Gregynog 2019 Abstracts

Monday 20th May – Music Room

16:40 – 17:40 Curing Cancer with Calculus by Integrating Information from Bench to Bedside Helen Byrne

Clinicians routinely generate multiple sources of data when treating cancer patients. Such data ranges from macroscale images of tumour size and composition to cell scale histology images. In this talk I will present recent results from a multiphase model of avascular tumour growth that provide a possible explanation for different tumour responses to radiotherapy that have been observed at the macroscale. If time permits, I will explain how we are applying spatial statistics to histolof data in order to characterise immune cell infiltration into solid tumours.

17:40 – 18:10 Counting Sum Systems Karl Michael Schmidt

Sum systems are finite collections of finite sets of integers such that the sums formed by taking one element from each set and adding them up form an arithmetic progression, without repetitions. Such systems play a crucial role in the construction of matrices and higher-order tensors with integer entries and magic-square or reversible symmetries. It has been shown that, given the number and sizes of the sets, there is a bijection between the possible sum systems and joint ordered factorisations of the set cardinalities. This talk addresses the question of how many possible sum systems there are. The answer hinges on solving the related, somewhat simpler combinatorial problem of counting paths connecting the origin to a given point in a multi-dimensional integer lattice which change direction after each step. This is joint work with Matthew C. Lettington (Cardiff).

18:10 – 18:40 Opportunities in Mathematical Sciences at EPSRC Joseph Westwood

Joe Westwood is a portfolio manager in the Mathematical Sciences team at EPSRC. In this talk Joe will outline roles, responsibilities and activities in the team, give details of the current strategy within Mathematical Sciences, and provide a broad overview of the context in which the team now work under the recent formation of UKRI. Included will be an update on recent and upcoming events, details of current projects and an opportunity to ask questions about our work.

Tuesday 21st May morning – Music Room

9:00 – 10:00 Viruses and Geometry: Models of virus architecture based on group and tiling theory Reidun Twarock

Viruses package their genetic material into protein containers that are remarkable examples of symmetry and order in biology. For over half a century, icosahedral virus architectures have been classified in terms of specific types of polyhedral shapes in the seminal Caspar-Klug theory. However, following developments in our ability to image viral particles, it has become apparent that many virus structures do not conform to these blueprints. The design principle for icosahedral architectures described here using group and tiling theory simultaneously covers the classical viral architectures and solves open problems in structural virology. I will demonstrate that it provides a framework for analysing biophysical properties of viral capsids, such as their stability. Applications of the results in vaccine design will also be discussed.

10:00 – 10:30 Doubly nonlocal Fisher-KPP equation: Features and peculiarities Dmitri Finkelshtein

We overview properties of solutions to a reaction-diffusion equation, arising, in particular, in population ecology, where both reaction and diffusion parts are nonlocal. We describe a criterion for the comparison principle to hold. We consider sufficient and necessary conditions for the linear speed of propagation, and discuss two possible asymptotics of traveling waves with minimal speeds. We discuss also mechanisms and present rates for the accelerated propagation.

10:30 – 11:00 Obstructions for the torus and proving non-toroidality Andrei Gagarin

Given a graph G, a classic problem is how to determine whether it is possible to draw G in the plane (on the sphere) with no edge crossings. Such drawing of G in the plane would be a planar embedding. The torus is the sphere with a handle, i.e. an orientable topological surface of genus one, which is closest to the sphere. A similar problem is how to determine whether it is possible to draw G on the torus with no edge crossings, i.e. to obtain a toroidal embedding of G.

Kuratowski's theorem provides natural certificates to show non-planarity of graphs: a graph G is planar if and only if it does not contain a subdivision of K_5 or $K_{3,3}$ as a subgraph. Wagner's theorem says that a graph G is planar if and only if it does not contain a minor isomorphic to K_5 or $K_{3,3}$. In other words, K_5 and $K_{3,3}$ are the only two obstructions to planarity in the sense of minimal forbidden subgraphs-subdivisions and minors. Therefore, they can be used efficiently and explicitly as certificates of non-planarity.

The complete lists of obstructions for the torus are not known and turn out to be very large, although finite. On the other hand, the complete lists of obstructions for the toroidal graphs with no $K_{3,3}$-subdivisions consist of only four minors and eleven subgraphs-subdivisions. These obstructions, as well as the three 8-vertex obstructions for the torus, can be used to prove non-toroidality explicitly. We show some particular examples how to decide on toroidality of non-planar graphs containing $K_{3,3}$-subdivisions in an ad hoc way.

(Joint work with William Kocay, Wendy Myrvold, and R. Rajkumar)

11:30 – 12:30 Mathematical approaches to modelling and remodelling biological tissues Helen Byrne

Biological tissues are complex, evolving structures, characterised by interactions that act across diverse space and time scales. In this talk I aim to illustrate how theoretical studies of biological tissues can provide new mechanistic insight into their behaviours while also acting as a source of mathematically challenging problems. I will take inspiration from recent studies of tissue engineering and blood flow in vascular tumours.

12:30 – 13:00 Packings in cylinders: columnar crystals, helical viruses and hysteresis Adil Mughal

That nature creates forms and structures of great diversity according to the requirements of simple physical laws is a subject of endless fascination. The possible ways in which atoms, spheres or cells fit together into alternative structures depends on both symmetry and the nature of the physical forces involved. While these physical interactions maybe simple, nevertheless the high pressures encountered in strongly confined systems can compel molecules to adopt complex yet ordered arrangements. In such systems there exists an intimate connection between morphology and the precise shape of the container. An example of this is the dense packing of idealised particles inside narrow channels. Extensive results from simulations and experiments (over the last thirty years) have shown that in such systems the particles form extended helical or chiral structures - of the type usually associated with various biological microstructures (e.g. flagella, the morphology of the tobacco virus and microtubules). Such one-dimensional structures are the focus of considerable scientific attention because of their potential utilisation as functionalized devices. This presentation will give a broad historical overview of columnar crystals, the progress that has been made in rationalising, review some relevant experiments and show that these results generalise to cylinders packed with soft (deformable) spheres

Tuesday 22nd May afternoon – English – Seminar Rooms 1 and 2

14:00 – 15:00 Applications of delay differential equations: an introduction Stephen Gourley

This talk will explore some of the applications of simple systems of delay differential equations, particularly in ecology, epidemiology and in machine tool vibration. The talk will explore the details of why the time delays are important, and how models containing delays are derived, and I will discuss simple analytical techniques that can be applied to the study of such systems.

15:00 – 15:30

How nearly optimal are the Watt and Chebyshev linkages? John Pryce

Watt's linkage, described in the patent specification of 1784 for his steam engine, is a simple way to make approximate straight line motion, and still widely used e.g. in vehicle suspensions. It is called a four-bar linkage, meaning three moving jointed bars AB, BC, CD, with the fixed ends A and B counting as the fourth bar. Chebyshev's four-bar linkage (around 1853) does the same, but Watt's straight line segment S is transverse (not quite perpendicular) to AB, while Chebyshev's S is parallel to AB. With both, the point P that approximately traces S is the midpoint of the middle bar BC. See `en.wikipedia.org/wiki/Watt's_linkage` and `en.wikipedia.org/wiki/Chebyshev_linkage`.

Watt was a practical engineer and I assume the design parameters (relative dimensions of the bars) of his linkage were found by experiment. They were improved slightly by Phineas Crowther in 1800. Chebyshev was a top-class approximation theorist and numerical analyst so his design parameters were mathematically arrived at.

How close were they to a truly best design? I am treating this as a problem of minimising some objective function $f(\mathbf{p})$ over the space of design parameters $\mathbf{p}$ comprising the bar lengths, the position of P on the middle bar (is it really best for it to be on line BC?) and the position of line segment S relative to the fixed points AB. Devising a suitable $f(\mathbf{p})$ is not obvious and probably should be parameterised by the length of S. The problem is highly nonlinear, and one easily treads into regions of $\mathbf{p}$ space where the linkage can't be assembled so f doesn't exist.

This is work in progress. First I'll study if small changes to the Watt or Chebyshev $\mathbf{p}$ can improve f, i.e. local optimisation. But since the Watt and Chebyshev solutions are so very different it makes sense to think globally: is there another design somewhere in $\mathbf{p}$ space that is even better? A move into 3D looks fun - the so-called RSCR mechanism generalises the 4-bar linkage and can draw 3D curves.

A convex relaxation for IMSE optimal design in random-field interpolation models Bertrand Gauthier

The definition of an Integrated Mean-Squared Error (IMSE) criterion yields a particular Karhunen-Love expansion of the underlying random field. After spectral truncation, the model can be interpreted as a Bayesian (or regularised) linear model based on eigenfunctions of this KarhunenLove expansion, and can be further approximated by a linear model involving orthogonal observation errors. Using the continuous relaxation of approximate design theory, the search of an IMSE optimal design can then be turned into a Bayesian A-optimal design problem, which can be efficiently solved by convex optimisation. A careful analysis of this approach is presented, also including the situation where the model contains a linear parametric trend, which requires specific treatments; depending on the presence or absence of a prior on the initial random-field trend parameters, different approaches are proposed (based on the notions of kernel augmentation and kernel reduction). Convex optimisation, based on a quadrature approximation of the IMSE criterion and a discretisation of the design space, yields an optimal design in the form of a probability measure with finite support. A greedy extraction procedure of the exchange type is proposed for the selection of observation locations within this support, the size of the extracted design being controlled by the level of spectral truncation. The performance of the approach is investigated on a series of examples indicating that designs with high IMSE efficiency are easily obtained.

Related article: Convex relaxation for IMSE optimal design in random-field interpolation models, with Luc Pronzato (2017). http://www.sciencedirect.com/science/article/pii/S0167947316302456

16:00 – 16:20	Evolutionary dataset optimisation: learning algorithm quality through evolution — Henry Wilde	Generalised braid actions — Lorenzo De Biase
	This talk will introduce a new approach to learning the performance of an algorithm through evolution. Classically, algorithms are compared on a finite number of existing benchmark data sets based on some fixed metric, and the algorithm(s) with the optimal metric value are chosen to be the best performing'. The speaker instead aims to gain a richer picture of an algorithms performance by generating artificial data through an evolutionary algorithm, the purpose of which is to create populations of data sets for which a particular algorithm performs well. These data sets can be studied to learn as to what attributes lead to a particular progress of a given algorithm. The talk will conclude with some use cases for the proposed method including simple optimisation and the simulation of existing data sets.	In this talk, after giving some background on autoequivalences of derived categories of smooth projective varieties, I will define the generalised braid category and describe its action on the derived categories of (the cotangent bundles of) full and partial flag varieties. Generalised braids are the braids whose strands are allowed to touch in a certain way. The basic building blocks of their action on flag varieties are spherical and non-split P- functors together with the twist equivalences they induce. I will describe our present progress and future expectations. This is a joint project with Rina Anno and Timothy Logvinenko.

16:20 – 16:40	Statistical Inference for Entropy, Divergence and Renyi Information — Mehmet Cadirci	Prime Strictly Concentric Magic Squares — Anna Skelt
	Entropy and divergence (Shannon and Kullback-Leibler) estimation is a central problem in image processing, with many applications for image compression, segmentation, calibration, registration, etc. Mutual information, which is strongly related to Shannon entropy and Kullback-Leibler divergence, is a widely used measure of similarity between images. In a seminal paper, Kozachenko & Leonenko (1987) proposed an approach to the problem of entropy estimation, based on the expected distance between a point and its nearest neighbour in the sample. In a series of papers of Prof. Leonenko and his collaborators, the analogous of the nearest neighbour estimates of Rnyi entropy was constructed and studied. One of the main aims of the project is to develop an asymptotic theory of the nearest neighbor estimates of Shannon and Rnyi information, in particular to investigate a bias and to prove an asymptotic normality.	A Magic Square of order n is an n by n grid into which n^2 unique integers are placed such that all rows, columns and diagonals sum to the same value, termed the magic constant. This talk concerns specifically Prime Strictly Concentric Magic Squares (PSCMS). PSCMS are Magic Squares in which every integer in the square is a prime number, and for which every subsquare of lower order conforms to the constraints of a Magic Square. The number of minimum Prime Concentric Magic Squares (PSCMS) of odd order 5 to 19 has been calculated computationally, and presented without proof (Makarova, 2015). This talk presents relevant general definitions, examples and important properties of PSCMS. A minimum PSCMS of order 5 is defined. A construction is given and the number of PSCMS of order 5 is mathematically obtained.

16:40 – 17:00	Sequential change-point detection with epidemic alternatives — Jack Noonan	The enumeration of the higher spin alternating sign matrices — Hassan Izanloo
	In the 1940s Abraham Wald founded the modern theory of sequential analysis when considering the problem of testing two simple hypotheses. He showed that the fixed sample size likelihood ratio test of Neyman and Pearson can be modified into a more efficient sequential scheme where observations are collected one at a time and processed on-line. An important branch of sequential analysis is online change-point detection or sequential change-point detection. This is concerned with the design and analysis of techniques for on-line detection of a change in the state of a phenomenon, subject to a tolerable limit on the risk of false alarms. In this talk, we will focus on on-line change-point detection for an epidemic alternative and suggest an optimal testing procedure. Vital characteristics of the test such as Average Run length (ARL) and the power will be discussed.	The higher spin alternating sign matrices are generalization of alternating sign matrices ($n \times n$ matrices with entries from $\{0, 1\}$ such that all row and column sums equal 1 and along each row and column the nonzero entries alternate in sign). In this talk, I will provide a formula to enumerate these objects.

17:00 – 17:20	Input-Distributive Persistent Homology	Alvaro Torras Casas	Particle density of the CAR algebra and particle-hole duality in continuum	Maryam Alshehri
Persistent Homology has been developed as an important tool of Topological Data Analysis, with numerous applications in science and engineering. However, for very large data sets this tool can be very expensive to compute, both in terms of computational time and hard-disk memory. We will present a new distributive algorithm which takes part directly on the input data. This has some theoretical difficulties since we need to work within the category of persistence modules. In particular, we will see a solution to the extension problem for the Persistent Mayer-Vietoris spectral sequence. At the end we speculate that this approach might give us more information than ordinary Persistent Homology.			The talk will explain a particle-hole duality principle in the continuum. To this end, one will consider quasi-free representations of the canonical anticommutation relations, in which the role of the creation and annihilation operators will be swapped on part of the space. One then has to consider the corresponding operators of particle density and find the joint spectral measure for this family of commuting self-adjoint operators.	

17:30 – 17:50	The predictive potential of kernel principal components regression	Ben Jones	Near real-time calculation of submarine fault properties using an inverse model of acoustic waves	Bernabe Gomez Perez
Suppose we have a collection, denoted by X, of p real random variables and we are interested in their relationship with some real random variable Y. As an example, we could have Y to be the inflation rate and X to be a collection of economic data. When p is large, classical methods for studying this relationship (known as regression methods) fail for a number of theoretical and computational reasons particularly relating to matrix inversion. One well-known approach to handling this situation, called principal components regression, is to first summarise X by taking d (d ¡ p) linear combinations of its variables which have maximal variance subject to the coefficient vectors being orthonormal ("finding orthogonal directions with maximal variance") then applying classical regression techniques with this reduced collection of variables. This practice has been criticised because the procedure for obtaining the principal components makes no direct use of Y; there is therefore no guarantee that the components with most variance will be the most informative of Y. Recent research has given theoretical probabilistic justification for this procedure by showing that higher-ranking components are indeed more likely to be more highly correlated with Y than lower-ranking ones. The procedure described thus far only allows for linear combinations of X; by using the well-known "kernel trick", it is possible to extract nonlinear functions of X from some Hilbert space of real-valued functions. This is done by applying principal components analysis within this Hilbert space. Our work shows that the predictive tendency shown for the classical setting still holds in this nonlinear setting provided that the Hilbert space of functions is finite-dimensional. We thus greatly broaden the previous results. The talk will present these results and their significance.			Tsunamis are often generated by submarine earthquakes which also generate a family of acoustic modes along. Acoustic modes can act as early precursors since they propagate at speeds that far exceed the maximum tsunami phase speed and can leave measurable pressure signals on the bottom of the sea in the far field which can be recorded by distant hydrophones and also carry information about the generating source. In this project it is proposed the use of the mentioned waves to retrieve the disturbance properties in order to assess the potential incoming tsunami. An almost real time analysis of the signal is needed in order to maximize the time window between the acoustic waves recording and the Tsunami arrival. Based in previous studies, some techniques for applying inverse theory to pressure signals are discussed. The technique is general and can be employed to track various signals to their source, e.g. impacting objects, underwater explosions, landslides, rogue waves, and other violent events in the ocean. Hypoxia-Activated Prodrugs (HAPs) present a means to not only combat, but also exploit, hypoxia. HAPs are bioreductive prodrugs that reduce, and thus convert, to active cytotoxins upon reaching hypoxic regions. These drugs act as trojan horses, being harmless until they are converted in target areas. Despite being conceptually promising, clinical trials of HAPs have produced mixed results. In order to closely study the appropriate conditions and optimal delivery of multimodality treatment regimes that involve HAPs, we have developed a three-dimensional *in silico* framework. Our framework is based on a multiscale mathematical model, specifically a cellular automaton incorporating intracellular, extracellular and intercellular dynamics. Our results indicate that the successfulness of HAP-Radiation combination treatments depends not only on tumour oxygenation status, but also on spatio-temporal implications of hypoxia.	

17:50 – 18:10

Predictive Maintenance of Real Time Sensor Data

Ieuan Griffiths

Predictive Maintenance is an important and still up and coming area that allows manufacturing companies to minimise the number of maintenances based on real time information. This in turn improves yield, reduces downtime, and can stop any life-threatening events from happening. In all this improves company profits and creates a safer workplace. This research focuses on the complete construction of a Real Time Monitoring System from the ground up. This includes data logger construction, the use and development cutting edge Data Science approaches, and an interactive dashboard for mobile devices.

A class of nonlinear Schrodinger-Poisson systems involving a nonradial charge density

Megan Tyler

We consider a class of nonlinear Schrödinger-Poisson systems

$$\begin{cases} -\Delta u + u + \rho(x)\phi u = |u|^{p-1}u, & x \in \mathbb{R}^3, \\ -\Delta \phi = \rho(x)u^2, & x \in \mathbb{R}^3, \end{cases}$$

in various functional settings corresponding to different hypotheses on the behaviour of $\rho : \mathbb{R}^3 \to \mathbb{R}_+$ at infinity. In the spirit of the classical work of P. H. Rabinowitz on nonlinear Schrödinger equations, we prove existence of mountain-pass solutions and least energy solutions to this system. Our results cover the difficult range $p \in (2, 3)$ where the lack of compactness phenomena may be due to the combined effect of the invariance by translations of a 'limiting problem' at infinity and of the possible unboundedness of the Palais-Smale sequences. Moreover, we find necessary conditions for concentration at points to occur for solutions to the singularly perturbed problem

$$\begin{cases} -\epsilon^2\Delta u + u + \rho(x)\phi u = |u|^{p-1}u, & x \in \mathbb{R}^3, \\ -\Delta \phi = \rho(x)u^2, & x \in \mathbb{R}^3. \end{cases}$$

**This is a joint work with Carlo Mercuri (Swansea University).*

18:10 – 18:30

Clinical Pathway Modelling

Emma Aspland

Clinical pathways are an effective and efficient approach in standardising the progression of treatment to support patient care and facilitate clinical decision making. Our review of the related literature highlighted a need to better integrate data engineering and OR techniques with expert/domain knowledge to assist with clinical pathway discovery and formation. Consequently, we have produced a decision support tool that facilitates expert interaction with data mining, through the application of clustering. This has involved the development of a new distance metric, modified from the Needleman-Wunsch algorithm, that considers weightings and groupings of activities as specified by an expert user. The resulting set of pathways will then be automatically translated into the basis of a discrete event simulation to model patient flows through the captured clinical pathways. Our research is in partnership with Velindre Cancer Centre, the largest specialist cancer centre in Wales, and has the overall goal to improve patient care and outcomes by reducing time to diagnosis and treatment for those with lung cancer.

Distances to Lattice Points in Rational Polyhedra

Aled Williams

It is well known that finding a solution to an integer linear program (ILP) in general is NP-complete. Despite this one can obtain an approximation within polynomial time by solving its related linear program (LP). Because of this it should come as no surprise that a central problem within this research domain is to estimate the distance from an approximate solution (obtained from solving the LP) to some nearby feasible integer solution (that solves the ILP). We will use the term (maximum) vertex distance to denote this distance. During this session we provide some worst case upper bounds on the (maximum) vertex distance after making several assumptions about the underlying integral constraint matrix.

18:30 – 18:50	Big Data Analytics of historical Caster data for Predictive Maintenance	Rebecca Peters	Horizontal mean curvature in $\mathbb{H}^1$	Raffaele Grande
The Internet of Things (IoT) has seen an explosion in the development of sensing devices gathering and producing ubiquitous amounts of high volume and velocity data contributing to the big data environment. Today Industry 4.0 is driving advances in innovative technologies to help digitise manufacturing processes, enabling business to make more informed decisions. Sensors play a fundamental role in either monitoring or controlling the continuous casting of steel. Sensors continuously collect and transmit measurements and contain rich information about the condition of equipment. This research explores the use of data mining techniques to generate failure prediction models where the pre-failure conditions are learnt from historical sensor data. The suitability of different failure detection approaches are reviewed in collaboration with a large Steel Manufacturer, Tata Steel UK. Ultimately, this information will be applied in real time to predict future failures and to help optimise the scheduling of maintenance.			The *horizontal mean curvature flow* (HMCF) in sub-Riemmanian setting is a partial differential equation which has applications in biomathematics and neurogeometry. Unfortunately in these spaces there is a very weak regularity (Hormander's condition) then the associated PDEs are very degenerate. One possible approach is to complete the underlying sub-Riemmanian geometry to a Riemmanian geometry depending upon a small parameter $\varepsilon > 0$, then the associated PDEs became much more regular. Thus we can derive informations on the starting degenerate problem as $\varepsilon \to 0$. We study the case of HMCF in *Heisenberg group* with a stochastic approach via a Riemmanian approximation.	

Tuesday 21st May – Welsh – Writing Room

16:00 – 16:30 Modelu'r rhyngweithiad rhwng ewyn trefniedig a gwrthrych solid Tudur Davies

Mae ewynnau hylifol yn llifyddion cymleth iawn syn meddu ar briodweddau hynod syn golygu eu bod yn ddefnyddiol mewn ystod eang o sefyllfaoedd, o rai domestig i brosesau diwydiannol. Maent yn ddeunyddiau dwy wedd o swigod nwy wediu gwahanu ag arwynebau a sianeli o hylif. Er hynny, gall ewyn ymateb fel elastig solid o dan ddiriant isel! Maer arwynebedd uchel ar ysgafnder mae ewyn yn ei gynnig yn ei wneud yn ddefnyddiol ar gyfer prosesau pwysig fel arnofiant, lle gwahanir mwynau o ddeunydd gwastraff gan lif ewyn. Caiff y broses yma ei gyrru gan y rhyngweithiad syn digwydd rhwng arwynebaur ewyn gronynnaur mwynau ar deunydd gwastraff sydd ynghrog yn y llif. Maen bosib hefyd y gall yr un rhyngweithiad rhwng gwrthrychau solid ac ewynnau trefnedig ganfod defnydd mewn technolegau lab ar sglodyn micro-hylifegol, lle gellir defnyddio ewyn trefnedig fel hidlydd neu declyn ar gyfer didoli gronynnau. Byddaf yn cyflwyno canlyniadau efelychiadau rhifiadol 3D syn modelur rhyngweithiad rhwng gwrthrychau caled ac ewynnau trefnedig gan ddefnyddio model lled-statig. Yn y patrymedd hwn, maen bosib y gall grym tensiwn arwyneb strwythur trefnedig rhai ewynnau gael eu defnyddio i adleoli neu ail-gyfeirio gwrthrychau a gronynnau mewn ffordd reoledig.

16:30 – 16:50 Llif llifydd diriant ildio drwy geometregau tebyg i wythiennau Tirion Roberts

Drwy ystyried llif llifydd diriant ildio syn cael ei yrru gan bwysau drwy sianeli geometregau cymhleth, byddwn yn cymharur data rhifiadol a'r proffiliau cyflymder dadansoddol perthnasol a sefydlir. Bydd hynnyn ein galluogi ni i gadarnhau cywirdeb ein hefelychiad.

Tuesday 21st May – English – Writing Room

17:30 – 17:50 Perverse Schobers in Algebraic Geometry Chris Seaman

Derived categories $D(X)$ were developed in the 1960s and can be viewed as powerful invariants of certain geometric objects X. One of the reasons for studying these is a long-outstanding conjecture arising from string theory, known as the homological mirror symmetry conjecture. In order to work towards proving this conjecture, we seek to understand the structure of these derived categories better. One of the ways in which we can do this is to study the group of autoequivalences of $D^b(X)$, the structure-preserving maps from $D(X)$ to itself. This talk will include a brief summary of known results, as well as some more modern technology which is currently being used to further our understanding of derived categories.

17:50 – 18:10 Effective numerical model for hydraulic fracturing Gaspare Da Fies

Hydraulic fracturing (HF) is a process in which a fluid is pumped at high pressure into a solid material, with or without a pre-existing crack or fault. The push of the fluid makes the fracture open and propagate. This coupled problem (fluid-solid interaction) reveals very hard to solve because of numerical stiffness, strong non-linearity, presence of singularities and moving boundaries.

There are a number of numerical simulators (mostly commercial ones) dealing with this problem, but even for the simplest 1D models (a planar straight or radial fracture, time dependent and 1D in space) there is still room for improvement and better understanding [1]. Recently, several groups have been working on the topic, resulting in some significant improvements [2, 3]. We have built a fast and accurate algorithm for the full PKN model based on the use of asymptotic analysis and we are implementing the same approach to solve KGD and radial models. We also use of a modified version of the model that takes in account the shear stress induced by the fluid, previously neglected [4], obtaining computational advantages.

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References

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Wednesday 22nd May – Seminar Room 1

9:00 – 10:00 Differential equations with variable time delays Stephen Gourley

In this talk I will discuss the fact that the realistic incorporation of time delays may require the delay itself to be a function of time, or even of the state of the system (i.e. the delay may depend on the unknown solution of the differential equation). For example the developmental time of an insect larva may depend strongly on temperature and therefore on the time of year. Or, it may depend on how many larvae are present, since greater numbers of them will hamper the ability of an individual larva to find enough food and this will slow down its growth. In some modern lathes and milling machines the spindle speed can be made to vary sinusoidally, as a vibration elimination measure, and this also gives rise to differential equations with time-dependent delays.

10:00 — 10:30 Stochastic differential equations driven by fractional Brownian motion with locally Lipschitz drift and their implicit Euler approximation Shao-Qin Zhang

We study a class of one-dimensional stochastic differential equations driven by fractional Brownian motion with Hurst parameter $H > \frac{1}{2}$. The drift term of the equation is locally Lipschitz and unbounded in the neighborhood of the origin. We show the existence, uniqueness and positivity of the solutions. The estimates of moments, including the negative power moments, are given. We also developed the implicit Euler scheme, proved that the scheme is positivity preserving and strong convergent, and obtained rate of convergence. Furthermore, by using Lamperti transformation, we show that our results can be applied to stochastic interest rate models such as mean-reverting stochastic volatility model and strongly nonlinear Aït-Sahalia type model. This is joint work with Prof. Chenggui Yuan.

10:30 – 11:00 The Support of Integer Optimal Solutions Timm Oertel

The support of a vector is the number of nonzero-components. We show that given an integral mxn matrix A, the integer linear optimization problem $\max c^T x : Ax = b, x >= 0, x \in Z^n$ has an optimal solution whose support is bounded by $2mlog(2\sqrt(m)||A||)$, where $||A||$ is the largest absolute value of an entry of A. We furthermore provide a nearly matching asymptotic lower bound on the support of optimal solutions.

11:30 – 12:00 A symmetry result for a general overdetermined boundary value problem Friedemann Brock

Solutions to overdetermined elliptic boundary value problems appear naturally as optimisers of some shape optimization problems. In this talk we give a short list of solved and open problems. The following general symmetry result was proved by using the method of continuous Steiner symmetrization, in: NoDEA **23** (2016), no. 3, art. 36:

Let Ω be a bounded smooth domain in $\mathbb{R}^n$, and let $u \in C^1(\overline{\Omega})$ be a weak solution of the following problem,

$$\begin{cases} -\nabla\left(g(|\nabla u|)\frac{\nabla u}{|\nabla u|}\right) = f(|x|,u), \quad u > 0 \quad \text{in } \Omega \\ u = 0, \quad |\nabla u| = \lambda(|x|) \quad \text{on } \partial\Omega \end{cases},$$

where
$g \in C[0,\infty) \cap C^1(0,\infty)$ with $g(0) = 0$, $g'(t) > 0$ for $t > 0$,
$f \in C([0,\infty) \times (0,\infty))$, f is nonincreasing in $|x|$,
$\lambda \in C[0,\infty)$ and λ is positive and nondecreasing.
Then Ω is a ball and u satisfies some "local" kind of symmetry.

12:00 – 13:00 Viruses and Geometry: Implications for virus assembly, evolution and therapy Reidun Twarock

Insights into viral geometry enable a better understanding of how viruses form and evolve, and are therefore important for the development of novel anti-viral strategies. In particular, our models of viral geometry provide a graph theoretical means of describing the formation of viruses as a travelling salesman problem. This approach has been instrumental in the discovery and analysis of an assembly mechanism that is mediated by a virus assembly code embedded with the genetic message of many viral pathogens. Using multi-scale Gillespie models of viral evolution in the context of a viral infection, I will demonstrate that anti-viral strategies inhibiting this mechanism are promising routes for therapy of both chronic and acute viral infections.