### 2013 Colloquia in Combinatorics

Two consecutive one-day events hosted by QMUL and LSE

### A full report of the event can be read here



Wednesday 15th May 2013

Thursday 16th May 2013



THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Noga Alon (Tel Aviv)

Roman Glebov (Warwick)

Gábor Kun (Budapest)

Viresh Patel (Birmingham)

Endre Szemerédi (Budapest)

Julia Wolf (Paris)

Venue: New Theatre, East Building, LSE (room number: EAS.E171)

Contact: Dr Jozef Skokan (j.skokan@lse.ac.uk)

Those interested are welcome to attend for all or any part of the event. The two hosting institutions are less than half an hour apart by tube; it is hoped that many people will be able to attend for both days. There is no formal registration process and seats will be allocated each day on a first come, first served basis.

Queries should be sent to Rebecca Lumb.

### Funding

Some funds are available to contribute to the **basic** travel expenses of research students who wish to attend the meetings. We would ask you to keep costs to a minimum, using public transport on **all** occasions and off-peak student travel tariffs wherever possible. Receipts for all journeys must be maintained as proof of travel. At this stage, we are unable to confirm the maximum amount available; please contact <u>Rebecca Lumb</u> for further information.

There are also some funds available from the London Mathematical Society for help with childcare costs. Further details can be found at <a href="http://www.lms.ac.uk/content/childcare-supplementary-grants">http://www.lms.ac.uk/content/childcare-supplementary-grants</a>.

### Event Support

Support for this event by the <u>London Mathematical Society</u> and the <u>British Combinatorial</u> <u>Committee</u> is gratefully acknowledged by the organisers.









### Wednesday 15 May 2013 Start time: 10:30 (coffee from 10:00)

Venue: Maths Lecture Theatre, Mathematical Sciences Building, QMUL (campus

map: http://www.qmul.ac.uk/docs/about/26065.pdf. Please note: this is not the same venue as last year)

Time	Speaker (Institution)	Presentation title
10:00	Coffee	
10:30	Anusch Taraz (Munich)	Density and Ramsey results concerning graphs with sublinear bandwidth
11:20	Julia Böttcher (LSE)	A Blow-up Lemma for sparse graphs
12:10	Lunch (own arrangements – options on campus and nearby)	
13:30	Wojciech Samotij (Tel Aviv)	Typical structure of graph homomorphisms
14:20	Danny Hefetz (Birmingham)	Winning strong games through fast strategies for weak games
15:10	Afternoon tea break	
15:40	Simon Griffiths (IMPA)	The triangle-free process and R(3,k)
16:30	Ben Green (Cambridge)	The sum-free set constant is 1/3
17:20	End	



THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

### Thursday 16 May 2013 Start time: 10:00

### Venue: New Theatre, East Building, LSE (room number: EAS.E171)

(map and directions: <u>http://www2.lse.ac.uk/mapsAndDirections/findingYourWayAroundLSE.aspx</u>)

Time	Speaker (Institution)	Presentation title
10:00	Roman Glebov (Warwick)	On bounded degree spanning trees in the random graph
10:50	Coffee break	
11:20	Endre Szemerédi (Budapest)	A new proof of the Pósa-Seymour Conjecture
12:10	Gábor Kun (Budapest)	A measurable version of the Lovász Local Lemma
13:00	Lunch (own arrangements – options on campus and nearby)	
14:10	Viresh Patel (Birmingham)	A conjecture of Thomassen on Hamilton cycles in highly connected tournaments
15:00	Afternoon tea break	
15:30	Julia Wolf (Paris)	Sumsets, sampling and almost periodicity
16:20	Noga Alon (Tel Aviv)	THE NORMAN BIGGS LECTURE: Random Cayley graphs
17:20	End	





## **Queen Mary, University of London**

## The London School of Economics and Political Science

# Two One-Day Colloquia in Combinatorics 2013



15th & 16th May 2013

If attending both days, please keep this programme for day two

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## **INFORMATION**

Those interested are welcome to attend for all or any part of the event; it is hoped that many people will be able to attend for both days.

Some funds are available to contribute to the **basic** travel expenses of **research students** who attend the meetings. We ask you to keep costs to a minimum, using public transport on **all** occasions and off-peak student travel tariffs wherever possible. Receipts for all journeys must be maintained as proof of travel. At this stage, we are unable to confirm the maximum amount available; please contact Rebecca Lumb (r.c.lumb@lse.ac.uk) for further information.

Event organisers: Prof Peter Keevash (QMUL) and Dr Jozef Skokan (LSE).

## **SUPPORT**

Support for this event by the London Mathematical Society (<u>www.lms.ac.uk</u>) and the British Combinatorial Committee (<u>www.maths.qmul.ac.uk/~pjc/bcc</u>) is gratefully acknowledged.





## WEDNESDAY 15<sup>th</sup> MAY 2013: Schedule

The first day of the Colloquia in Combinatorics will be held at Queen Mary, University of London on Wednesday 15<sup>th</sup> May, starting at 10.30am. Everyone interested is welcome to attend any part of the event. All the talks will be held in the Maths Lecture Theatre, Mathematical Sciences Building, Mile End Campus, QMUL.

Time	Speaker (Institution)	Presentation title	
10:00		Coffee	
10:30	Anusch Taraz (Munich)	Density and Ramsey results concerning graphs with sublinear bandwidth	
11:20	Julia Böttcher (LSE)	A Blow-up Lemma for sparse graphs	
12:10	<b>Lunch</b> (own arrangements – options on campus and nearby)		
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16:30	Ben Green (Cambridge)	The sum-free set constant is 1/3	
17:20	End		

### Density and Ramsey results concerning graphs with sublinear bandwidth

### Anusch Taraz

The existence of Hamilton paths and cycles in host graphs satisfying certain conditions is one of the central questions in extremal graph theory. We survey recent results that generalize these questions from paths to spanning graphs with sublinear bandwidth and discuss bounds on the 2- and 3-colour Ramsey numbers of planar graphs and grids in particular.

#### A Blow-up Lemma for sparse graphs

### Julia Böttcher

The Blow-Up Lemma of Komlós, Sárközy and Szemerédi is an important tool for embedding large graphs H into dense graphs G. We recently obtained versions of this lemma for subgraphs G of sparse random and pseudo-random graphs.

In the talk I will explain our results, outline the methods we use in the proofs and describe some applications.

Joint work with Peter Allen, Hiep Hán, Yoshi Kohayakawa and Yury Person

### Typical structure of graph homomorphisms

### Wojciech Samotij

Given two graphs G and H, a graph homomorphism from G to H is a mapping of V(G) to V(H) that maps edges of G to edges of H. Counting and describing the typical structure of homomorphisms between graphs have many interesting aspects and a surprising number of applications. Numerous models in statistical mechanics and questions in extremal graph theory can be phrased in these terms.

In this talk, we will focus our attention on the case when H is some small fixed graph, which can be thought of as a generalization of graph coloring. For many natural classes C of graphs, one observes the following phenomenon: A typical homomorphism from every G in C to H is very rigid, exhibiting strong spatial correlations. We will discuss several examples of this phenomenon, focusing on two particular settings:

(i) G is (a large subbox of) the d-dimensional integer grid;

(ii) G is a regular bipartite graph with strong expansion properties.

We will also state several open questions. No prior knowledge of graph homomorphism or expander graphs will be assumed.

Joint work with Ron Peled (Tel Aviv University) and Amir Yehudayoff (Technion).

#### Winning strong games through fast strategies for weak games

#### Danny Hefetz

Given a strong game which is known to be a first player's win, one would like to know how to win the game, that is, to have an explicit winning strategy for the first player. Unfortunately, this is a very hard problem in general and very few such strategies are known. In this talk we will see how such strategies can be found by using explicit fast winning strategies for the corresponding weak games.

### The triangle-free process and R(3, k)

### Simon Griffiths

The *triangle-free process* (introduced by Bollobás and Erdős) starts with the empty graph on n vertices, and at each step thereafter a uniformly random edge is added subject to the condition that no triangle is created in the graph. The process ends when we reach a maximal triangle-free graph; which we denote  $G_{n,\triangle}$ . Bohman, using the differential equations method of Wormald, proved that

$$e(G_{\mathsf{n},\triangle}) = \Theta(n^{3/2}\sqrt{\log n}),$$

with high probability.

In this talk we discuss recent progress in understanding this process. Using the self-correcting nature of families of random variables associated with the evolution of the process we prove that

$$e(G_{\mathsf{n},\triangle}) = \left(\frac{1}{2\sqrt{2}} + o(1)\right) n^{3/2} \sqrt{\log n} \,,$$

with high probability.

In addition, this improved understanding allows us to bound the independence number of  $G_{n,\triangle}$  by  $(\sqrt{2}+o(1))\sqrt{n \log n}$ , which implies the following lower bound on off-diagonal Ramsey numbers:

$$\left(\frac{1}{4} - o(1)\right) \frac{k^2}{\log k} \le R(3,k) \le \left(1 + o(1)\right) \frac{k^2}{\log k} \,,$$

the upper bound here is due to Shearer.

Based on joint work with Gonzalo Fiz Pontiveros and Robert Morris. Similar results have been obtained independently by Thomas Bohman and Peter Keevash.

### The sum-free set constant is 1/3

### Ben Green

A well-known argument of Erdős, often used as a simple example to illustrate the probabilistic method, proves that any set of n integers contains a sum-free subset of size at least n/3. (Sum-free means it has no solutions to x + y = z.) Recently, jointly with Sean Eberhard and Freddie Manners, we have shown that the constant 1/3 is best possible. The proof uses an "arithmetic" version of the regularity lemma, some sumset estimates and the Brunn-Minkowski theorem about convex bodies. I will try and give an overview of it.



## **PLACES TO EAT: in and around QMUL**

Drapers Bar and Kitchen – wide range to suit all dietary requirements, Bancroft Road Drunken Monkey – Asian fusion, Westfield Way Greedy Cow – gastropub food, Grove Road Half Moon Pub – Wetherspoons serving standard pub food, Mile End Road Matsu – Japanese food, Mile End Road Morgan Arms – Up-market pub food, Morgan Street Mucci's – Italian trattoria, Library Square Nandos – Portuguese Chicken, Mile End Road Pride of Asia – Bangladeshi restaurant with all-you-can-eat buffet, Mile End Road The Curve – international food to eat-in or take away, Westfield Way The Jasmine Kitchen – railway arch café serving Thai food, White Church Lane



### Mile End Campus Map Index

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**Facilities** 

#### (i) Information

Visitors who require further information or assistance please go to the Main Reception in the Queens' Building.

- Please do not smoke on the campus.
- These premises are alarmed and monitored by CCTV, please call security on 020 7882 5000 for more information.
- Library/bookshop
- (b) Fitness centre
- 🕦 Bar
- Coffee place
- Eatery
- (P) Staff Car Park
- Hicycle Parking
- (£) Cash Machine





## THURSDAY 16<sup>th</sup> MAY 2013: Schedule

The second day of the Colloquia in Combinatorics will be held at the London School of Economics and Political Science on Thursday 16<sup>th</sup> May, starting at 10.00am. Everyone interested is welcome to attend any part of the event. The talks will be held in the New Theatre (room number: EAS.E171), East Building, LSE; refreshments breaks will be taken in EAS.E168, East Building, LSE.

Time	Speaker (Institution)	Presentation title	
10:00	Roman Glebov (Warwick)	On bounded degree spanning trees in the random graph	
10:50		Coffee break (room EAS.E168)	
11:20	Endre Szemerédi (Budapest)	A new proof of the Pósa-Seymour Conjecture	
12:10	Gábor Kun (Budapest)	A measurable version of the Lovász Local Lemma	
13:00	<b>Lunch</b> (own arrangements – options on campus and nearby)		
14:10	Viresh Patel (Birmingham)	A conjecture of Thomassen on Hamilton cycles in highly connected tournaments	
15:00	Afternoon tea break (room EAS.E168)		
15:30	Julia Wolf (Paris)	Sumsets, sampling and almost periodicity	
16:20	Noga Alon (Tel Aviv)	THE NORMAN BIGGS LECTURE: Random Cayley graphs	
17:20	End		

#### On bounded degree spanning trees in the random graph

### Roman Glebov

The appearence of certain spanning subraphs in the random graph is a wellstudied phenomenon in probabilistic graph theory. In this talk, we present results on the threshold for the appearence of bounded-degree spanning trees in G(n, p)as well as for the corresponding universality statements. In particular, we show hitting time thresholds for some classes of bounded degree spanning trees.

Joint work with Daniel Johannsen and Michael Krivelevich.

#### A new proof of the Pósa-Seymour Conjecture

#### Endre Szemerédi

In 1974 Paul Seymour conjectured that any graph G of order n and minimum degree at least  $\left(\frac{k-1}{k}\right)n$  contains the  $(k-1)^{th}$  power of a Hamiltonian cycle. This conjecture was proved by Komlós, Sárközy and Szemerédi earlier with the help of the Regularity Lemma – Blow-up Lemma method for  $n \ge n_0$  where  $n_0$  is very large. Here we present another proof that avoids the use of the Regularity Lemma and thus the resulting  $n_0$  is much smaller. The main ingredient is a new kind of connecting lemma.

This work is joint with Asif Jamshed.

### A measurable version of the Lovász Local Lemma

#### Gábor Kun

The Lovász Local Lemma was first applied to hypergraph colouring problems. Lovász and Erdős proved that for every subset S of the real numbers if  $k \gg 1 + |S|\log(|S|)$  then the real line can be coloured by k colours so that every translate S + x will contain all k colours. But can we get measurable colour classes in similar theorems?

We give a measurable version of the Lovász Local Lemma. We apply this to the dynamical version of the von Neumann problem.

### A conjecture of Thomassen on Hamilton cycles in highly connected tournaments

#### Viresh Patel

A conjecture of Thomassen from 1982 states that for every k there is an f(k) such that every strongly f(k)-connected tournament contains k edge-disjoint Hamilton cycles. A classical theorem of Camion, that every strongly connected tournament contains a Hamilton cycle, implies that f(1) = 1. Until now, even the existence of f(2) was open. In this talk, I will discuss a proof of Thomassen's conjecture. Our methods in fact allow us to show that  $f(k) = O(k^2 \log^2 k)$ , which is best possible up to the logarithmic factor.

This is joint work with Daniela Kühn, John Lapinskas, and Deryk Osthus.

### Sumsets, sampling and almost periodicity

### Julia Wolf

So-called "almost-periodicity" results for sumsets, first introduced by Croot and Sisask in 2009, have led to important quantitative advances in additive combinatorics in recent years. We explain the general philosophy and give a new statement and proof that avoids  $L^p$  norms and relies exclusively on Chernoff-type tail estimates. If time permits, we will sketch an application to the decoding of Reed-Muller codes of order 2.

This is joint work with Eli Ben-Sasson, Noga Ron-Zewi and Madhur Tulsiani.

## "The Norman Biggs Lecture"

### **Random Cayley Graphs**

Noga Alon

The study of random Cayley graphs of finite groups is related to the investigation of Expanders and to problems in Combinatorial Number Theory and in Information Theory. I will discuss this topic, describing the motivation and focusing on the question of estimating the chromatic number of a random Cayley graph of a given group with a prescribed number of generators.



THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

## **PLACES TO EAT: in and around LSE**

### **Close by:**

All Bar One - Kingsway Belgo - Kingsway Café Amici - Kingsway Café Nero - Kingsway Costa - Kingsway EAT - Kingsway Hot - Kingsway Paul - Kingsway Pret a Manger - Kingsway Sainsburys - Kingsway Starbucks - Kingsway Subway - Kingsway The Delaunay - Aldwych Wasabi - Kingsway

### **On campus:**

3 Tuns - Ground floor, Clare Market St Café 54 - Ground floor, New Academic Building Fourth Floor Café Bar - Old Building Fourth Floor Restaurant - Old Building George IV Pub - Portugal Street LSE Garrick - Ground floor, Columbia House Mezzanine Café - New Academic Building Plaza Café - John Watkins Plaza





**Disabled** access

Disabled lift

P& Disabled parking

Toilets for

wheelchair user

Unisex toilets

disabled access

information

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Portable ramp for 20 Kingsway (KSW only) is located in entrance fover. Please call 020 7955 6200 for Security staff to set up the ramp on request.

After 6.30pm, please call Security Control on 020 7955 6200 to ensure that any disabled access doors are open.





King's Chambers Portugal Street

#### 20 Kingsway

KGS

KSW

50L

32L

LCH

LAK

LRB

NAB

50 Lincoln's Inn Fields Portsmouth Street

- 32 Lincoln's Inn Fields
- Lincoln Chambers Portsmouth Street
- Lakatos Building Portugal Street

Lionel Robbins Building, Library and LSE Research Lab

- New Academic Building Lincoln's Inn Fields
- New Students' Centre Development NSC Sheffield Street OLD PAR PEA POR SAR

Old Building Houghton Street
Parish Hall Sheffield Street
Peacock Theatre Portugal Street
1 Portsmouth Street

Sardinia Ho	use Sardinia	Stree
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**Student Services Centre** Ground floor, Old Building

**Graham Wallas Room** OLD 5.25, Old Building

**Hong Kong Theatre** Ground floor, Clement House

New Theatre EAS E171, East Building

**Old Theatre** Ground floor, Old Building

Shaw Library Sixth floor, Old Building

Sheikh Zayed Theatre New Academic Building

Thai Theatre New Academic Building

The Wolfson Theatre New Academic Building

**Vera Anstey Room** Between ground and first floor, Old Building

3 Tuns Ground floor, Clare Market St

Café 54 Ground floor, New Academic Building

Daily Grind Tower 1/2 Reception Fourth Floor Café Bar Old Building

**Fourth Floor Restaurant** 

Old Building

George IV pub Between LCH and KGS, Portugal Street

LSE Garrick Ground floor, Columbia House

Mezzanine Café New Academic Building

Plaza Café John Watkins Plaza

**Senior Common Room** and Dining Room Fifth floor, Old Building

**Student Common Room** Ground floor, King's Chambers

HF	Sheffield Street
тс	St Clement's Clare Market
W1	Tower One Clement's Inn
W2	Tower Two Clement's Inn
W3	Tower Three Clement's Inn

January 2013





### Queen Mary, University of London & The London School of Economics and Political Science

### Two One-Day Colloquia in Combinatorics, 2013 15<sup>th</sup> & 16<sup>th</sup> May 2013

### Event organisers: Prof Peter Keevash (QMUL) and Dr Jozef Skokan (LSE)

The website associated with the conference is: <a href="http://www2.lse.ac.uk/maths/Seminars/Colloquia">http://www2.lse.ac.uk/maths/Seminars/Colloquia</a> 2013.aspx

The conference followed the successful format established over the past seven years: six invited talks were delivered on each of the two days. The meeting went according to plan, and our expectations were met in full. Most participants attended both days. The conference attracts both excellent speakers and a steadily growing audience, with participants coming not only from the UK but also from continental Europe.

The Queen Mary day started with two talks on topics from extremal graph theory: first, Anusch Taraz surveyed recent results and methods for finding spanning subgraphs in a given host graph, and he also discussed how to adopt these methods for the use in Ramsey theory. Then, Julia Böttcher gave a great talk about the new extension of the Blow-up Lemma to sparse graphs and its applications. Afterwards, Wojciech Samotij talked about counting and describing the typical structure of homomorphisms between graphs and Danny Hefetz spoke about finding winning strategies in two-player games on graphs. In the next talk, Simon Griffiths gave an excellent exposition of some of the recent intriguing work on the triangle-free processes that yielded the best known lower bounds on the Ramsey number R(3,k). The programme culminated in an excellent talk by Ben Green who outlined the proof of a conjecture of Paul Erdős from 1965: For every c>0 there exists a set A of n integers with the following property: every subset B of A with at least (1/3 + c)n elements contains three distinct elements x, y, z with x + y = z.

At the LSE day, the first talk was by Roman Glebov who discussed thresholds for the appearance of bounded-degree spanning trees in the random graph G(n, p). In the next talk, Endre Szemerédi (2012 Abel Prize Laureate) revisited some classical results proved 20 years ago using his famous Regularity Method and showed how to obtain quantitative improvements of the same results by avoiding the very same Regularity Method. The morning session was concluded by Gábor Kun who talked on the measurable version of the Lovász Local Lemma. In the afternoon, Viresh Patel gave a beautiful talk about his recent proof of a conjecture of Thomassen on Hamilton cycles in highly connected tournaments. Afterwards, Julia Wolf spoke about the role of almost periodicity results for sumsets in additive combinatorics. The final talk, the traditional Norman Biggs lecture, was delivered by Noga Alon. In his captivating talk, Professor Alon talked about random Cayley graphs of finite groups and discussed their connection and relations to problems in combinatorial number theory and information theory.

Support for this event by the London Mathematical Society and the British Combinatorial Committee is gratefully acknowledged by the organisers.