Bo Hou and Huijuan Xue.

On triple intersection numbers of association schemes

Alexander Gavrilyuk
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Abstract: Let $\mathfrak{X} = (X, \{R_0, \dots, R_D\})$ be a symmetric association scheme of D classes. For a 3-tuple xyz of points of X, let $[\ell, m, n] := [\ell, m, n]_{x,y,z}$ denote the *triple intersection number* (with respect to xyz) defined by:

$$[\ell, m, n] = \#\{w \in X \mid wR_\ell x, wR_m y, wR_n z\}.$$

Unlike the intersection numbers, the triple intersection numbers $[\ell, m, n]$ depend, in general, on the choice of x, y, z. On the other hand, vanishing of some

of the Krein parameters of $\mathfrak{X}$ often leads to non-trivial linear Diophantine equations involving triple intersection numbers as the unknowns (perhaps, it was first observed by Cameron, Goethals and Seidel in [2], see also [1, Theorem 2.3.2]). This fact has been used to compute triple intersection numbers of certain putative distance-regular graphs with feasible intersection arrays, from which non-existence of the corresponding graphs has been shown, see [3–5]. An implementation of this approach is now available as a part of a package for the Sage computer algebra system for checking feasibility of a given intersection array of a distance-regular graph, [6]. Recently, Williford [7] has published lists of feasible Krein parameters for primitive 3-class Q-polynomial association schemes on up to 2800 vertices, and for Q-bipartite (but not Q-antipodal) 4- and 5-class association schemes on up to 10000 and 50000 vertices, respectively. In this work, by computing triple intersection numbers, we rule out many open cases from these lists. If time permits, we will discuss a generalization of triple intersection numbers to quadruples. This is based on joint work with Janoš Vidali.

[1] A.E. Brouwer, A.M. Cohen, A. Neumaier, Distance-regular graphs. *Ergebnisse der Mathematik und ihrer Grenzgebiete*, (3), 18, Springer-Verlag, Berlin, 1989.

[2] P.J. Cameron, J.M. Goethals, J.J. Seidel, Strongly regular graphs having strongly regular subconstituents. *J. Algebra*, 55:257–280, 1978.

[3] K. Coolsaet, A. Jurišić, Using equality in the Krein conditions to prove nonexistence of certain distance-regular graphs. *J. Combin. Theory Ser. A*, 115(6):1086–1095, 2008.

[4] A. Jurišić, J. Vidali, Extremal 1-codes in distance-regular graphs of diameter 3. *Designs, Codes and Cryptography*, 65(1–2):29–47, 2012.

[5] M. Urlep, Triple intersection numbers of Q-polynomial distance-regular graphs. *European J. Combin.*, 33(6):1246–1252, 2012.

[6] J. Vidali, Using symbolic computation to prove nonexistence of distance-regular graphs. *Electron. J. Combin.*, 4:P4.21, 2018.

[7] J.S. Williford, http://www.uwyo.edu/jwilliford/homepage/homepage.html: Tables of feasible Q-polynomial association schemes, 2017.

On strictly Neumaier graphs

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Abstract: A clique in a regular graph is called *m-regular* if every vertex that doesn't belong to the clique is adjacent to precisely m vertices from the

clique. An edge-regular graph is called a *Neumaier graph* if it contains a regular clique. A Neumaier graph is called a *strictly Neumaier graph* if it is not strongly regular (see [1]). In this talk we discuss recent results from [1] and [2]. This is joint work with Rhys Evans and Dmitry Panasenko.

[1] R.J. Evans, S.V. Goryainov, D.I. Panasenko, The smallest strictly Neumaier graph and its generalisations, arXiv:1809.03417.

[2] G.R.W. Greaves, J.H. Koolen, Another construction of edge-regular graphs with regular cliques, arXiv:1810.07454.

Leonard pairs and quantum algebra $U_q(sl_2)$

Bo Hou
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Abstract: Let $\mathbb{K}$ denote an algebraically closed field of characteristic zero. Let V denote a vector space over $\mathbb{K}$ with finite positive dimension. A *Leonard pair* on V is an ordered pair of linear transformations in $\mathrm{End}(V)$ such that for each of these transformations there exists a basis for V with respect to which the matrix representing that transformation is diagonal and the matrix representing the other transformation is irreducible tridiagonal. Fix a nonzero scalar $q \in \mathbb{K}$ which is not a root of unity. Consider the quantum algebra $U_q(sl_2)$ with equitable generators $x^{\pm 1}, y, z$. Let d denote a nonnegative integer and let $V_{d,1}$ denote an irreducible $U_q(sl_2)$-module of dimension $d+1$ and of type 1. In this paper, we determine all linear transformations A is $\mathrm{End}(V_{d,1})$ such that on $V_{d,1}$, the pair A, x^{-1}, the pair A, y and the pair A, z are all Leonard pairs. The talk is based on the joint work with Suogang Gao and Man Sang.

The spectrum and automorphism group of the set-inclusion graph

Xueyi Huang
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Abstract: For any given integers n, k and l with $0 \leq k < l \leq n$, the set-inclusion graph $G(n,k,l)$ is the graph whose vertex set consists of all k- and l-subsets of $[n] = \{1, 2, \ldots, n\}$, where two distinct vertices are adjacent if one of them is contained in another. In this talk, we determine the spectrum and automorphism group of $G(n,k,l)$ (and its line graph) for arbitrary k, l, which generalizes two former results of Mirafzal regarding the spectra and automorphism group of the subgraphs (and their line graphs) of the hypercube induced by two consecutive layers.

TD-pairs at $q = -1$

Tatsuro Ito
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Abstract: It is known that a TD-pair supports a $U_{\sqrt{q}}(\widehat{\mathfrak{sl}}_2)$-module structure when the ground parameter q is not a root of unity. We discuss TD-pairs at $q = -1$, extending this result. This is joint work with Makoto Tagami and Paul Terwilliger.

Erasure combinatorial batch codes based on nonadaptive group testing

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Abstract: Erasure combinatorial batch codes are a family of codes for distributed storage systems which not only allow for the retrieval of any set of a limited number of items even in presence of server failures, but also balance the load among the servers when retrieving. To present new constructions is one of the objectives of studying erasure combinatorial batch codes. Nonadaptive group testing has many applications to various fields such as DNA library screening and multi-access communications, etc. A lot of constructions of nonadaptive group testing have been given by many authors. In this talk, based on nonadaptive group testing, we present three classes of erasure combinatorial batch codes. This is joint work with Gengsheng Zhang.

On a generalization of a theorem of Neumaier

Jack H. Koolen
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Abstract: In 1979, Neumaier showed that a strongly regular graph with fixed smallest eigenvalue $\lambda_{\min}$ either belongs to three infinite families or its number of vertices is bounded by a function in $\lambda_{\min}$. In this talk I will generalize this result to the class of co-edge-regular graphs, that is, regular graphs such that any pair of distinct non-adjacent vertices have a constant number of common neighbours. This is based on joint work with Brhane Gebremichael and Jae Young Yang.

On the number of latin trades of order 3

Denis Krotov
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Abstract: The family of multidimensional latin trades belong to a class of families for which the problem of evaluating the number N of (different or nonequivalent) objects is problematic even at the stage of determining the asymptotic of $\log(\log(N))$. Usually, the number has the form $\exp(\exp(cn))$, and the lower bound on the constant c is based on the switching approach (possibility to switch an exponential number of independent subsets without changing the property of the set to belong to the considered family), while the upper bound is trivial or close to be so. Famous examples of such families are the latin hypercubes (the order is fixed, the dimension n tends to infinity), the 1-perfect codes in Hamming spaces (the alphabet is fixed, the length n tends to infinity), the Boolean bent functions. The latin trades generalize the latin hypercubes (to be tight, they generalize the differences between two latin hypercubes). Formally, a latin trade can be defined as a $\{0, 1, -1\}$-valued function on the vertices of the Hamming graph $H(n, q)$ such that the values on every q-clique are either all zeros or one 1, one -1 and $q - 2$ zeros. The case of order 3 is special because one cannot obtain a doubly exponential number of objects based on the switching approach. On the other hand, the variety of such trades is rather reach (which is quite surprising because there is only one equivalence class of latin hypercubes of order 3 for every n), and the best known upper bound on their number is doubly exponential.

In the current work, we prove an exponential lower bound on the number of nonequivalent latin trades of order 3 and an upper bound of form $exp(exp(cn))$, where c is slightly smaller than for the trivial upper bound 2^{2^n}.

The problem has an interesting treatment as follows. Define the set $S_0 = \{-1, 0, 1\}$. Recursively, define S_n as the set of triples (a, b, c) of elements from S_{n-1} satisfying $a + b + c = 0$ over R (for example, $S_1 = \{(0, 0, 0), (0, 1, -1), (0, -1, 1), (1, 0, -1), (-1, 0, 1), (1, -1, 0), (-1, 1, 0)\}$, $S_2 = \{((0, 0, 0), (0, 0, 0), (0, 0, 0)), ((0, 0, 0), (0, 1, -1), (0, -1, 1)), ...\}$. The set S_n is essentially the set of latin trades of order 3 and dimension n, and we are interesting how $|S_n|$ grows. The work is funded by the Russian Science Foundation (14-11-00555, 18-11-00136). This is based on joint work with Vladimir Potapov.

Arc-transitive embeddings of graphs

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Abstract: I will report on recent progress of a project (jointly with Cheryl Preager and Shujiao Song) on arc-transitive maps, which includes a theory of arc-transitive embeddings of graphs associated with group actions, and a classification of vertex-primitive graphs admitting an almost simple group and having arc-transitive embeddings.

The Terwilliger algebra of a tree

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Abstract: Let Γ be a finite connected simple graph. Let X denote the vertex set of Γ and $V = \bigoplus_{x\in X} \mathbb{C}x$ the standard module, i.e., the vector space for which X is an orthonormal basis. Fix a vertex $x_0 \in X$ and let X_i be the set of vertices that have distangce i from x_0. Then the standdard module V is decomposed into the orthogonal sum $V = \bigoplus_{i=0}^{D} V_i^*$, where $V_i^* = \bigoplus_{x\in X_i} \mathbb{C}x$. The Terwilliger algebra T of Γ is by definition the subalgebra of $\mathrm{End}(V)$ generated by the adjacency matrix A of Γ and the orthogonal projections $E_i^* : V \to V_i^*$, $0 \leq i \leq D$. Let G be the automorphism group of Γ and H the stabilizer in G of the base vertex x_0: $G = Aut(\Gamma)$, $H = G_{x_0}$. Then it is easy to see that T is contained in the centralizer algebra of H, i.e., each element of T commutes with the action of every element of H: $T \subseteq \mathrm{Hom}_H(V, V)$.

In this talk, we discuss the Terwilliger algebra of a tree. Precisely s-peaking, we assume Γ is a rooted tree with the root x_0 and we let T be the Terwilliger algebra of Γ with respect to x_0. Firstly we will show: The T-module V determines the rooted tree Γ up to isomorphism. In particular, T=$\mathrm{End}(V)$ holds if and only if the rooted tree Γ does not have any symmetry, i.e., H=1. Note that the Terwilliger algebra as an abstract algebra cannot determine the rooted tree Γ up to isomorphism. Secondly we will introduce an associated weighted tree and determine, in terms of the weighted tree, when T coincides with the centralizer algebra $\mathrm{Hom}_H(V, V)$.

This talk is based on joint work with Jing Xu, Masoud Karimi, Yizheng Fan and Tatsuro Ito, which was motivated by Jack Koolen's conjecture: the Terwilliger algebra coincides with the full matrix algebra for most of connected simple graphs, regardless of the base point.

On the existence of O'Nan configurations in Buekenhout unials in $PG(2, q^2)$

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Abstract: A unital is a design with parameters $2-(q^3+1, q+1, 1)$. In 1972, O'Nan observed that the classical unitals contains no O'Nan configuration, which is a configuration consisting of four distinct lines intersecting in six distinct points. Later, Piper conjectured that the absence of O'Nan configurations characterizes the classical unitals. We establish the existence of O'Nan configurations in all nonclassical Buekenhout unitals in $PG(2, q^2)$. Such results provide evidence to Piper's conjecture. This is joint work with Tao Feng.

T-modules for the Grassmann graph $J_q(N, D)$

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Abstract: We discuss the structure of irreducible T-modules for the Grassmann graph $J_q(N, D)$ from two viewpoints: (1) the action of the quantum affine algebra $U_{q^{\frac{1}{2}}}(\widehat{sl_2})$ on the Grassmann space, which is established in [1], (2) the action of the maximal parabolic subgroup of $GL(N, q)$, which stabilizes the base point for the Terwilliger algebra T, on the subconstituents of the Grassmann graph $J_q(N, D)$.

[1] Y. Watanabe, An algebra associated with a subspace lattice over a finite field and its relation to the quantum affine algebra $U_{q^{\frac{1}{2}}}(\widehat{sl_2})$, *J. Algebra*, 489:475–505, 2017.

A variation of Godsil–McKay switching

Akihiro Munemasa
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Abstract: We introduce a variation of Godsil–McKay switching. If one can partition the vertex set of a graph Γ as $C_1 \cup C_2 \cup D$ and require that (1) $C_1 \cup C_2$ is an equitable partition and that (2) either $|\Gamma(x) \cap C_1| = |\Gamma(x) \cap C_2|$ or $\Gamma(x) \cap (C_1 \cup C_2) \in \{C_1, C_2\}$ for all vertices x in D, then we can define a switching operation that results in a cospectral graph.

This switching explains a geometric construction obtained by Ihringer for the collinearity graph of polar spaces. Furthermore, we apply the newly obtained switching to show that the strongly regular graph on non-isotropic points of the polar space $U(n, q)$ and the strongly regular graph on non-isotropic points of one type of the polar spaces of type $O(n, 3)$, $O(n, 5)$, $O^+(n, 3)$, and $O^-(n, 3)$ is not determined by its parameters for $n \geq 6$.

This is joint work with Ferdinand Ihringer.

Quadratic embedding constants of graphs

Nobuaki Obata
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Abstract: A finite or infinite connected graph is said to be of QE class if it admits a quadratic embedding in an Euclidean or Hilbert space, or equivalently, if the distance matrix is conditionally negative definite. For the criterion we introduce a new characteristic of a graph called the QE constant and show its basic properties. We discuss methods for computing the QE constants, concrete examples, and some open questions.

[1] N. Obata, Quadratic embedding constants of wheel graphs, *Interdiscip. Inform. Sci.*, 23:171–174, 2017.

[2] N. Obata and A.Y. Zakiyyah, Distance matrices and quadratic embedding of graphs, *Electron. J. Graph Theory Appl.*, 6:37–60, 2018.

[3] W. Mlotkowski and N. Obata, On quadratic embedding constants of star product graphs, *Hokkaido Math. J.*, to appear.

On Unique Maximal Fixed Point Automorphisms of Graphs

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Abstract: We call a non-identity automorphism σ of a graph Γ a *unique maximal fixed point automorphism (UFA)* if every automorphism of Γ fixing all fixed points of σ is equal to σ or the identity, i.e., there is no non-identity automorphism of Γ which fixes all fixed points of σ. Since every UFA is an involution, every involution-free graph is a UFA-free graph. In 2017, minimal involution-free graphs are completely classified with 18 graphs. In this talk, we show the classification of minimal UFA-free graphs. This is joint work with Yun Jeong Kim.

On the integrability of strongly regular graphs

Masood Ur Rehman
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Abstract: Let Λ be a subset of $\mathbb{R}^n$. We say that Λ is a *lattice* if there exist vectors $\mathbf{u}_1, \mathbf{u}_2, ..., \mathbf{u}_m \in \mathbb{R}^n$ (for some m) such that $\{\sum \alpha_i \mathbf{u}_i \mid \alpha_i \in \mathbb{Z}\}$ and we call $\{\mathbf{u}_1, ..., \mathbf{u}_m\}$ a *generator* set of the lattice Λ. A lattice Λ is called *integral*,

if the inner product of any two vectors in Λ is integral. An integral lattice Λ is s-integrable, for a positive integer s, if it can be described by vectors $\frac{1}{\sqrt{s}}(v_1, ..., v_k)$ with all $v_i \in \mathbb{Z}$ in $\mathbb{R}^k$ for some $k \geq n$.

Let G be a connected graph with adjacency matrix A, and smallest eigenvalue $-\lfloor \theta_{\min} \rfloor$. Then the matrix $A - \lfloor \theta_{\min} \rfloor I = N^T N$ is positive semidefinite and hence the Gram matrix. Let $\Lambda(G)$ be the integral lattice generated by the columns of N. Then the lattice $\Lambda(G)$ is an integral lattice generated by norm $-\lfloor \theta_{\min} \rfloor$ vectors. We say the graph G is *s-integrable* if the corresponding lattice $\Lambda(G)$ is s-integrable. If the lattice $\Lambda(G)$ is 1-integrable, we also say that the graph G is integrable. In this talk, we will discuss the integrability of strongly regular graphs. This is joint work with J. H. Koolen and Qianqian Yang.

Harmonic Index t-design in Hamming Schemes

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Abstract: The notion of harmonic index (or simply HI) spherical design was introduced as a finite set on sphere in the form extending the notion of usual spherical designs by Bannai-Okuda-T [BOT] (2015). They studied about a Fisher type inequality and they gave a construction for HI spherical design. Also they discussed the non-existence of tight HI spherical designs. In Zhu-Bannai-Bannai-Ikuta-Kim[ZBBIK] (2017) reintroduced the notion of HI t-design in symmetric association schemes (in fact, which has been already defined by Delsarte(1973) although the name was different from theirs.), and they studied about HI t-designs in binary Hamming schemes. In this talk, we will study them in Hamming scheme $H(n, q)$ for arbitrary q, following [BOT] and [ZBBIK] .

Current progress in the Delsarte theory

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Abstract: I will review several recent results which extend and generalize techniques from the Delsarte theory in 1973. Planned topics include the semidefinite programming bounds for codes, relative t-designs, and Erdős–Ko–Rado-type intersection theorems. I also plan to report possible implications to Shannon's theory on the zero error capacity of noisy channels.

An infinite-dimensional $\mathbf{BOX}_q$ module obtained from the q-shuffle algebra for affine $\mathbf{sl}_2$

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Abstract: We will discuss the quantum group for affine sl_2, focussing on a certain subalgebra BOX_q. We will show how BOX_q comes up naturally in the theory of tridiagonal pairs. A tridiagonal pair is a linear-algebraic object, consisting of two diagonalizable linear transformations that each act on the eigenspaces of the other one in a tridiagonal fashion. We consider an attractive infinite-dimensional BOX_q-module, said to be NIL. We will describe the NIL BOX_q-module from sixteen points of view. In this description we will use the free algebra V on two generators, as well as a q-shuffle algebra structure on V. This is joint work with Sarah Post.

Quantum State Revivals, Graphs and Orthogonal Polynomials

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Abstract: This lecture will describe how certain features of quantum transport along spin networks can be enabled. It will discuss connections with quantum walks on graphs of the Hamming scheme and one of its generalizations. Some univariate and multivariate orthogonal polynomials will be seen to play a central role.

Are almost all regular graphs determined by their spectrum?

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Abstract: A graph G is said to be determined by it spectrum (DS for short), if any graph having the same spectrum as G is isomorphic to G. J. Koolen once asked "Are almost all regular graphs DS?" In this talk, I shall give some evidence which shows that it might be true that almost all regular graphs are DS.

Thick weakly distance-regular digraphs

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Abstract: The concept of weakly distance-regular digraphs (*wdrdg* for short) was firstly introduced by Suzuki and Wang in [1]. In this talk, we will consider thick wdrdg, and obtain the result that any commutative thick wdrdg with $n(\geq 3)$ types of arcs can be constructed from a thick wdrdg with $n-1$ or $n-2$ types of arcs. And we also give the classification of thick wdrdg with at most two types of arcs under the assumption of the commutativity.

Keywords: Weakly distance-regular digraph, Cayley digraph.

[1] K. Wang and H. Suzuki, Weakly distance-regular digraphs, *Discrete Math.*, 264:225–236, 2003.

Algebraic Heun operator of Bannai-Ito type

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Abstract: The algebraic Heun operators are extensions of bispectral operators of the Askey scheme. They play an important role in many applications, e.g. in the theory of time and band limiting. We consider properties of algebraic Heun operators of Bannai-Ito type.

Tight complex spherical $\mathcal{T}$-designs

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Abstract: Let $\mathcal{T} \subset \mathbb{N} \times \mathbb{N}$ and $\Omega(d)$ be the unit sphere in $\mathbb{C}^d$. Denote $\mathrm{Hom}(k,\ell)$ as the set of polynomials which are homogeneous of degree k in $\{z_1,\ldots,z_d\}$ and homogeneous of degree ℓ in $\{\bar{z}_1,\ldots,\bar{z}_d\}$. A finite subset X on the unit complex sphere $\Omega(d)$ is called a complex spherical $\mathcal{T}$-design if

$$\frac{1}{|\Omega(d)|}\int_{\Omega(d)} f(\boldsymbol{z})\mathrm{d}\boldsymbol{z} = \frac{1}{|X|}\sum_{\boldsymbol{z}\in X} f(\boldsymbol{z})$$

holds for all $f(\boldsymbol{z}) \in \mathrm{Hom}(k,\ell)$ with $(k,\ell)\in\mathcal{T}$.

There are several classes of important and interesting complex spherical $\mathcal{T}$-designs with $\mathcal{T}_t^{(1)} := \{(k,\ell) \mid 0 \leq k+\ell \leq t\}$, $\mathcal{T}_t^{(2)} := \{(k,\ell) \mid 0 \leq k,\ell \leq t\}$

as well as $\mathcal{T}_t^{(3)} := \{(k, k) \mid 0 \leq k \leq t\}$. A design is called *tight* if its size attains some lower bound.

In this talk, we will focus on the existence of tight complex spherical $\mathcal{T}_4^{(1)}$-designs which are cloesly related to (real) spherical t-designs and non-symmetric association shemes.

This is joint work with Eiichi Bannai, Etsuko Bannai, Takayuki Okuda and Da Zhao.

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