Titles and Abstracts

1. Guantao Chen, Georgia State University

Title: Graph Knitting

Abstract: A graph $G$ is $\ell$-knitted if for every $S \subseteq V(G)$ with $|S| = \ell$ and any partition $S_1|S_2|\ldots|S_k$ of $S$, there exist vertex-disjoint connected subgraphs $G_1, G_2, \ldots, G_k$ such that $S_i \subseteq V(G_i)$ for each $i = 1, 2, \ldots, k$. When the partitions are restricted to $|S_1| = |S_2| = \cdots = |S_k| = 2$, graph $G$ is called $k$-linked, which is a well-studied subject in graph theory. We show that every $5\ell$-connected graph is $\ell$-knitted and applied it to show that if there is a counterexample to Hadwiger’s conjecture that every $t$-chromatic graph has a $K_t$-minor, then the minimum counterexample (in terms of graph minors) is $t/5$-connected.

2. Ilkyoo Choi, Hankuk University of Foreign Studies

Title: Coloring squares of planar graphs with no 4-cycles

Abstract: We study list coloring squares of planar graphs with no 4-cycles. We show that if $G$ is such a graph, then $\chi_l(G^2) \leq \Delta(G) + 73$. When $\Delta(G)$ is sufficiently large, we strengthen this bound to $\chi_l(G^2) \leq \Delta(G) + 2$. Our bounds also hold for Alon–Tarsi number, paint number, and correspondence chromatic number. To complement these results, we show that 4-cycles are unique in having this property. Specifically, let $S$ be a finite list of positive integers, with $4 \notin S$. For each constant $C$, we construct a planar graph $G_{S,C}$ with no cycle with length in $S$, but for which $\chi(G_{S,C}) > \Delta(G_{S,C}) + C$. This is joint work with Dan Cranston and Tho Pierron.

3. Laihao Ding, Central China Normal University

Title: Properly colored cycles in colored graphs without properly colored $K_{s,t}$

Abstract: In this talk, I will introduce an important structure of edge-colored graphs without properly colored $K_{s,t}$s. Using this structure, we reduce the problem of finding properly colored cycles under color degree constraints to finding directed cycles under out-degree constraints and obtain an asymptotically optimal color degree condition for the existence of PC $K_{s,t}$ with $2 \leq s \leq t$. Moreover, based on the structure, we show that every edge-colored graph on $n$ vertices with minimum color degree at least $n/3 + 24\sqrt{n}$ contains a rainbow $C_4$. This color degree threshold is asymptotically best possible. We also give an asymptotically tight lower bound $n/5 + 3\sqrt{n}$ forcing a rainbow $C_4$ in edge-colored triangle-free graphs.

4. Zdeněk Dvořák

Title: F2-commodity flows and 3-coloring graphs in the cylinder

Abstract: (joint work with Jakub Pekárek) The problem whether a precoloring of two cycles in a planar graph extends to a proper 3-coloring can be reformulated in
5. Jaroslaw Grytczuk, Warsaw University of Technology

**Title:** Nonrepetitive coloring of graphs; new challenges

**Abstract:** A coloring of the vertices of a graph $G$ is *nonrepetitive* if there is no simple path of even order whose first half has exactly the same color sequence as the second half. The least number of colors needed is denoted by $\pi(G)$ and called the *nonrepetitive chromatic number* of a graph $G$. In 1906 Thue proved that $\pi(P) \leq 3$ for every path $P$. It has also been proved that $\pi(G)$ is bounded for graphs of bounded degree and for graphs of bounded treewidth. A major conjecture in this topic, stating that the same is true for planar graphs, or more generally for any proper minor-closed class of graphs, has been recently settled (https://arxiv.org/abs/1904.05269). I will present some old and new challenges in this area.

6. Xiaolan Hu, Central China Normal University

**Title:** Planar graphs without 4- and 6-cycles are $(7:2)$-colorable

**Abstract:** Let $G = (V(G), E(G))$ be a graph and $s, t$ integers with $s \leq t$. If we can assign an $s$-subset $\phi(v)$ of the set $\{1, 2, \ldots, t\}$ to each vertex $v$ of $V(G)$ such that $\phi(u) \cap \phi(v) = \emptyset$ for every edge $uv \in E(G)$, then $G$ is called $(t:s)$-colorable, and such an assignment $\phi$ is called a $(t:s)$-coloring of $G$. Let $C_n$ denote a cycle of length $n$. In this paper, we show that every planar graph without $C_4$ and $C_6$ is $(7:2)$-colorable and thus has fractional chromatic number at most $7/2$.

This is a joint work with Yaojun Chen and Haitao Wu.

7. Seog-jin Kim, Konkuk University

**Title:** Coloring squares of graphs with mad constraints

**Abstract:** The square $G^2$ of a graph $G$ is the graph defined by $V(G) = V(G^2)$ and $uv \in E(G^2)$ if and only if the distance between $u$ and $v$ is at most two. We denote by $\chi(G^2)$ the chromatic number of $G^2$, which is the least integer $k$ such that a $k$-coloring of $G^2$ exists. In this paper, we prove that the square of every graph $G$ with $\text{Mad}(G) < 4$ and $\Delta(G) \geq 8$ is $(3\Delta(G) + 1)$-choosable and even correspondence-colorable. Furthermore, we show a family of 2-degenerate graphs $G$ with $\text{Mad}(G) < 4$, arbitrarily large maximum degree, and $\chi(G^2) \geq \frac{5\Delta(G)}{2}$, improving a result of Kim and Park. This is joint work with Hervé Hocquard and Théo Pierron (Unversity of Bordeaux, France).

8. Alexander Kostochka, University of Illinois

**Title:** Monochromatic paths and cycles in 2-edge-colored multipartite graphs

**Abstract:** We solve four similar problems: For every fixed $s$ and large $n$, we describe all values of $n_1, \ldots, n_s$ such that for every 2-edge-coloring of the complete $s$-partite graph $K_{n_1, \ldots, n_s}$ there exists a monochromatic (i) cycle $C_{2n}$ with $2n$ vertices, (ii) cycle
$C_{\geq 2n}$ with at least $2n$ vertices, (iii) path $P_{2n}$ with $2n$ vertices, and (iv) path $P_{2n+1}$ with $2n+1$ vertices.

In particular, this settles the conjecture by Gyárfás, Ruszinkó, Sárközy and Szemerédi that for every 2-edge-coloring of the complete 3-partite graph $K_{n,n,n}$ there is a monochromatic path $P_{2n+1}$. An important tool is our stability theorem on monochromatic connected matchings.

This is joint work with J. Balogh, M. Lavrov and X. Liu.

9. Wei-Tian Li, National Chung-Hsing University

**Title:** Shifted-antimagic Labeling for Graphs

**Abstract:** The concept of antimagic labelings of a graph is to produce distinct vertex sums by labeling edges through consecutive numbers starting from one. A long-standing conjecture is that every connected graph, except a single edge, is antimagic. Some graphs are known to be antimagic, but little has been known about sparse graphs, not even trees. In this talk, we will study a weak version called $k$-shifted-antimagic labelings which allow the consecutive numbers starting from $k+1$, instead of starting from 1, where $k$ can be any integer. We establish connections among various concepts proposed in the literature of antimagic labelings and extends previous results in three aspects: (1) Some classes of graphs, including trees and graphs whose vertices are of odd degrees, which have not been verified to be antimagic are shown to be $k$-shifted-antimagic for sufficiently large $k$. (2) Some graphs are proved $k$-shifted-antimagic for all $k$, while some are proved not for some particular $k$. (3) Disconnected graphs are also considered. Joint work with Fei-Huang Chang, Hong-Bin Chen, and Zhishi Pan.

10. Xiangwen Li, Central China Normal University

**Title:** Every planar graph with girth 5 is (1,9)-colorable

**Abstract:** A graph is $(d_1,\ldots,d_k)$-colorable if the vertex set can be partitioned into $k$ sets $V_1,\ldots,V_k$ such that the maximum degree of the subgraph $G[V_i]$ is at most $d_i$ for $1 \leq i \leq k$. Montassier and Ochem (2015), Choi and Raspaud (2015), independently, asked whether every planar graph of girth 5 is (1,4)-colorable. In this paper, we prove that every planar graph of girth 5 is (1,9)-colorable, which improves the result of Choi, Choi, Jeong and Suh who showed that every planar graph of girth 5 is (1,10)-colorable [J. Graph Theory, 84 (2017) 521–535]. (with Jie Liu and Jian-Bo Lv).

11. Henry Liu, Sun Yat-sen University, China

**Title:** Multicoloured Ramsey number of the path of length four

**Abstract:** Given a graph $H$, the $m$-coloured Ramsey number of $H$, denoted by $R_m(H)$, is the minimum integer $n$ such that whenever the complete graph $K_n$ is given an $m$-edge-colouring, there is a monochromatic copy of $H$. Let $P_\ell$ denote the path of length $\ell$. The Ramsey numbers $R_m(P_2)$ and $R_m(P_3)$ have previously been determined exactly, which are approximately $m$ and $2m$. In this talk, we determine the Ramsey number $R_m(P_4)$ exactly, which is approximately $3m$. 
This talk is based on part of a joint work in progress with Bojan Mohar (Simon Fraser University, Canada and University of Ljubljana, Slovenia) and Yongtang Shi (Nankai University, China).

12. Ruth Luo, University of Illinois

**Title:** 2-connected hypergraphs with no long cycles

**Abstract:** The Erdos–Gallai theorem gives an upper bound for the maximum number of edges in an n-vertex graph with no cycle of length k or longer. Recently, many analogous results for r-uniform hypergraphs with no Berge cycle of length k or longer have appeared. In this talk, we present a result for 2-connected hypergraphs without long Berge cycles. For n large with respect to r and k, our bound is sharp and is significantly stronger than the bound without restrictions on connectivity. This is joint work with Zoltan Furedi and Alexandr Kostochka.

13. Jie Ma, University of Science and Technology of China

**Title:** Tight bounds on consecutive cycles in graphs

**Abstract:** We present tight bounds on consecutive paths and cycles in general graphs with given min-degree and given chromatic number. Among others, this fully implies conjectures of Thomassen on cycle lengths modulo k and a conjecture of Sudakov and Verstraete on longest consecutive cycles. This work is based on some previous work on related topics, however several new ideas are employed in order to obtain these sharper bounds.

14. Martin Merker, Technology University of Denmark

**Title:** Cycle lengths modulo k in cubic graphs

**Abstract:** It is known that for odd natural numbers k, if a graph has sufficiently large minimum degree then it contains cycles of every length modulo k. Thomassen proved in 1983 that also cubic graphs of large girth have this property. In this talk I will present a new result of this type for cubic graphs which states that every sufficiently large 3-connected cubic graph has cycles of every length modulo k. I will also show that this is not true in general for large 2-connected cubic graphs. Joint work with Kasper Lyngsie.

15. Bojan Mohar, Simon Fraser University.

**Title:** The last temptation of Tutte

**Abstract:** In 1960’s, Tutte introduced the notion a coloring complex and a coloring invariant that gives rise to a notion of even and odd 4-colorings. The speaker will discuss a resolution of a problem posed by Tutte in 1999. This is joint work with Nathan Singer.

16. Sang-il Oum, Institute for Basic Science (IBS) & KAIST

**Title:** Branch-depth: generalizing tree-depth of graphs
Abstract: We present a concept called the branch-depth of a connectivity function, that generalizes the tree-depth of graphs. Then we prove two theorems showing that this concept aligns closely with the notions of tree-depth and shrub-depth of graphs as follows. For a graph $G = (V, E)$ and a subset $A$ of $E$ we let $\lambda_G(A)$ be the number of vertices incident with an edge in $A$ and an edge in $E \setminus A$. For a subset $X$ of $V$, let $\rho_G(X)$ be the rank of the adjacency matrix between $X$ and $V \setminus X$ over the binary field. We prove that a class of graphs has bounded tree-depth if and only if the corresponding class of functions $\lambda_G$ has bounded branch-depth and similarly a class of graphs has bounded shrub-depth if and only if the corresponding class of functions $\rho_G$ has bounded branch-depth, which we call the rank-depth of graphs. Furthermore we investigate various potential generalizations of tree-depth to matroids and prove that matroids representable over a fixed finite field having no large circuits are well-quasi-ordered by the restriction. This is a work-in-progress, jointly with Matt DeVos (SFU) and O-joung Kwon (Incheon National University).

17. Boram Park, Ajou University

Title: On 5 star-coloring of some sparse graphs

Abstract: Given a graph $G$, a star $k$-coloring of $G$ is a proper (vertex) $k$-coloring of $G$ such that the vertices on a path of length three receive at least three colors. The star chromatic number, denoted $\chi_s(G)$, of a graph $G$ is the minimum integer $k$ for which $G$ admits a star $k$-coloring. Studying star coloring of sparse graphs is an active area of research, especially in terms of the maximum average degree of a graph; the maximum average degree, denoted $\text{mad}(G)$, of a graph $G$ is $\max \left\{ \frac{2|E(H)|}{|V(H)|} : H \subseteq G \right\}$.

It is known that for a graph $G$, if $\text{mad}(G) < \frac{\Delta}{3},$ then $\chi_s(G) \leq 6$ and if $\text{mad}(G) < \frac{18}{7}$ and its girth is at least 6, then $\chi_s(G) \leq 5$. For a graph $G$, let $\Delta(G)$ denote the maximum degree of $G$. In this paper, we show that for a graph $G$, if $\text{mad}(G) \leq \frac{8}{3}$ and $\Delta(G) \notin \{4, 5, 6\}$ then $\chi_s(G) \leq 5$. This is based on joint work with Ilkyoo Choi.

18. Kent Ozeki, Yokohama National University

Title: Spanning trees with few number of leaves in 4-connected graphs on higher genus surface

Abstract: In 1956, Tutte proved that every 4-connected planar graph is Hamiltonian. Since planar graphs can be regarded as graphs on the sphere, it is natural to think about graphs on higher genus surfaces. With this direction, the most attractive conjecture is due to Nash-Williams and Grünbaum, which says that every 4-connected graph on the torus is Hamiltonian. This conjecture is still open. Note that for any such a surface $F^g$ with genus more than the torus, there exist infinitely many 4-connected non-Hamiltonian graphs on $F^g$. However, we can expect the existence of some structures which have weaker (but still interesting) property than the Hamiltonicity. The author conjectured that for any surface of Euler genus $g$, there exists a spanning tree with at most $O(g)$ leaves. In this talk, we will give a recent progress on the conjecture. This work is a joint work with Atsuhiro Nakamoto (Yokohama National University).
19. Douglas B. West, Zhejiang Normal University and University of Illinois,

**Title:** Reconstruction from the deck of $k$-vertex induced subgraphs

**Abstract:** The $k$-deck of a graph $G$ is its multiset of subgraphs induced by $k$ vertices. Letting $n = |V(G)|$, the famous Reconstruction Conjecture is that the $(n-1)$-deck determines $G$ when $n \geq 3$. Always the $k$-deck determines the $(k-1)$-deck, so an enhanced version of the reconstruction problem is to seek the least $k$ such that the $k$-deck determines $G$.

Past results of Spinoza and West include the following:

1. For $l = (1 - o(1))n/2$, almost every graph is determined by its $(n-l)$-deck.
2. When $l = n/2$, the $(n-l)$-deck may not determine whether $G$ is connected.
3. For fixed $l$, the $(n-l)$-deck determines whether $G$ is connected when $n \geq t(l+1)^2$.
4. For every graph $G$ with maximum degree 2, the least $k$ such that $G$ is reconstructible from its $k$-deck is known.

New results, joint with A.Y. Kostochka, M. Nahvi, and D. Zirlin, include the following:

1. When $n \geq 7$, the $(n-3)$-deck determines the degree list (this is sharp).
2. When $n \geq 7$, the $(n-3)$-deck determines whether $G$ is connected (also sharp).

20. Xingxing Yu, Georgia Institute of Technology

**Title:** Coloring graphs without subdivisions of $K_5$

**Abstract:** We study structures of those graphs containing no subdivision of $K_5$ and use them to investigate whether such graphs are 4-colorable. If true this would be a natural extension of the well known Four Color Theorem. We report some recent progress we have made. This is joint work with Q. Xie, S. Xie, and X. Yuan

21. Wenan Zang, University of Hong Kong

**Title:** Proof of the Goldberg-Seymour Conjecture on Edge-Colorings of Multigraphs

**Abstract:** Let $G = (V, E)$ be a multigraph. The chromatic index $\chi(G)$ of $G$ is the least integer $k$ for which there is a coloring of $E$ with $k$ colors such that each vertex of $G$ is incident with at most one edge of each color. Let $\Delta(G)$ be the maximum degree of $G$ and let $\Gamma(G)$ be the density of $G$, defined by

$$\Gamma(G) = \max \left\{ \frac{2|E(U)|}{|U| - 1} : U \subseteq V, \ |U| \geq 3 \text{ and odd} \right\},$$

where $E(U)$ is the set of all edges of $G$ with both ends in $U$. Clearly, $\chi(G) \geq \max\{\Delta(G), \Gamma(G)\}$. In the 1970s Goldberg and Seymour independently conjectured that $\chi'(G) \leq \max\{\Delta(G) + 1, \left\lceil \Gamma(G) \right\rceil\}$. In this talk I shall present a proof of this conjecture. (Joint work with Guantao Chen and Guangming Jing)

21. Peter Zeman, Charles University

**Title:** Testing isomorphism of circular-arc graphs in polynomial time

**Abstract:** A graph is said to be circular-arc if the vertices can be associated with arcs of a circle so that two vertices are adjacent if and only if the corresponding arcs
overlap. It is proved that the isomorphism of circular-arc graphs can be tested by the
Weisfeiler-Leman algorithm after individualization of two vertices.

22. Xiao-Dong Zhang, Shanghai Jiao Tong University

Title: The Turán Numbers for Linear Forests

Abstract: The Turán number of a graph $H$, $ex(n, H)$, is the maximum number of
edges in a simple (bipartite) graph of order $n$ which does not contain $H$ as a subgraph.
In this talk, we introduce how to determine the exact value $ex(n; H)$ when $H$ is linear
forest, i.e., the union of disjoint paths and characterize all extremal graphs. Moreover,
some problems are included.

23. Xuding Zhu, Zhejiang Normal University

Title: A refinement of choosability of graphs

Abstract: A partition of a positive integer $k$ is a multiset $\lambda = \{k_1, k_2, \ldots, k_q\}$ of
positive integers such that $\sum_{j=1}^{q} k_j = k$. Given a partition $\lambda = \{k_1, k_2, \ldots, k_q\}$
of $k$ and a graph $G$, a $\lambda$-list assignment of $G$ is a $k$-list assignment $L$ of $G$ such
that the colour set $\bigcup_{v \in V(G)} L(v)$ can be partitioned into $q$ subsets $C_1 \cup C_2 \ldots \cup C_q$
such that for each vertex $v$ of $G$, $|L(v) \cap C_i| = k_i$. We say $G$ is $\lambda$-choosable if for
each $\lambda$-list assignment $L$ of $G$, $G$ is $L$-colourable. If $\lambda = \{k\}$, then $\lambda$-choosable is
the same as $k$-choosable. If $\lambda = \{1, 1, \ldots, 1\}$, then $\lambda$-choosable is equivalent to $k$-
colourable. For other partitions $\lambda$ of $k$, $\lambda$-choosability form a complex hierarchy of
colourability of graphs. In this sense, we view the concept of $\lambda$-choosability as a
refinement of the choosability of graphs. We prove that for two partitions $\lambda$ and $\lambda'$
of $k$, every $\lambda$-choosable graph is $\lambda'$-choosable if and only if $\lambda'$ is a refinement of $\lambda$.
For planar graphs, it is known that every planar graph is $\{1, 1, 1, 1\}$-choosable (i.e.,
4-colourable), and there are planar graphs that are not $\{4\}$-choosable. We construct
a planar graph which is not $\{1, 3\}$-choosable, and conjecture that every planar graph
is $\{2, 2\}$-choosable, and every planar graph is $\{1, 1, 2\}$-choosable. These conjectures
are related to colouring of signed planar graphs.