

Extremal Graph Theory

BÉLA BOLLOBÁS



Extremal Graph Theory

Zhe Xu



Extremal Graph Theory:

Extremal Graph Theory Béla Bollobás, 2004-01-01 The ever expanding field of extremal graph theory encompasses an array of problem solving methods including applications to economics computer science and optimization theory This volume presents a concise yet comprehensive treatment featuring complete proofs for almost all of its results and numerous exercises 1978 edition *Extremal Graph Theory with Emphasis on Probabilistic Methods* Béla Bollobás, 1986 Problems in extremal graph theory have traditionally been tackled by ingenious methods which made use of the structure of extremal graphs In this book an update of his 1978 book Extremal Graph Theory the author focuses on a trend towards probabilistic methods He demonstrates both the direct use of probability theory and more importantly the fruitful adoption of a probabilistic frame of mind when tackling main line extremal problems Essentially self contained the book does not merely catalog results but rather includes considerable discussion on a few of the deeper results The author addresses pure mathematicians especially combinatorialists and graduate students taking graph theory as well as theoretical computer scientists He assumes a mature familiarity with combinatorial methods and an acquaintance with basic graph theory The book is based on the NSF CBMS Regional Conference on Graph Theory held at Emory University in June 1984 **Extremal**

Graph Theory with Emphasis on Probabilistic, 1986 *Four Problems in Extremal Graph Theory* Florian Pfender, 2002

Extremal Graph Theory: Supersaturation and Enumeration Hong Liu, 2015

Topics in Extremal Graph Theory

Brandon Cruz, 2009 Topics in Extremal Graph Theory Peter Keevash, 2003 *Problems in Extremal Graph Theory* Kamil

Popielarz, 2018 *Extremal Graph Theory* Maya Jakobine Stein, 2010 **Problems in Extremal Graph Theory** André

Kündgen, 1999 *Topics in Extremal Graph Theory* Myung Sook Chung, 1993 New results are proved on several problems in

extremal graph theory Let $exsp D H$ denote the maximum number of edges in a connected graph with maximum degree D and no induced subgraph isomorphic to the graph H It is shown that this is finite if and only if H is a disjoint union of paths

Several specific forbidden subgraphs H have been studied and the following results have been proved 1 $exsp D Psb_4 Dsp_2$ for all D uniquely achieved by $Ksb D D$ If in addition the maximum clique size is ω then the number of edges is at most $Dsp_2 D \omega$

2 $exsp D Psb_5 2over 27 Dsp_3 O Dsp_2 3 exsp D 2Psb_3 1over 8 Dsp_4 1over 8 Dsp_3 O Dsp_2 4 exsp D Psb_3$

Psb_2 **Problems in Structural and Extremal Graph Theory** Jennifer L. Diemunsch, 2015 Extremal Graph Theory

and Dimension Theory for Partial Orders David Lewis, 2020 This dissertation analyses several problems in extremal combinatorics In Part I we study the following problem proposed by Barrus Ferrara Vandenbussche and Wenger Given a graph H and an integer t what is the minimum number of coloured edges in a t edge coloured graph G on n vertices such that G does not contain a rainbow copy of H but adding a new edge to G in any colour creates a rainbow copy of H We determine the growth rates of these numbers for almost all graphs H and all $t \in H$ In Part II we study dimension theory for finite partial orders In Chapter 1 we introduce and define the concepts we use in the succeeding chapters In Chapter 2 we determine the

dimension of the divisibility order on n up to a factor of $\log \log n$ In Chapter 3 we answer a question of Kim Martin Masak Shull Smith Uzzell and Wang on the local bipartite covering numbers of difference graphs In Chapter 4 we prove some bounds on the local dimension of any pair of layers of the Boolean lattice In particular we show that the local dimension of the first and middle layers is asymptotically $n \log n$ In Chapter 5 we introduce a new poset parameter called local t dimension We also discuss the fractional variants of this and other dimension like parameters All of Part I is joint work with Antnio Giro of the University of Cambridge and Kamil Popielarz of the University of Memphis Chapter 2 of Part II is joint work with Victor Souza of IMPA Instituto de Matemática Pura e Aplicada Rio de Janeiro Chapter 3 of Part II is joint work with Antnio Giro

Three Existence Problems in Extremal Graph Theory Paul S. Wenger, 2010 Proving the existence or nonexistence of structures with specified properties is the impetus for many classical results in discrete mathematics In this thesis we take this approach to three different structural questions rooted in extremal graph theory When studying graph representations we seek efficient ways to encode the structure of a graph For example an interval representation of a graph G is an assignment of intervals on the real line to the vertices of G such that two vertices are adjacent if and only if their intervals intersect We consider graphs that have k visibility representations a generalization of both interval representations and another well studied class of representations known as visibility representations We obtain results on \mathcal{F}_k the family of graphs having k visibility representations We also study $\text{bigcup}_k \mathcal{F}_k$ In particular we determine the largest complete graph having a k visibility representation and we show that there are graphs that do not have k visibility representations for any k Graphs arise naturally as models of networks and there has been much study of the movement of information or resources in graphs Lampert and Slater cite LS introduced it acquisition in weighted graphs whereby weight moves around G provided that each move transfers weight from a vertex to a heavier neighbor Our goal in making acquisition moves is to consolidate all of the weight in G on the minimum number of vertices this minimum number is the it acquisition number of G We study three variations of acquisition in graphs when a move must transfer all the weight from a vertex to its neighbor when each move transfers a single unit of weight and when a move can transfer any positive amount of weight We consider acquisition numbers in various families of graphs including paths cycles trees and graphs with diameter 2 We also study under the various acquisition models those graphs in which all the weight can be moved to a single vertex Restrictive local conditions often have far reaching impacts on the global structure of mathematical objects Some local conditions are so limiting that very few objects satisfy the requirements For example suppose that we seek a graph in which every two vertices have exactly one common neighbor Such graphs are called it friendship graphs and Wilf cite Wilf proved that the only such graphs consist of edge disjoint triangles sharing a common vertex We study a related structural restriction where similar phenomena occur For a fixed graph H we consider those graphs that do not contain H and such that the addition of any edge completes exactly one copy of H Such a graph is called it uniquely H saturated We study the existence of

uniquely H saturated graphs when H is a path or a cycle. In particular we determine all of the uniquely C_4 saturated graphs there are exactly ten. Interestingly the uniquely C_5 saturated graphs are precisely the friendship graphs characterized by Wilf.

Extremal Graph Theory Via Structural Analysis Frederik Garbe, 2018. We discuss two extremal problems in extremal graph theory. First we establish a precise characterisation of 4 uniform hypergraphs with minimum codegree close to $n/2$ which contain a Hamilton 2 cycle. As a corollary we determine the exact Dirac threshold for Hamilton 2 cycles in 4 uniform hypergraphs and we provide a polynomial time algorithm which answers the corresponding decision problem for 4 graphs with minimum degree close to $n/2$. In contrast we also show that the corresponding decision problem for tight Hamilton cycles in dense k graphs is NP complete. Furthermore we study the following bootstrap percolation process: given a connected graph G we infect an initial set A of vertices and in each step a vertex v becomes infected if at least a p proportion of its neighbours are infected. A set A which infects the whole graph is called a contagious set. Our main result states that for every $p \in (0, 1)$ and for every connected graph G on n vertices the minimal size of a contagious set is less than $2pn$ or 1. This result is best possible but we provide a stronger bound in the case of graphs of girth at least five. Both proofs exploit the structure of a minimal counterexample.

Some Results in Extremal Graph Theory Olof Barr, 1996. Problems and Conjectures in Extremal Graph Theory A. J. Harris, 1985. Extremal Graph Theory: Ramsey-Turán Numbers, Chromatic Thresholds, and Minors John E. Lenz, 2011. This dissertation investigates several questions in extremal graph theory and the theory of graph minors. It consists of three independent parts: the first two parts focus on questions motivated by Turán's Theorem and the third part investigates a problem related to Hadwiger's Conjecture. Let H be a graph, t an integer and $f: \mathbb{N} \rightarrow \mathbb{N}$ a function. The t -Ramsey Turán number of H , $RT_t(n, H, f)$ is the maximum number of edges in an n -vertex H -free graph with K_t -independence number less than $f(n)$ where the K_t -independence number of a graph G is the maximum number of vertices in a K_t -free induced graph of G . In the first part of this thesis we study the Ramsey Turán numbers for several graphs and hypergraphs proving two conjectures of Erdős, Hajnal, Simonovits, Sos and Szemerédi. In joint work with József Balogh our first main theorem is to provide the first lower bounds of order $\Omega(n^2)$ on $RT_t(n, K_t, 2o(n))$. Our second main theorem is to prove lower bounds on $RT(n, K_r, s o(n))$ where K_r, s is the r -uniform hypergraph formed from K_s by adding $r-2$ new vertices to every edge. Let \mathcal{F} be a family of r -uniform hypergraphs. Introduced by Erdős and Simonovits the chromatic threshold of \mathcal{F} is the infimum of the values $c \geq 0$ such that the subfamily of \mathcal{F} consisting of hypergraphs with minimum degree at least $c \binom{n-1}{r-1}$ has bounded chromatic number. The problem of chromatic thresholds of graphs has been well studied but there have been no previous results about the chromatic thresholds of r -uniform hypergraphs for $r \geq 3$. Our main result in this part of the thesis in joint work with József Balogh, Jane Butterfield, Ping Hu and Dhruv Mubayi is to prove a structural theorem about hypergraphs with bounded chromatic number. Corollaries of this result show that the chromatic threshold of the family of F -free hypergraphs is zero for several hypergraphs F including a hypergraph generalization of

cycles A graph H is a minor of a graph G if starting with G one can obtain H by a sequence of vertex deletions edge deletions and edge contractions Hadwiger's famous conjecture from 1943 states that every t -chromatic graph G has K_t as a minor Hadwiger's Conjecture implies the following weaker conjecture every graph G has $K_{\lceil \alpha(G) \rceil}$ as a minor where $\alpha(G)$ is the independence number of G The main theorem in the last part of this thesis in joint work with Jozsef Balogh and Hehui Wu is to prove that every graph has $K_{\lfloor 2\alpha(G) \log \alpha(G) \rfloor}$ as a minor

Some Turán-type Problems in Extremal Graph Theory Jangwon Yie, 2018 Since the seminal work of Turán the forbidden subgraph problem has been among the central questions in extremal graph theory Let $ex(n, F)$ be the smallest number m such that any graph on n vertices with m edges contains F as a subgraph Then the forbidden subgraph problem asks to find $ex(n, F)$ for various graphs F The question can be further generalized by asking for the extreme values of other graph parameters like minimum degree maximum degree or connectivity We call this type of question a Turán type problem In this thesis we will study Turán type problems and their variants for graphs and hypergraphs Chapter 2 contains a Turán type problem for cycles in dense graphs The main result in this chapter gives a tight bound for the minimum degree of a graph which guarantees existence of disjoint cycles in the case of dense graphs This in particular answers in the affirmative a question of Faudree Gould Jacobson and Magnant in the case of dense graphs In Chapter 3 similar problems for trees are investigated Recently Faudree Gould Jacobson and West studied the minimum degree conditions for the existence of certain spanning caterpillars They proved certain bounds that guarantee existence of spanning caterpillars The main result in Chapter 3 significantly improves their result and answers one of their questions by proving a tight minimum degree bound for the existence of such structures Chapter 4 includes another Turán type problem for loose paths of length three in a 3-graph As a corollary an upper bound for the multi color Ramsey number for the loose path of length three in a 3-graph is achieved

Some Problems in Algebraic and Extremal Graph Theory Edward Tauscher Dobson, 1995

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