Birmingham Young Mathematicians Colloquium

18th April 2018

University of Birmingham

Plenary Speakers

Pure mathematics:

Kenneth Falconer
University of St Andrews

Valentina Grazian
University of Aberdeen

Annika Heckel
University of Oxford

Applied mathematics:

Daniel Jones
INRIA and École Polytechnique

Fabian Spill
University of Birmingham

James Sprittles
University of Warwick

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Organising Committee

Alexander Brune, Padraig Condon, Alberto Espuny Díaz (chair), Joel Mitchell

The organisers would like to thank The University of Birmingham and MAGIC for their financial support.

UNIVERSITY OF BIRMINGHAM

MAGIC

Schedule

Time	Lecture theatre A	Lecture theatre B	Lecture theatre C	Seminar room R17/18
9:30–10:00	Registration			
10:00–10:50	Results and problems in fractal geometry, (p. 1) **Kenneth Falconer**		Nanoscale free surface flows: modelling beyond Navier-Stokes-Fourier, (p. 2) **James Sprittles**	
10:50–11:15	Coffee break			
11:15–11:40	Fractal-Dimensional Properties of Non-Decreasing Levy Processes, (p. 4) **Adam Barker**	Bochner-Riesz Means on H-Type Groups, (p. 5) **Adam Horwich**	Comparisons between BEM and MFS solutions in composite bi-material domain, (p. 9) **Taysir Dyhoum**	
11:40–12:05	On Julia sets for quasimeromorphic mappings, (p. 8) **Luke Warren**	Getting what you pay for: an introduction to algebraic K-theory, (p. 6) **Dylan Madden**	A stochastic epidemic model for interacting populations, (p. 9) **Sophie Meakin**	
12:05–13:35	Lunch Break			
13:35–14:25	I'm a fusion system, nice to meet you, (p. 1) **Valentina Grazian**		Tropical cellular automata – why urban fires propagate according to polyhedral balls, (p. 2) **Daniel Jones**	
14:25–15:15	Colouring random graphs, (p. 1) **Annika Heckel**		Uncovering the malignant interplay of geometrical, physical and molecular drivers of tumour progression through mathematical models, (p. 2) **Fabian Spill**	
15:15–15:45	Coffee Break			

15:45–16:10	Solvability of boundary value problems for the Schrödinger equation with non-negative potentials, (p. 7) **Andrew Turner**	Jordan-Lie inner Ideals of associative algebras, (p. 7) **Hasan Shlaka**	Modelling The Gene Regulatory Network Governing Efflux Pump Expression In Gram-Negative Bacteria, (p. 10) **George Youlden**	Maximal Cocliques in $\mathrm{PSL}_2(q)$, (p. 7) **Jack Saunders**
16:10–16:35	The Schrödinger equation and the wavelet transform, (p. 4) **Fadhel Almalki**	The Noetherianity of some Idealiser Subrings, (p. 7) **Ruth Reynolds**	Mathematical Modelling of Buruli Ulcer Lesion Development, (p. 8) **Fatumah Atuhaire**	A bandwidth theorem for approximate decompositions, (p. 5) **Padraig Condon**
16:35–17:00	Existence of extremizers for a Strichartz estimate for the fourth order Schrödinger equation, (p. 5) **Gianmarco Brocchi**	Graded multiplicities in the exterior algebra of the little adjoint module, (p. 4) **Ibukunoluwa Ademehin**	The bending edge wave on an orthotropic elastic plate supported by the Winkler-Fuss foundation, (p. 8) **Saad Althobaiti**	Equicontinuity, Transitivity and Chaos, (p. 6) **Joel Mitchell**
17:00–17:25	A Hausdorff measure result for a problem of approximation by polynomials, (p. 7) **Alessandro Pezzoni**	Recent developments in the study of finite p-groups and Higman's PORC conjecture, (p. 6) **Seungjai Lee**	Analysis of the dispersion relation for an incompressible isotropic elastic three-layered laminated structure with free faces, (p. 9) **Maha Mohammed Helmi**	Rainbow H-factors, (p. 5) **Matt Coulson**

Lecture theatre A:	ground floor
Lecture theatre B:	1st floor
Lecture theatre C:	ground floor
Seminar room R17/18:	1st floor

For directions to the School of Mathematics, see page 11.

Plenary talks

Pure mathematics

Results and problems in fractal geometry

Kenneth Falconer, University of St Andrews
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I will talk about a number of easily appreciated problems in fractal geometry some of which have been solved, at least partially, and some of which remain major challenges.

I'm a fusion system, nice to meet you

Valentina Grazian, University of Aberdeen
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In finite group theory, the word fusion refers to the study of conjugacy relations between subgroups of a group. More precisely, if G is a finite group, p is a prime dividing the order of G and S is a Sylow p-subgroup of G, we say that subgroups X and Y of S are fused in G if there is an element g of G such that $g^{-1}Xg = Y$. The modern way to solve problems involving fusion is via the theory of fusion systems. The aim of this talk is to introduce the theory of fusion systems, with particular emphasis on its connections with the theorem of Classification of Finite Simple Groups.

Colouring random graphs

Annika Heckel, University of Oxford
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The chromatic number of a graph is the least number of colours needed to colour its vertices so that no two adjacent vertices are coloured the same. In this talk we will consider the chromatic number of the random graph $G(n, p)$, which is the random graph on n vertices where each potential edge is included with probability $p = p(n)$. Determining the chromatic number of $G(n, p)$ is one of the classic challenges in random graph theory which has been studied intensively since at least the 1970s. We will give an overview of known results for different ranges of $p = p(n)$, before focussing on recent developments in the dense case where p is constant and in particular when $p = 1/2$. We also discuss related colouring concepts such as equitable colourings.

Applied mathematics

Tropical cellular automata – why urban fires propagate according to polyhedral balls

Daniel Jones, INRIA and École Polytechnique

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In order to analyse the propagation of fire in urban areas, we study a deterministic percolation model on a regular grid in which fire propagates from a point to a bounded neighbourhood of this point (with time constants depending on the jump). Using discrete geometry methods, we obtain an explicit formula for the propagation speed. We show in particular that for a large time horizon, the wave front is close to the boundary of a ball with respect to a polyhedral weak-Minkowski semi-norm which can be determined analytically from the time constants. We illustrate the model by simulations on data from the Kobe fire following the 1995 Southern Hyōgo Prefecture Earthquake, indicating that this deterministic model gives an accurate account of actual urban fires.

Uncovering the malignant interplay of geometrical, physical and molecular drivers of tumour progression through mathematical models

Fabian Spill, University of Birmingham

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Cancer is long known to be a genetic disease, where mutations drive malignant behaviour such as increasing cellular growth or causing the cells to migrate to distant organs, leading to deadly metastases. Yet, it is increasingly appreciated that genes are not everything, and the behaviour of cancer cells is highly context dependent. Physical properties are some of these factors that may vary in different tumours and cause different cell behaviour, and the geometry of a cell may also determine its malignant potential. For instance, recent evidence shows that cellular forces or extracellular stiffness of the tumour may change the conformation of signalling molecules within tumour cells, which thus changes their biochemistry and may increase their malignant behaviour. This means that molecules in intracellular reaction networks may not necessarily be approximated by point particles, but the forces acting on them may need to be taken into account. Similarly, many mathematical models describing reactions within cells assume these molecules are well mixed. Yet, in reality, many molecules localise to specific compartments within the cell. Changes in the geometry of the cell may then redistribute the molecules, altering their effective biochemical behaviour. In this talk, I will show some examples of mathematical models that take the geometry of the cell or physical forces into account and show how this can lead to novel insights into the behaviour of cancer cells.

Nanoscale free surface flows: modelling beyond Navier-Stokes-Fourier

James Sprittles, University of Warwick

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Understanding the behaviour of liquid-gas interfaces at the micro and nano scale is key to a myriad of phenomena, ranging from the formation of clouds through to 3D printing. Accurate experimental observation of such phenomena is complex due to the small spatio-temporal scales of interest and,

consequently, mathematical modelling and computational simulation become key tools with which to probe such flows.

As the characteristic scales of interest become comparable to microscopic scales, for a gas the mean free path and for a liquid the molecular diameter, the basic Navier-Stokes-Fourier (NSF) paradigm no longer provides an accurate description of the flow physics. However, microscopic models such as the kinetic theory of gases or molecular dynamics (MD) of liquids become computationally intractable for many flows of practical interest. In this talk I will consider a number of approaches to going beyond NSF, whilst remaining in a continuum framework that allows for efficient computation and clear analysis of results.

I will consider two specific free surface flows which are influenced by nanoscale physics, namely, the breakup of liquid nanojets, where MD will provide a benchmark, and the role of gas nano films trapped under impacting of liquid drops, where we can compare directly to recent experimental observations. In each case a model going beyond NSF will be developed and its implications will be discussed.

Short talks

Pure mathematics

Graded multiplicities in the exterior algebra of the little adjoint module

Ibukunoluwa Ademehin, University of Manchester

The algebraic problem of decomposing the exterior algebra of a Lie algebra g-module is as old as Kostant's work on the structure of the invariant ring of the exterior algebra of the adjoint module of a simple complex Lie algebra g. I will be talking about the graded multiplicities of the invariants and the little adjoint module in the exterior algebra of the little adjoint module, obtained from Macdonald's and Cherednik's weight functions and inner products on irreducible characters of g-modules and from an application of Cherednik's algebra with unequal parameters on Weyl orbits. I will show how these results shed some light on other submodules/subalgebras of the exterior algebra of the little adjoint module linking my work to the recent results of De Concini, Frajria, Papi and Procesi.

The Schrödinger equation and the wavelet transform

Fadhel Almalki, University of Leeds
This research is joint work with Vladimir V. Kisil

I will present a method of reduction that leads to an exact generic solution to the Schrödinger equation based on using basic properties of the wavelet transform of nilpotent Lie groups, the Heisenberg group and a three-step nilpotent Lie group which has been referred to as anharmonic group. The method reveals an interesting connection between the wavelet transform of the anharmonic group and the notion of the squeezed states in quantum optics.

Fractal-Dimensional Properties of Nondecreasing Levy Processes

Adam Barker, University of Reading

We consider the box-counting dimension of sets related to nondecreasing Levy processes (subordinators). It was recently shown in [2] that $U(\delta)N(t,\delta)$ converges to t almost surely as δ tends to zero, where $N(t,\delta)$ is the minimal number of boxes of size at most δ needed to cover a subordinator's range up to time t, and $U(\delta)$ is the subordinator's renewal function. The main result is a central limit theorem (CLT) for $N(t,\delta)$, complementing and refining work in [2].

Box-counting dimension is defined in terms of $N(t,\delta)$, but for subordinators we prove that it can also be defined using a new process obtained by shortening the original subordinator's jumps of size greater than δ. This new process can be manipulated with remarkable ease in comparison to $N(t,\delta)$, and allows us to understand the box-counting dimension of a subordinator's range in terms of its Levy measure, significantly improving upon [2, Corollary 1]. Corresponding CLT and almost sure convergence results for the new process are then given for all subordinators with fractal structure (those with infinite Levy measure).

[1] A. Barker. Fractal-dimensional properties of subordinators. *J. Theor. Probab. (accepted)*, 2018.

[2] M. Savov. On the range of subordinators. *Elec. Commun. Probab.*, 2014.

Existence of extremizers for a Strichartz estimate for the fourth order Schrödinger equation

Gianmarco Brocchi, University of Birmingham
This research is joint work with Diogo Oliveira e Silva and René Quilodrán

In dispersive PDE, Strichartz estimates are a fundamental tool in understanding the evolution of waves. The search for extremizers in the corresponding inequalities is an active area of research, and is intimately related with the study of the Fourier extension operator from certain hypersurfaces. In this talk, we discuss a sharp Strichartz estimate for the fourth order Schrödinger equation. A careful analysis of the convolution measure on the quartic shows that extremizers for this inequality do exist.

A bandwidth theorem for approximate decompositions

Padraig Condon, University of Birmingham
This research is joint work with Jaehoon Kim, Daniela Kühn and Deryk Osthus

We provide a degree condition on a regular n-vertex graph G which ensures the existence of a near optimal packing of any family $\mathcal{H}$ of bounded degree n-vertex k-chromatic separable graphs into G. In general, this degree condition is best possible.

Here a graph is separable if it has a sublinear separator whose removal results in a set of components of sublinear size. Equivalently, the separability condition can be replaced by that of having small bandwidth. Thus our result can be viewed as a version of the bandwidth theorem of Böttcher, Schacht and Taraz in the setting of approximate decompositions.

As an example, our result implies that if $\mathcal{H}$ is a family of bounded degree n-vertex trees with $|\mathcal{H}| \leq (1 - o(1))\, d/2$ and G is any d-regular n-vertex graph with $d \geq (1 + o(1))\, n/2$, then there is an (edge-disjoint) packing of these trees into G. This yields an approximate version of the tree packing conjecture of Gyarfas and Lehel in the setting of regular host graphs of high degree.

Rainbow H-factors

Matt Coulson, University of Birmingham
This research is joint work with Peter Keevash, Guillem Perarnau and Liana Yepremyan

The study of rainbow substructures goes back to the Ryser-Brualdi-Stein conjecture on transversalis in Latin squares which can be thought of as rainbow matchings in properly edge coloured complete bipartite graphs. A subgraph H of the edge coloured r-graph G is called rainbow if every edge of H has an unique colour.

For any r-graph H, we consider the problem of finding a rainbow H-factor in an r-graph G with large minimum ℓ-degree and an edge-colouring that is suitably bounded. We show that the asymptotic degree threshold is the same as that for finding an H-factor.

Bochner-Riesz Means on H-Type Groups

Adam Horwich, University of Birmingham

Let G be a stratified Lie group G and $\{X_1, \ldots, X_m\}$ be a set of invariant vector fields forming an orthonormal basis of the first layer of the corresponding Lie algebra. A sub-Laplacian on G is then defined by $L = -\sum_{l=1}^{m} X_l$ with the Bochner-Riesz operator T_r^λ given by $(1 - rL)_+^\lambda$.

The question of when $T_r^\lambda f \to f$ almost-everywhere as $r \to 0$ has been studied in many contexts.

We briefly recall the known results for $\mathbb{R}^n$ [1] and when G is a Heisenberg group [2]. We will then discuss a result for H-type groups that also helps to simplify the proof of [2].

[1] Anthony Carbery, José L. Rubio de Francia, and Luis Vega. Almost everywhere summability of fourier integrals. *Journal of the London Mathematical Society*, s2-38(3):513–524, 1988.

[2] Dirk Gorges and Detlef Müller. Almost everywhere convergence of bochner–riesz means on the heisenberg group and fractional integration on the dual. *Proceedings of the London Mathematical Society*, 85(1):139–167, 2002.

Recent developments in the study of finite p-groups and Higman's PORC conjecture

Seungjai Lee, University of Oxford

Study of finite p-groups has always been one of the major topics in group theory. In 1960, Higman conjectured that the function $f(p^n)$ enumerating the number of groups of order p^n is Polynomial On Residue Classes (or PORC), which means for a fixed n, there is a finite set of polynomials in $p, g_1(p), g_2(p), \ldots, g_k(p)$, and a fixed integer M, such that for each prime p, $f(p^n) = g_i(p)$ for some $i\ (1 \leq i \leq k)$, with the choice of i depending on the residue class of p mod M. This is one of the fundamental conjectures in the theory of finite p-groups, and is still open for $n \geq 8$. In this talk I will survey some recent developments made on the conjecture.

Getting what you pay for: an introduction to algebraic K-theory

Dylan Madden, University of Warwick

An important notion in modern mathematics is that of an *invariant*. Informally, one may think of an invariant as a kind of machine which takes in one kind of mathematical object and spits out another, such that the output encodes information about the input. One elementary example would be the 'machine' which takes in a vector space and spits out its dimension.

Unsurprisingly, not all invariants are created equal. Some are 'expensive', that is, difficult to calculate, while others are 'low-quality', that is, not containing much information. In this talk, we will focus particularly on algebraic K-theory, which is an invariant of rings. We aim to demonstrate that K-theory is often difficult to calculate, but that the payoff for doing so is correspondingly large; in other words, you get what you pay for.

Equicontinuity, Transitivity and Chaos

Joel Mitchell, University of Birmingham

We provide a classification of topologically transitive dynamical systems in terms of equicontinuity pairs. We define what it means for a system to be eventually sensitive; we give a dichotomy for transitive dynamical systems in relation to eventual sensitivity. We discuss Devaney chaos and suggest an alternative, weaker, definition of chaos for which we give some modest results.

A Hausdorff measure result for a problem of approximation by polynomials

Alessandro Pezzoni, University of York

The study of the set $L_n(w)$ of points $x \in \mathbb{R}$ for which there are infinitely many integer polynomials of degree up to n such that

$$|P(x)| < H(P)^{-w}$$

has a long history, which dates back to 1932 with Kurt Mahler. In this talk we will introduce this problem in the context of Metric Number Theory and we shall show how to determine the generalised Hausdorff measure of $L_3(w)$ for a given dimension function g. Time permitting, we will also discuss how one might try to do this for $n > 3$.

The Noetherianity of some Idealiser Subrings

Ruth Reynolds, University of Edinburgh

In a ring R, the idealiser of a right ideal I in R is the largest subring of R in which I becomes a two-sided ideal. Idealisers often have interesting properties and can exhibit pathological behaviour. In particular, in this talk we will describe the noetherianity of idealisers in certain noncommutative rings.

Maximal Cocliques in $\mathrm{PSL}_2(q)$

Jack Saunders, University of Birmingham

The generating graph of a finite group is a graph whose vertices are the elements of the group and an edge is drawn between two vertices whenever these two elements generate the group, this is a structure which may be used to encode certain information about the group. We investigate the maximal cocliques (totally disconnected induced subgraphs) of the generating graph of $\mathrm{PSL}_2(q)$ for $q = p^n$ a prime power and provide a classification for when $n = 1$. We then outline an example for n even which shows that this result does not extend to the general case as-is.

Jordan-Lie inner Ideals of associative algebras

Hasan Shlaka, University of Leicester

This research is joint work with A. Baranov

A subspace B of a Lie algebra L is said to be an inner ideal if $[B, [B, L]] \subseteq B$. Suppose that L is a Lie subalgebra of an associative algebra A. Then an inner ideal B of L is said to be Jordan-Lie if $B^2 = 0$. In this talk, we describe Jordan-Lie inner ideals of the derived Lie subalgebras of finite dimensional associative algebras over an algebraically closed field F of characteristic not 2 or 3.

Solvability of boundary value problems for the Schrödinger equation with non-negative potentials

Andrew Turner, University of Birmingham

We consider Schrödinger equations of the form $\operatorname{div} A\nabla u + Vu = 0$, where V is a non-negative potential and A is a complex-valued, bounded multiplication matrix. We prove well posedness for boundary value problems in the upper half-space with L^2-Neumann and Dirichlet boundary data when A is complex Hermitian or of a certain block-type. We build on methods for unperturbed second-order elliptic systems by incorporating the potential V as an additive perturbation of a first order system DB with bounded holomorphic functional calculus.

On Julia sets for quasimeromorphic mappings

Luke Warren, University of Nottingham

Within complex dynamics, the key objects of study are the Fatou set and the Julia set. These are sets that partition the complex plane into 'stable' points and 'chaotic' points, based on the behaviour of the iterates of the function at that point. Quasiregular and quasimeromorphic mappings form higher dimensional analogues in real space of analytic and meromorphic mappings respectively. It is therefore reasonable to ask whether there is analogous Fatou-Julia theory in the new setting.

In this talk, we shall begin by briefly introducing Fatou and Julia sets from complex dynamics. From here, we shall introduce quasiregular and quasimeromorphic mappings with some examples. Then we shall briefly discuss the Fatou-Julia theory in the new setting, concluding with a new definition of a Julia set for quasimeromorphic mappings with an essential singularity at infinity and at least 1 pole.

Applied mathematics

The bending edge wave on an orthotropic elastic plate supported by the Winkler-Fuss foundation

Saad Althobaiti, Keele University

We consider bending edge wave on a semi-infinite orthotropic Kirchhoff plate Kirchhoff plate supported by a Winkler-Fuss foundation [1]. Then from the analysis of the dispersion relation, a local minimum of the phase velocity is observed. Due to a presence of a foundation, the bending edge wave possesses a cut-off frequency.

This local minimum is associated with the critical speed of the moving load. It is shown that the steady-state solution of a problem for moving bending moment corresponds to a beam-like behaviour on the edge. This feature is then confirmed from the specialised parabolic-elliptic formulation, oriented to extracting the contribution of the bending edge wave to the overall dynamic response.

Mathematical Modelling of Buruli Ulcer Lesion Development

Fatumah Atuhaire, University of Southampton

This research is joint work with Rachel Simmons (University of Surrey), Ben MacArthur (University of Southampton) and Rebecca Hoyle (University of Southampton)

Buruli ulcer (BU) is a neglected tropical disease caused by infections with *Mycobacterium ulcerans* (M. ulcerans). When M. ulcerans enters the subcutaneous fat, it secretes a polyketide derived macrolide lipid toxin known as mycolactone. This toxin is responsible for skin cell death leading to large wound ulcers observed in the BU disease. Cells also die because of ischemia (lack of oxygen) caused by interrupted blood supply. We are developing a mathematical model which uses partial differential equations to describe the space time dynamics of bacteria, mycolactone, skin cell density as well as oxygen concentration. Our results show how direct toxicity and ischemia cause cell death and lesion formation.

Comparisons between BEM and MFS solutions in composite bi-material domain

Taysir Dyhoum, University of Leeds

This presentation discusses solving the direct problem for electrical resistance tomography (ERT) using the boundary element method (BEM) and the method of fundamental solutions (MFS). The mathematical model is governed by Laplace's equation with the most general boundary conditions forming the so-called complete-electrode model (CEM) in a composite bi-material case. The MBE and MFS solutions are represented by the potential, current flux and the voltages on the boundary and the interior potential. They are compared in terms of accuracy, convergence and stability. The BEM was considered as the 'exact' solution because in such ERT problems the analytic solutions are impossible to obtain and its solution is convergent and stable. Whilst the MFS needs much less computational work and places some restrictions on the number and location of the source points.

Analysis of the dispersion relation for an incompressible isotropic elastic three-layered laminated structure with free faces

Maha Mohammed Helmi, Keele University

This study considers long-wave propagation in elastic layers. We impose the constraint of incompressibility on a linear isotropic 3-layered structure with traction-free upper and lower boundaries. The dispersion relation is obtained by applying solutions of the proposed boundary-value problems in the form of travelling waves, taking into consideration symmetric and antisymmetric cases. The numerical and asymptotic analysis of dispersion relation for both aforementioned cases is carried out. The dispersion relations are analysed numerically to identify their principal properties as well as to distinguish between different asymptotic regimes of wave propagation. Finally, a complete long-wave asymptotic model for low-frequency motion is presented.

[1] Yibin Fu and Graham A. Rogerson. An asymptotic analysis of the dispersion relation of a pre-stressed incompressible elastic plate. *Acta Mechanica*, 111:59–74, 1995.

[2] Michael Lutianov and Graham A. Rogerson. Long wave motion in layered elastic media. *International Journal of Engineering Science*, 48(12):1856 – 1871, 2010.

[3] G Rogerson and Kevin J. Sandiford. The effect of finite primary deformations on harmonic waves in layered elastic media. *International Journal of Solids and Structures*, 37:2059–2087, 04 2000.

A stochastic epidemic model for interacting populations

Sophie Meakin, University of Warwick

Heterogeneity in the interaction between individuals plays an important role in the dynamics, persistence, evolution and control of infectious diseases. This can be incorporated into epidemiological models by dividing the population into multiple interacting subpopulations; however, a limitation of this approach is how to infer the level of interaction, or coupling, between the subpopulations. We present a method that circumvents this problem by finding an analytic relationship between the coupling and correlation between the number of infected individuals in a pair of populations; the coupling can then be estimated using more widely-available data on disease incidence. We show that our result holds for a range of parameter values and is supported by stochastic simulations, using a measles-like disease as a specific example. Our result can also be generalised to three or more populations, to asymmetric transmission or to non-identical populations.

Modelling The Gene Regulatory Network Governing Efflux Pump Expression In Gram-Negative Bacteria

George Youlden, University of Birmingham

Efflux pumps are an essential mechanism for bacteria that can account for antibiotic resistance. If an efflux pump can expel an antibiotic so that its concentration within the cell is below a killing threshold the bacteria can become resistant to the antibiotic. Efflux pumps may be specific or they may pump various different substances and compounds. The latter is one main reason that many efflux pumps are linked with multi drug resistance (MDR). In particular over expression of the AcrAB-TolC efflux pump system is commonly linked with MDR in both *E. coli* and *Salmonella*. We look at the complex gene regulation network that controls expression of genes central to controlling the efflux pump genes *acrAB* and *acrEF* in Salmonella. By using mathematical modelling, we represent this gene regulatory network as a model in the form of a system of ordinary differential equations (ODEs). Using time dependent asymptotic analysis, we can examine in detail the behaviour of the efflux system on various different timescales. By obtaining asymptotically approximated steady states, we are then able to look into various different methods to inhibit efflux pumps to counter MDR.

Maps & Directions

Conference

The School of Mathematics is situated in the Watson Building, labeled R15 on the campus map on the next page. Lunch will be held at the Staff House (R24). Both buildings are located in the red zone of the map which can also be downloaded at:

https://www.birmingham.ac.uk/Documents/university/edgbaston-campus-map.pdf

Accessibility

The ground floor of the Watson Building is accessible via the main-/west-entrance. To take the lift to the first floor, enter on the basement level through the east entrance. There are two sets of non-automatic doors on this level. Please contact the organisers if you require any assistance.

Conference Dinner

The conference dinner will be held at:

Jamie's Italian
Birmingham Middle Mall
Bullring Shopping Centre
Birmingham B5 4BE

https://www.jamieoliver.com/italian/restaurants/birmingham/

The easiest way to get there from the University of Birmingham is to take the train from Birmingham University Rail Station (on the western end of campus, next to the canal, see campus map) to Birmingham New Street. Any train departing from platform 1 will call at New Street station. From there, it is a 10 minute walk to Jamie's.

Edgbaston Campus Map

Index to buildings by zone

Red Zone

R1 Law Building
R2 Frankland Building
R3 Hills Building
R4 Aston Webb – Lapworth Museum
R5 Aston Webb – B Block
R6 Aston Webb – Great Hall
R7 Aston Webb – Student Hub
R8 Physics West
R9 Nuffield
R10 Physics East
R11 Medical Physics
R12 Bramall Music Building
R13 Poynting Building
R14 Barber Institute of Fine Arts
R15 Watson Building
R16 Arts Building
R17 Ashley Building
R18 Strathcona Building
R19 Education Building
R20 J G Smith Building
R21 Muirhead Tower
R23 University Centre
R24 Staff House
R25 Munrow Sports Centre
R26 Geography
R27 Biosciences Building
R28 Murray Learning Centre
R29 The Alan Walters Building
R30 Main Library

Blue Zone

B1 Medical School
B2 Institute of Biomedical Research including IBR West
B3 Wellcome Clinical Research Facility
B4 Robert Aitken Institute for Clinical Research
B5 CRUK Institute for Cancer Studies and Denis Howell Building
B6 Research Park
B7 90 Vincent Drive
B8 Henry Wellcome Building for Biomolecular NMR Spectroscopy
B9 Medical Practice and Dental Centre
B10 Advanced Therapies Facility
B11 BioHub Birmingham
B12 Health Sciences Research Centre (HSRC)

Orange Zone

O1 The Guild of Students
O2 St Francis Hall
O3 University House
O4 Ash House
O5 Beech House
O6 Cedar House
O7 Sport & Fitness

Green Zone

G1 32 Pritchatts Road
G2 31 Pritchatts Road
G3 European Research Institute
G4 3 Elms Road
G5 Computer Centre
G6 Metallurgy and Materials
G7 IRC Net Shape Laboratory
G8 Gisbert Kapp Building
G9 52 Pritchatts Road
G10 54 Pritchatts Road
G11 Nicolson Building
G12 Winterbourne House and Garden
G15 Westmere
G18 Priorsfield
G19 Park House
G20 Elms Plant
G22 Elms Day Nursery
Green Zone Conference Park
G13 Hornton Grange
G14 Garth House
G16 Lucas House
G17 Peter Scott House

Yellow Zone

Y1 Old Gymnasium
Y2 Haworth Building
Y3 Mechanical and Civil Engineering Building
Y4 Terrace Huts
Y5 Estates West
Y6 Maintenance Building
Y7 Grounds and Gardens
Y8 Chemistry West
Y9 Computer Science
Y10 Alta Bioscience
Y11 Chemical Engineering
Y12 Biochemical Engineering
Y13 Chemical Engineering Workshop
Y14 Sport, Exercise and Rehabilitation Sciences
Y15 Civil Engineering Laboratories
Y16 Occupational Health
Y17 Public Health