

Extremal Graph Theory

Lectured by A. Thomason

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Extremal Graph Theory

Béla Bollobás



Extremal Graph Theory:

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 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, 1986 *Four Problems in Extremal Graph Theory* Florian Pfender, 2002 *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 Turan's Theorem and the third part investigates a problem related to Hadwiger's Conjecture Let H be a graph t an integer and f_n a function The t Ramsey Turan number of H $RT_t(n, H, f_n)$ 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 Turan numbers for several graphs and hypergraphs proving two conjectures of Erdos Hajnal Simonovits Sos and Szemerédi In joint work with Jozsef Balogh our first main theorem is to provide the first lower bounds of order $\Omega(n^2)$ on $RT_t(n, K_{t-2}, o(n))$ Our second main theorem is to prove lower bounds on $RT(n, tk_r, s, o(n))$ where tk_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 Erdos 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 $\binom{n-r}{c}$ 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 Jozsef 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 \mathcal{F} free hypergraphs is

zero for several hypergraphs \mathcal{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 $K_{\lceil n/\alpha(G) \rceil}$ 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 $K_{\lfloor 2\alpha(G) \rfloor}$ as a minor.

Extremal Graph Theory Maya Jakobine Stein, 2010 [Extremal Graph Theory: Supersaturation and Enumeration](#) Hong Liu, 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, Vandenburg 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 $t \in \mathbb{H}$. 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.

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.

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Extremal Graph Theory Brandon Cruz,2009

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 $\text{bigcup}_{k \geq 0} \mathcal{F}_k$ 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

Topics in Extremal Graph Theory Peter Keevash,2003

Problems in Extremal Graph Theory André Kündgen,1999

Results in Extremal Graph Theory, Ramsey Theory and Additive Combinatorics Oliver Janzer,2020

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

Problems in Extremal Graph Theory and Euclidean Ramsey Theory Sergei Tsaturian, 2019 This thesis addresses problems of three types The first type is finding extremal numbers for unions of graphs each with a colour critical edge joint work with V Nikiforov In 1968 Simonovits found extremal numbers $ex(n, H)$ for graphs with a colour critical edge for large n without specifying how large A similar result for unions of graphs each with a colour critical edge can be deduced from Simonovits 1974 work Nikiforov and I improved this result giving a precise bound for n The second type of problem considered is maximizing the number of cycles in a graph joint work with A Arman and D Gunderson It is proved that for sufficiently many vertices the complete balanced bipartite graph is the unique triangle free graph with the maximum number of cycles thus answering a conjecture posed by Durocher et al Other results include upper and lower bounds on the maximum number of cycles in graphs and multigraphs with a given number of edges or with a given number of vertices and edges The lower bounds in some cases come from random graphs the asymptotics for the expected number of cycles in the random graph $G(n, m)$ is found for all possible relations between n and m The final chapter is dedicated to Euclidean Ramsey theory Two results about two colouring of Euclidean spaces are given One of the results answers in the affirmative a question asked in 1973 by Erdős and others if the Euclidean plane is coloured in red and blue are there either two red points at distance one or five blue points on a line with distance one between consecutive points The second result joint work with A Arman answers the similar question for six points in 3 dimensional space

Problems in Extremal Graph Theory Kamil Popielarz, 2018 [The Mathematics of Paul Erdős II](#) Ronald L. Graham, Jaroslav Nešetřil, Steve Butler, 2013-08-04 This is the most comprehensive survey of the mathematical life of the legendary Paul Erdős 1913-1996 one of the most versatile and prolific mathematicians of our time For the first time all the main areas of Erdős research are covered in a single project Because of overwhelming response from the mathematical community the project

now occupies over 1000 pages arranged into two volumes. These volumes contain both high level research articles as well as key articles that survey some of the cornerstones of Erdős's work, each written by a leading world specialist in the field. A special chapter, "Early Days," rare photographs and art related to Erdős complement this striking collection. A unique contribution is the bibliography on Erdős's publications, the most comprehensive ever published. This new edition, dedicated to the 100th anniversary of Paul Erdős's birth, contains updates on many of the articles from the two volumes of the first edition, several new articles from prominent mathematicians, a new introduction and more biographical information about Paul Erdős with an updated list of publications. The second volume contains chapters on graph theory and combinatorics, extremal and Ramsey theory, and a section on infinity that covers Erdős's research on set theory. All of these chapters are essentially updated, particularly the extremal theory chapter that contains a survey of flag algebras, a new technique for solving extremal problems.

The Mathematics of Paul Erdős II Ronald L. Graham, Jaroslav Nešetřil, 2012-12-06

In 1992, when Paul Erdős was awarded a Doctor Honoris Causa by Charles University in Prague, a small conference was held bringing together a distinguished group of researchers with interests spanning a variety of fields related to Erdős's own work. At that gathering, the idea occurred to several of us that it might be quite appropriate at this point in Erdős's career to solicit a collection of articles illustrating various aspects of Erdős's mathematical life and work. The response to our solicitation was immediate and overwhelming, and these volumes are the result. Regarding the organization, we found it convenient to arrange the papers into six chapters, each mirroring Erdős's holistic approach to mathematics. Our goal was not merely a random collection of papers, but rather a thoroughly edited volume composed in large part by articles explicitly solicited to illustrate interesting aspects of Erdős and his life and work. Each chapter includes an introduction which often presents a sample of related Erdős problems in his own words. All these, sometimes lengthy, introductions were written jointly by editors. We wish to thank the nearly 70 contributors for their outstanding efforts and their patience. In particular, we are grateful to Bela Bollobás for his extensive documentation of Paul Erdős's early years and mathematical high points in the first part of this volume; our other authors are acknowledged in their respective chapters. We also want to thank A. Bondy, G. Hahn, I. [Extremal Graph and Hypergraph Theory](#) Dhruv Mubayi, Jacques A. Verstraëte, 2026-04-30

Providing a cohesive reference for advanced undergraduates, graduate students, and even experienced researchers, this text contains both introductory and advanced material in extremal graph theory, hypergraph theory, and Ramsey theory. Along the way, the book includes many modern proof techniques in the field, such as the probabilistic method and algebraic methods. Several recent breakthroughs are presented with complete proofs, for example, recent results on the sunflower problem and off-diagonal and geometric Ramsey theory. It is perhaps unique in containing material on both hypergraph regularity and containers. Featuring an extensive list of exercises, the text is suitable as a teaching text for a variety of courses in extremal combinatorics. Each of the two parts can form the basis of separate courses, and the majority of sections are designed to match the length of a single lecture.

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