



The Fields Medal: Serendipity and J.L. Synge

THE FIRST PROTOTYPE OF THE FIELDS MEDAL, cast in bronze in 1933, was recently discovered by accident among ephemera in archives at University of Toronto. It is in the original small box in which it was mailed in 1933 to J.L. Synge (1897–1995) by the Medallist Art Company of New York, which cast it for the sculptor. There are plans to put the medal and box on display at the Fields Institute, through the generosity of mathematician Cathleen Synge Morawetz (Courant Institute), J.L. Synge’s daughter.

A promising young mathematical physicist known for his ready wit, Synge came to University of Toronto from Ireland in 1920. He served as secretary of the 1924 Toronto Congress, which J.C. Fields organized. Despite the difference in their ages, the two men became friends. When Fields was ill in early August 1932 and realized he would be unable to attend the Zurich Congress the following month to finalize arrangements for the medal, he entrusted these to Synge.

Synge’s account of how the IMU came to accept the medal is amusing. The groundwork for the medal had been well-laid by Fields. During the summer of 1930, he toured Europe consulting individual mathematicians in Belgium, Britain, France, Germany, Italy, and Switzerland about the possibility of an international medal. On December 30, 1930, Fields appeared before the council of the American Mathematical Society in Cleveland to propose a medal. The AMS gave their approval. With their endorsement in hand, he returned to Europe the following summer to seek official support from the Société Mathématique de France, the Circolo Matematico di Palermo, the Deutsche Mathematiker Vereinigung, and the Société Mathématique Suisse. In this he was successful, but he died on August 9, 1932, his arrangements for the medal incomplete. Carrying out Fields’ wishes, Synge appeared in Zurich before the Council of the



IMU chaired by then IMU President W.H. Young. There was discussion of the pros and cons of such a medal. Some Council members said that mathematics should be its own reward (Synge privately felt that way). Others supported it as a badly needed international gesture. Oswald Veblen (Princeton) was opposed; G.D. Birkhoff (Harvard) was in favour. Young kept mixing up the speakers, unable to sort out who was who at the meeting. In this slightly absent-minded, comedic atmosphere, J.C. Fields’ medal was accepted by the Council of the IMU and announced to delegates at the opening session of Congress the following day.

While Fields was seeking approval for the notion of an international medal, he was also considering its design. He had determined that the language of the medal should be

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MEDAL

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ancient Greek or Latin, and that it should not bear the name of any person or country. Having consulted various mathematical historians, he mulled over possible designs. One idea was to have an outline of the coastlines bordering the Atlantic on one side of the medal and Pacific coastlines on the other. Fields visited sculptors in Europe during the summer of 1931, but was not satisfied. During the spring of 1932, he wrote R. Tait McKenzie (1867–1938), a Canadian sculptor on the faculty of the University of Pennsylvania, who accepted the commission. It is possible that Fields saw a preliminary sketch before his death. Final acceptance of the design was made by Synge, who travelled to Philadelphia to meet McKenzie. Synge commented that, whereas he and other colleagues at Toronto feared that design selection might be difficult, in the end the artistic views of the sculptor prevailed. This is the design familiar to all mathematicians. Accordingly, the prototype was cast. Synge sent photographs of the medal to the IMU and to various mathematics societies. The original bronze casting somehow found its way into the unrelated papers of University of Toronto Bursar (and University Organist) Ferdinand Mouré. There it remained until discovered by chance.

When Fields' medal was announced in 1932, it drew little attention in the public press or in mathematics bulletins. At the Oslo Congress in 1936, the first medals were awarded to Jesse Douglas (USA) and Lars Ahlfors (Finland). Dreadful events in the world followed, and only at the 1950 Harvard Congress was the medal again given out. The prize money is modest (Fields' estate was not large), but the medal, cast in gold by the Canadian Mint, has gained lustre in recent decades from the distinguished mathematicians who have received it. Also recently found,

in the public stacks of the University of Toronto Gerstein Science Library, is Fields' hand-written manuscript for his book, *Theory of Algebraic Functions of a Complex Variable* (1906). It is likely the version he wrote in 1898 while doing postdoctoral work in Berlin. The 385 pages, carefully numbered, neatly written on one side of paper now beginning to yellow, are bound in two volumes. Although the fountain pen had been invented, Fields wrote in ink using a straight pen. He dips his pen, writes a few lines, the ink fades, and he dips again. Fields sent his manuscript to Gösta Mittag-Leffler, founding editor of *Acta Mathematica*, whom he had met on an excursion in Scotland in 1901. Mittag-Leffler recommended the publishing firm of Mayer and Müller of Berlin. But as their presses were busy, Mittag-Leffler helped Fields further by arranging for printing on the presses of *Acta Mathematica*. Although a previous generation of Canadians (including Fields' teachers at University of Toronto) had published textbooks, this was one of the earliest research monographs by a Canadian mathematician.

In his correspondence with contemporary mathematicians around the world, Mittag-Leffler often requested photographs for his collection. At his home in Djursholm, Sweden (now the Institut Mittag-Leffler) the earliest known photograph of Fields, a formal portrait taken in a Toronto studio in 1905, was found among Mittag-Leffler's numerous photographs.

Thus, although neglect and a casual attitude towards documents and possibly Fields' own wishes have led to the disappearance of all Fields' personal effects, including his own collection of photographs and lantern slides and most of his voluminous correspondence, serendipity leads us to traces of the man and his work.

Elaine McKinnon Riehm (Fields)



DARRELL DUFFIE & DARK MARKETS

THOSE FOLLOWING THE CURRENT DEBATE around financial regulation reform in the U.S. Senate know that regulating derivatives trading is one of the centerpieces of the legislation under discussion. They would also probably have read articles in major newspapers and magazines quoting the expert opinion of Darrell Duffie, the Dean Witter Distinguished Professor of Finance at The Graduate School of Business, Stanford University.

Duffie delivered the Distinguished Lecture Series in connection with the thematic program on Quantitative Finance starting on the exact same day that a bipartisan bill on derivatives was introduced to the Senate floor. After spending most of the day being interviewed by several U.S. news outlets, he launched a three part study of “dark markets”—the theoretical framework underpinning the so-called over-the-counter (OTC) markets, of which exotic derivatives are but one example.

In the first lecture Darrell described how OTC markets differ from centralized ones, in particular with respect to the transfer of capital, which tend to be slow in the former, resulting in asset prices which can show a persistent deviation from “fundamentals.” He also remarked that prices for the same asset at the same time can show a large dispersion, since agents trade bilaterally, with no access to information that can reveal a unique “fair” price at the time of trade. He showed intriguing evidence from the time

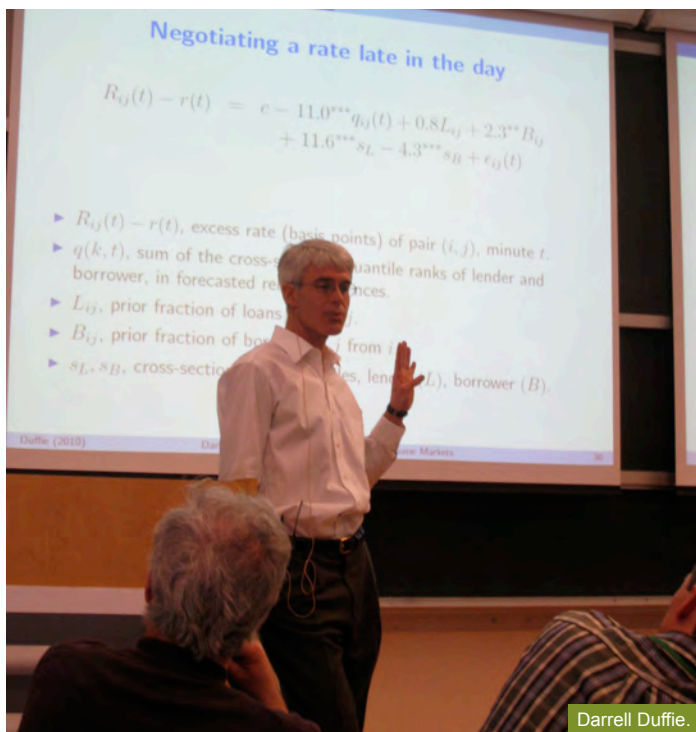
signature of prices for U.S. treasury bonds, and how they vary in time near the moment of issuance. He also showed cross-sectional dispersion in prices for municipal and corporate bonds. Based on these facts, the natural setting for describing such markets consist of models where agents meet at random and then negotiate bilaterally, each with the option to continue searching for another counterparty. The imperfect nature of this search for information among counterparties lead to the observed opaqueness and delay features in these markets. Towards the end of the lecture, he commented on the benefits of central clearinghouses in order to reduce the significant counterparty risk associated with bilateral contracts.

Having laid the intuition for OTC markets, Darrell used his second lecture to present an idealized mathematical model. This model explains the interaction of a continuum of agents meeting for bilateral trades at random times according to a given intensity. Through a heavy use of infinite population, the law of large numbers, and independence, he was able to derive an evolution equation (a version of the Boltzman equation) for the distribution of “types” of agents in the population. Here a “type” might include the agent’s current preference for the asset, private information, and the amount of asset held. At equilibrium bids and types are in a one-to-one correspondence. Therefore, this evolution equation describes how information “percolates” in the population through an infinite series of double auctions. He then discussed several extensions of this basic model, such as taking new private information into account, the release of public information, and segmented markets.

In the third and final lecture, which took place during the Financial Econometric workshop, Darrell focused on the interbank market for Fed Funds and used a logit model to describe the probability of a transaction occurring between two banks, fitting the model to a 2005 data set comprised of 225 million observations for 8000 banks.

The Distinguished Lecture Series provides an opportunity to attract some of the most inspiring researchers in the area of the corresponding thematic program. For the organizers of the program, who then have the privilege to act as hosts, it is a unique chance to interact with them for a few days in an informal setting. In Duffie’s case, this confirmed the ample anecdotal evidence that he is vastly knowledgeable, almost superhumanly competent, genuinely interested in what other people have to say, and an overall pleasure to be around.

Matheus Grasselli (McMaster)



Darrell Duffie.

Prospective: Thematic Program on Asymptotic Geometric Analysis

ASYMPTOTIC GEOMETRIC

Analysis is concerned with geometric and linear properties of finite dimensional objects, normed spaces and convex bodies, especially with asymptotics of their various quantitative parameters as the dimension tends to infinity. Deep geometric, probabilistic and combinatorial methods developed here are used outside the field in many areas, related to the subject of the program.

One of the main tools of the theory are concept of concentration phenomenon and large deviation inequalities. The concentration of measure is, in fact, an isomorphic form of isoperimetric problems. It was first developed inside asymptotic geometric analysis and then became pertinent to other branches of mathematics as an efficient tool and useful concept. Some new techniques of the theory are connected with measure transportation methods and with related PDE's. The concentration phenomenon is well-known to be closely linked with combinatorics (Ramsey theory), and such links have recently been better understood in the setting of infinite-dimensional transformation groups, by means of the so-called fixed point on compacta property: on the one hand, every classical Ramsey-type result is equivalent to the fixed point on compacta property of the group of automorphisms of a suitable structure, on the other hand, the fixed point on compacta property is often established by using concentration of measure in subgroups.

The last few years also witnessed the development of small ball probability estimates and their applications,

especially for quantitative results on random matrices. Deep understanding of classical convexity and its analytic methods is necessary to advance new type of “isomorphic” results. It is now difficult to draw a borderline between asymptotic and classical convexity theories; and results of each are used in the other and have numerous applications. Among recent important ones are results of a geometric-probabilistic flavour on volume distribution in convex bodies, central limit theorems for convex bodies and others, with close links to geometric inequalities and optimal transport. Actually, the same kind of results are proved for a larger category of log-concave distributions on Euclidean space, replacing uniform distributions on convex bodies. This is a remarkable extension of the whole theory which could be called *Geometrization of Probability* because it extends to the class of (log-concave) probability measures many typically geometric notions and results. For example, the notion of polarity, the Blaschke-Santaló inequality and its inverse (by Bourgain-Milman), Brunn-Minkowski inequality, Urysohn inequality and many others are formulated and proved now on this larger category. We see this as just the start of a new development.

The achievements of asymptotic geometric analysis demonstrate new and unexpected phenomena characteristic for high dimensions. These phenomena appear in a number of domains of mathematics and adjacent domains of science dealing with functions of infinitely growing numbers of variables.

Besides the main subject of our program, asymptotic theory of normed spaces and convex bodies, it includes the branch of discrete mathematics known as asymptotic combinatorics, including problems of complexity and graph theory; considerable parts of probability dealing with large numbers of correlated random components, including large deviation and the theory of random matrices, and many others. Recent results in asymptotic analysis lead to another link with the complexity theory. Namely, it is becoming clear that the procedure to find whether a convex body is logarithmically in dimension close to ellipsoids is not polynomial in the number of “simple” random steps. Advances in this direction will definitely lead to new interesting results and conjectures in both fields. The theory of computational complexity studies the inherent computational difficulty of various computational problems, mostly originating in combinatorial optimization. The complexity theory is, actually, a purely asymptotic field, as is the notion of complexity classes; the most basic notion here is formulated and seen as an asymptotic notion, where the growing parameter is the size of the computational problem under investigation. The famous “P versus NP” problem asks in fact to compare two asymptotic complexity classes. In recent years several important breakthroughs in complexity theory were obtained by applying such asymptotic mathematical tools as concentration of measure, spectral theory and discrete harmonic analysis.

The importance of advances in the subject is affirmed, among others, by the recent recognition at the last ICM in Madrid. There are numerous monographs dealing with various aspects of this subject area, in particular each one of the proposed organizers has written a book on the subject. Even more significantly, there have been very important developments during the past two years, and major results were obtained by very young mathematicians. At the last ICM congress in Madrid, all three invited talks

on the subject of Functional Analysis and related fields were from this direction, and two of the invited speakers were very young (Barthe and Klartag). This underlines the timeliness of the current thematic program.

The program continues an established tradition of previous large-scale programs devoted to the same general research direction. Among them are the program *Convex Geometry and Geometric Functional Analysis*, a half-year program at Berkeley, MSRI (1996), where Vitali Milman and Nicole Tomczak-Jaegermann were among the main organizers, *Phenomena in High Dimensions*, a three-month program at the Centre Émile Borel at the Institut Henri Poincaré (2006), where Vitali Milman was among the main organizers. In addition, Vitali Milman and Nicole Tomczak-Jaegermann were the main organizers of two summer thematic programs at the PIMS in Vancouver: a summer mini-programme in Geometric Functional Analysis (1999) and a PIMS thematics programme in Asymptotic Geometric Analysis (2002).

All four programs were very successful and involved many young mathematicians. In particular, among Ph.D. student participants at the time, three have already given talks at different ICM congresses and two received European prizes. Here are some names: S. Alesker (Tel Aviv), S. Artstein-Avidan (Tel Aviv), F. Barthe (Toulouse), D. Cordero-Erausquin (Paris 6), O. Guédon (Paris 6), B. Klartag (Princeton), R. Latała (Warsaw), A. Litvak (Edmonton), K. Oleszkiewicz (Warsaw).

The main directions of research include asymptotic theory of convexity and normed spaces, concentration of measure and isoperimetric inequalities, optimal transportation approach, applications of the concept of concentration, connections with transformation groups and Ramsey theory, geometrization of probability, random matrices, and connection with asymptotic combinatorics and complexity theory.

The keynote participants are Avi

Wigderson (Institute for Advanced Study) who will give the Distinguished Lecture Series during the week of September 13, and Shiri Artstein-Avidan (Tel-Aviv University), who will deliver the Coxeter Lecture Series.

There will be a small number of visitors staying over the duration of most of the program, a larger number between one and two months stays, and the bulk of visitors for stays of a few weeks. A number of people will visit the program for one week, or will participate in a specific event. There will be three workshops held during the program:

Workshop on Asymptotic Geometric Analysis and Convexity (September 13-17, 2010), organized by Monika Ludwig, Vitali Milman and Nicole Tomczak-Jaegermann, preceded by a concentration period on convexity (September 8-10, 2010) and followed by a concentration period on asymptotic geometric analysis (September 20-22, 2010).

Workshop on Concentration Phenomenon, Transformation Groups and Ramsey Theory (October 12-16, 2010), organized by Eli Glasner, V. Pestov and S. Todorćević.

Workshop on Geometric Probability and Optimal Transportation (November 1-5, 2010), organized by B. Klartag and R. McCann, preceded by a concentration period on partial differential equations and geometric analysis (October 25-29) and followed by a concentration period on nonlinear dynamics and applications (November 8-10).

There will be a number of Fields postdocs supported for the duration of the program. Particular attention will be paid to inviting PhD students.

A permanent weekly seminar at Fields will be run for the duration of the program, as well as a special weekly young researcher seminar.

As of the moment of writing, there are about 130 confirmed participants of the program, and the number will grow. It is promising to be another interesting and exciting large-scale thematic program at Fields.

Vladimir Pestov (Ottawa)

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NOTED

SUSAN THOMAS, daughter of Professor Donald H.S.M. Coxeter, has given a donation of \$30,000 in addition to her previous donation of the same amount. The Fields Institute is thankful for her generosity. Her donations will be used for upgrades to the Institute; Donald Coxeter's piano now sits on a beautiful new mahogany floor.

ICM SPEAKERS Several invited speakers at the upcoming ICM in Hyderabad have close connections to the Fields Institute. Among them are organizers of upcoming thematic programs, Jeremy Quastel and Justin Moore, as well as former or upcoming Distinguished Lecture Series speakers, Srinivasa Varadhan, Timothy Gowers, and Hugh Woodin. Among the Dean's Distinguished Visitors to the Institute who have been invited to the ICM are Artur Avila and Nizar Touzi. The Fields Scientific Advisory Panel is also represented by former member David Brydges and current member Philip Maini. Larry Guth and Alexander Nabutovsky are both faculty at University of Toronto, a Fields sponsoring university. Recent visitors to the Institute who have also been invited to speak at the ICM include Freddy Delbaen, Takeshi Saito, Sergei Starchenko, Zinovy Reichstein, and Jaroslav Neseteril.

Workshop on Financial Econometrics



THIS TWO-DAY WORKSHOP brought together a large audience of academics and practitioners in financial econometrics, including a group of leading econometricians and statisticians working in the area. Financial econometrics is a research area in which finance, economics, statistics, probability and applied mathematics are integrated.

The workshop summarized the state of the art in the field, with contributions ranging from methodologies to analyze high frequency financial data to low frequency financial models and their applications in derivative pricing, portfolio choice and asset allocation. Recently, high frequency econometric methods have been evolving rapidly, driven by the needs for accurate measurement of financial quantities using intra data. Inferences from finer models with jumps and many related applications are being investigated, bringing into focus a range of problems that were otherwise unobservable from daily or weekly data. Many talks were motivated by, or addressed, issues related to the recent financial crisis.

The workshop kicked off with a talk by Lars Hansen (Chicago), in which he employed particle filtering methods to characterize the learning behaviour of individual agents within an economic model, and shed more light on the decision problems of the agents. As part of the Distinguished Lecture Series, Darrell Duffie

(Stanford) described and analyzed the opaque nature of some financial markets, and in particular the over-the-counter federal fund market. The afternoon session started with a talk by Robert Engle (NYU) on a new measure of financial risk which amplifies the impact of the systematic market risk faced by individual firms. Yacine Aït-Sahalia (Princeton) echoed a similar point in his talk on modeling mutually exciting jumps, with an emphasis on the contagious financial shocks that may occur in different seemingly unrelated financial markets.

On the second day of the workshop, Eckhard Platen (UTS) demonstrated the optimality properties of large diversified indices. Then Joon Park (Indiana) presented his results on the properties of maximum-likelihood estimators of non-stationary models. In the afternoon, Andrew Lo (MIT) proposed an alternative perspective of economic behaviour based on a new taxonomy of uncertainty. He concluded with an “uncertainty checklist” for academics and practitioners when building their quantitative models. The next talk was given by Jianqing Fan (Princeton) who discussed the control of risk from a statistical point of view when managing asymptotically large portfolios. Later in the day, Jean Jacod's (Pierre et Marie Curie) talk on testing for co-dependence in jumps and volatility was right at the new frontier of high frequency financial econometrics, in contrast with the old-fashioned technology employed—chalk and blackboard!

The program committee and workshop participants are grateful to the local organizers at the Fields Institute and the conference sponsor TD Bank Financial Group.

Dacheng Xiu (Princeton)

WORKSHOP ON FOUNDATIONS OF MATHEMATICAL FINANCE

THIS WAS THE FIRST workshop of the six-month Thematic Program on Quantitative Finance: Foundations and Applications, held at Fields from January to June 2010. This workshop brought together more than 130 researchers in mathematical finance, including 25 invited speakers.

The first speaker, Hans Follmer, set the tone for the week by delivering a talk describing the state-of-the-art in dynamic risk measures and showing how aversion to model ambiguity is associated with asset bubbles. After the talks by Josef Teichmann, Mihai Sirbu and XunYu Zhou, the focus of the last lecture of the day, by Marco Frittelli, was again on dynamic risk measures, but with emphasis on the quasiconvexity property.

Nicole El Karoui opened the second day of the workshop with a new way to construct progressive utilities using optimal wealth processes. This gives additional mathematical weight to the general theme of dynamic utility functions, which were popularized in the mathematical finance community through the work of Marek Musiela and Thaleia Zariphopoulou on forward utilities. This was also the theme of the lecture delivered by Zariphopoulou on Thursday.

Paolo Guasoni analysed the fee incentives of hedge funds using utility functions for fund managers, and for the rest of the day, Semyon Malamud, Peter Bank, Kasper Larsen and Jaksa Cvitanic all talked about different aspects of markets with heterogeneous agents—one of the hottest as yet unexplored frontiers in mathematical finance.

With the exception of Damir Filipovic who talked about CDOs, and Nizar Touzi who explained how hedging under Gamma constraints or market illiquidity is the basic motivation for the study of second order BSDE and showed many results on existence, uniqueness and representation of their solutions, everyone spoke about equilibrium on the third day of the workshop. Equilibrium in incomplete markets was also the subject of the lecture by Patrick Cheridito on the last day of the workshop.

After the talks by Thaleia Zariphopoulou on forward utilities and Michael Monoyios on executive stock



options, the Thursday morning session ended with Martin Schweizer explaining how the optimal wealth and the optimal portfolio arising from a utility maximization problem depend on the time horizon. The result is intuitive enough, despite the technical proof, and ties in well with the general theme discussed during the workshop on forward utilities.

On the last day of the conference, a Levy market model was proposed in the talk by Rene Carmona, who also characterized the consistency of these models by a drift condition “a la HJM.” Bruno Bouchard talked about a general class of portfolio optimization problems that can be represented as optimal control under stochastic target constraints. One last talk on risk measures, by Emanuela Rosazza Gianin, showed how the theory of g -expectation can be applied to characterize the penalty function of convex risk measures in a Brownian environment. Miklós Rásonyi closed the workshop addressing the consistency of financial bubbles and arbitrage.

The fact that general equilibrium ended up being one of the dominant themes of the workshop shows that, as a community, Mathematical Finance has evolved from arbitrage pricing and risk preferences for individual agents (risk measures, utility, indifference price, etc.) and is finally arriving at the task of understanding how prices are formed in markets with multiple agents, which is of course the starting point of economic theory.

Marco Frittelli (Milano) & Matheus Grasselli (McMaster)

Workshop on Computational Methods in Finance



Workshop participants.

SOLVING PROBLEMS IN FINANCE USING computational methods has been a principal reason for the existence of many quantitative finance positions in the financial industry. From algorithms for trading, pricing complicated financial instruments, choosing optimal portfolios, and estimating the exposure of a portfolio to different financial risk factors, the field has proved to be a constant source of innovation. From March 22 to 24, 2010, many of the leading experts gathered at the Fields Institute to discuss recent advances in computational methods and computer hardware and their application to financial problems.

The workshop opened with Ralf Korn who discussed extending binomial methods to higher dimensional problems, using a method of decoupling based on a diagonalization of the correlation matrix, reducing the matching problem to several uncorrelated one-dimensional trees. His talk was followed by Kumar Muthuraman who presented a moving boundary method to solve free-boundary problems: start with a suboptimal boundary and systematically improve it in the region where the associated variational inequality is violated until the true free-boundary is well approximated. Muthuraman illustrated the range of applicability of his method in problems involving optimal stopping, as well as singular and impulse control. John Chadam gracefully replaced Garud Iyengar at the last moment, and explained how integral equation methods can lead to very detailed results for the boundary of the American put option problem. The last talk of the first session was given by Lorenzo Garlappi, who, in the context of portfolio optimization,

showed how a careful decomposition of the state variables into an observable component and a random error, combined with a Taylor expansion of the value function (expressed in terms of certainty equivalents) can lead to very accurate numerical approximations.

The afternoon session started with a panel discussion consisting of Jim Gatheral, Chris Rogers, Ernst Eberlein, and Jeremy Staum who discussed current challenges in the light of the 2008 crisis. Many interesting suggestions of problems were given, such as algorithmic trading, optimal liquidation strategies, the effect of latency on trading, dark markets, behavioral finance, liquidity, systemic risk management, interactions between financial institutions, contagion, robust techniques, econometrics under the real measure, aggregation of errors at the portfolio level, and modeling appropriate objective functions for institutions over long time horizons. In a memorable exchange, Ernst Eberlein lamented the use of Gaussian copula models for CDOs. He was followed by Chris Rogers, who said, “I enjoyed Ernst’s rant against the Gaussian copula. I think you are kicking a corpse.”

The panel was followed by a talk by Jeremy Staum on the potential of reusing simulation results. He made a distinction between the current, run-oriented, paradigm where runs are not stored but are repeated as needed, and a new, problem-oriented, paradigm where values are stored for multiple inputs are referred to in the future. Birgit Rudloff concluded the first day with an investigation on the effect of transaction costs on risk measures, touching upon the problem of super-replication and the use of good-deal bounds.

During the panel discussion on the first day of the workshop, Jim Gatheral pointed out that, with the recent market turmoil, exotic derivatives have gone out of fashion. As a result, talented quants have diverted their attention somewhere else, in particular to algorithmic trading. (Ed. note: Wikipedia defines a “quant” as a quantitative analyst.) Algorithmic trading is largely driven by market microstructure, and the first talk by Ciamac Moallemi discussed the dynamics of a fundamental microstructure concept, the limit order book, using a fluid model approximation. Jim Gatheral followed with a review of the best-known optimal execution models in the literature, leading up to his new results about the possibility of price manipulation. Petter Kolm shifted the focus of the discussion by considering the “buy-side,” and

‘Computational’ continued on page 16

Weekend Workshops on Algebraic Varieties with Special Emphasis on Calabi-Yau Varieties and Mirror Symmetry

ORIGINALLY INAUGURATED IN 2003 BY JAMES D. Lewis (Alberta), Stefan Müller-Stach (McMaster, now at Mainz, Germany) and Noriko Yui (Queen's), this series of weekend workshops has entered its seventh year. They are now a bi-annual event at Fields with meetings held in the fall and spring.

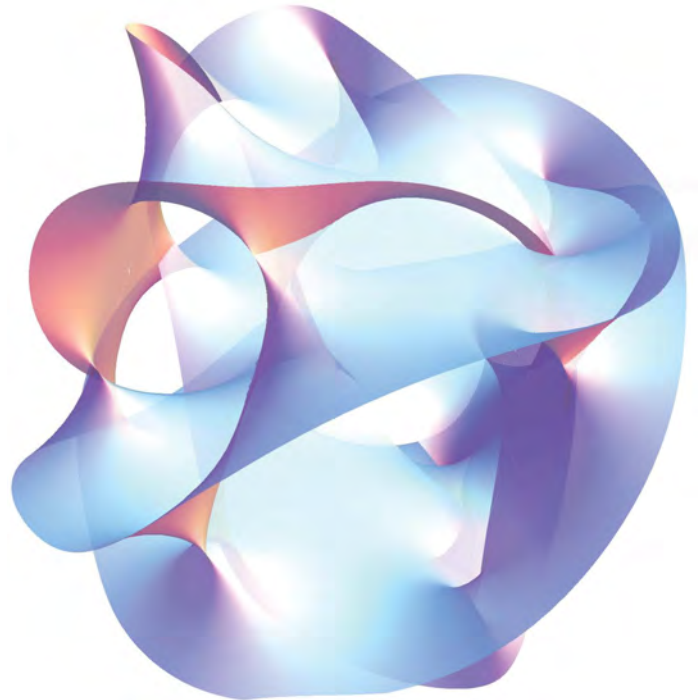
What is a Calabi-Yau variety?

A Calabi–Yau variety of dimension d is a complex manifold which admits a nowhere vanishing holomorphic d -form, and for which there are no nonzero holomorphic i -forms for $0 < i < d$. For instance, a dimension 1 Calabi–Yau variety is an elliptic curve, a dimension 2 Calabi–Yau variety is a K3 surface, and a dimension 3 one is a Calabi–Yau threefold. Elliptic curves already have a history of over 250 years, from the analytic work on certain differential equations and elliptic integrals by Euler, Legendre, Abel, Jacobi up to the number theoretic work of Wiles. Many aspects of the classical theory of elliptic curves are forerunners of modern developments in the subject. For instance the addition laws and periods of elliptic integrals evolved into the study of regulators of algebraic cycles of codimension ≥ 1 and corresponding Picard-Fuchs equations. Other aspects of classical elliptic curve theory found their generalizations in various cohomology theories.

One of the most significant developments in arithmetic geometry and number theory is the proof of the Taniyama-Shimura-Weil conjecture on the so-called modularity of elliptic curves defined over the field \mathbb{Q} by Andrew Wiles and his disciples. Wiles' idea is to exploit 2-dimensional Galois representations arising from elliptic curves and modular curves, and establish their equivalence. This in turn has led to a flurry of activity on the arithmetic of Calabi-Yau threefolds defined over number fields.

How do Calabi-Yau varieties arise?

Two of the most significant developments in the last two decades in theoretical physics (High Energy) are, arguably, string theory and mirror symmetry. String theory proposes a model for the physical world which purports its fundamental constituents as 1-dimensional mathematical objects “strings” rather than 0-dimensional objects “points.” Calabi–Yau manifolds appear in the theory because in passing from the 10-dimensional space time to



a physically realistic description in four dimension, string theory requires that the additional 6-dimensional space is to be a Calabi–Yau manifold. Mirror symmetry is a conjecture in string theory, that certain “mirror pairs” of Calabi–Yau manifolds give rise to isomorphic physical theories. Though the idea of mirror symmetry has originated in physics, in recent years, the field of mirror symmetry has exploded onto the mathematical scene. It has inspired many new developments in algebraic geometry, toric geometry, Riemann surfaces theory, infinite dimensional Lie algebras, among others. For instance, the mirror symmetry has been used to tackle the problem of counting number of rational curves on Calabi-Yau threefolds.

The development in physics stimulated the interest of mathematicians for Calabi–Yau varieties. One then realized that it may be worthwhile to look at modular forms (of one or more variables), algebraic cycles, L-series for these special varieties in particular. Understanding the many aspects of the mirror symmetry phenomena became a new challenge.

‘Calabi-Yau’ continued on page 16

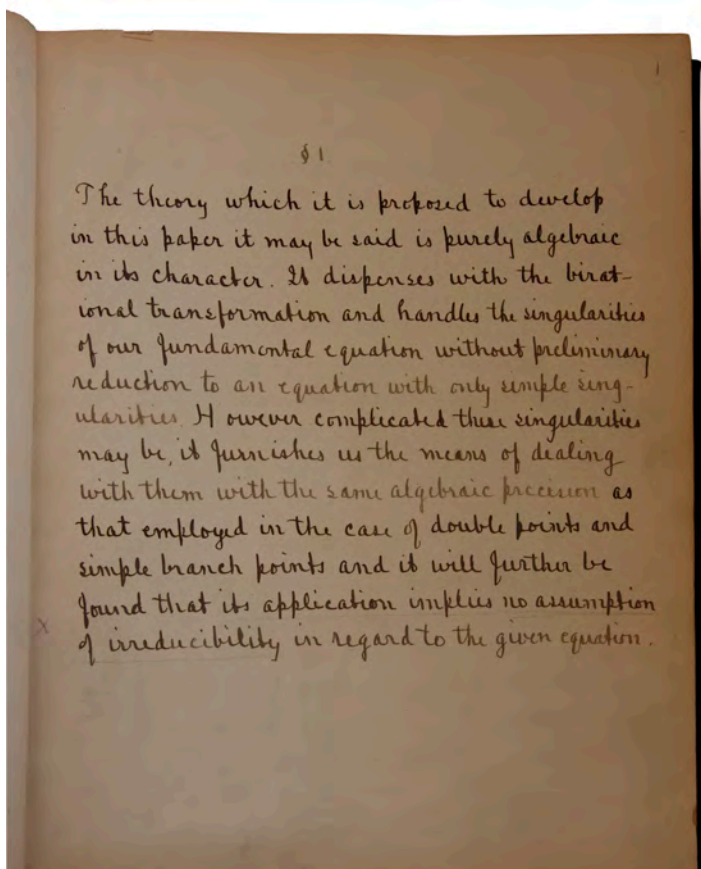
TRACKING J.C. FIELDS



J.C. Fields, circa 1924

THERE ARE MANY GAPS IN our knowledge of J.C. Fields' life. This is likely because, at either his own request or his brother's, most of his personal papers, lantern slides, and photographs were destroyed. Time and neglect also took their toll. What remains in Toronto are his published papers (including a number of non-mathematical articles), his many hand-written notebooks from courses he took while a post-graduate student in Berlin (1894–1900), the hand-written 1898 manuscript for his book *Theory of Algebraic Functions of a Complex Variable* (1906), and a few documents, now well-known, drawn up when he was establishing the medal named after him. Fortunately, some of his correspondents kept his letters, including former University of Toronto presidents James Loudon and Robert Falconer. These letters contain clues leading to archives elsewhere on both sides of the Atlantic.

Gradually, a man emerges: earnest, deeply committed to scientific research and building it in Canada, soft-spoken, persistent to the point of doggedness, a skilled but quiet negotiator, private, with no interest in material goods. His one extravagance was travel, which he loved. He has left his name in passenger lists of the great steamship lines of the late-nineteenth and early-twentieth centuries. Frances Hoffman and I are writing a monograph on Fields, pursuing him in scattered records to discover how it was that the 1924 International Mathematical Congress (IMC)* came to Toronto at a time when Canada had as yet no mathematics society. How did he raise the necessary money? How did he become enmeshed in the international politics of mathematics following World War I when a great schism in all the sciences, not just mathematics, occurred? What were the circumstances that gave rise to the



The first page of Fields' hand-written manuscript, *Theory of Algebraic Functions of a Complex Variable*.

friends among French mathematicians, particularly Gabriel Koenigs, professor of mechanics at the Sorbonne. Fields attended courses at the Sorbonne and the Collège de France. Judging by his lifelong habit, he very likely took careful notes, but these have been lost. He also attended the bi-monthly meetings of the SMF and heard papers (*mémoires* as they were then called) by the great French mathematicians of the day: Henri Poincaré, Émile Picard, Paul-Émile Appell, and Paul

Painlevé, among many others.

Fields' involvement in the international politics of mathematics during the 1920s was a natural outcome of having organized the Toronto IMC. He was thrust into the middle of the affairs of the International Mathematics Union (IMU) at a time when scientists from Germany and the other Central Powers were excluded from participation, which was limited to members of the victorious Entente Cordiale and nations neutral in the war. The question of the inclusion or exclusion of Germany dominated mathematics from 1918 to 1936. Fields considered himself to be "persona grata" to both sides, and made several trips to Europe between 1929 and 1931 to see what he might do to heal the breach and bring

Germany into the IMU.

The opposition to German membership was led by Émile Picard of France. An unanswered question is the extent to which Picard represented the general French point of view. Accordingly, I visited archives at the Collège de France and Sorbonne to try to determine what other opinions there may have been. I found three records of interest. One was a small book written by Paul-Émile Appell, *Souvenirs d'un alsacien* (1923). This is a bitter account of the Alsatian experience from the time of Appell's childhood in Alsace before the Franco-Prussian War up to 1923. Another sign that Picard's view was widely shared may be found in the SMF meeting minutes from 1920 to 1930, which were all prefaced by a reminder that the names of its members who were from "*nations ennemies*" were excluded and could only be restored through a personal petition. This was twelve years after the end of the war. The third was a reference to an article by Jacques Hadamard entitled "*Les Responsabilités de la guerre*" (*Cahiers des droits de l'homme*, 1929), which I hope to receive soon by inter-library loan. It may be that by 1929 the French attitude had begun to soften.

Fields' visits to French and German colleagues in Europe in the late 1920s convinced him that, in his words, "the rift is still deep." It was through this prism of rupture that he created an international medal in mathematics that he wanted to be free of identification with any person, nation, or modern language.

* The Toronto International Mathematical Congress (IMC) in 1924 was the only one so named. All the others were International Congress of Mathematicians (ICM).

Elaine McKinnon Riehm (Fields)

medal? In the midst of the schism, how did Fields gain the agreement of the French and Germans, both haunted by memories of the war?

One of the gaps in our knowledge of Fields concerns the two years he spent in Paris (1893–94) before moving on to Göttingen and then Berlin. Recently, the Fields Institute announced its Outreach Competition designed to further the culture of mathematics, and provided us with a travel grant for research abroad on Fields. Fields is hard to find in Paris. Encouraged by his teacher at Johns Hopkins University, Thomas Craig, he joined the Société Mathématique de France (SMF) while still a graduate student, a membership he maintained for life. He published nothing while in Paris, but learned to speak creditable French and made acquaintances and

On Growth and Form: Mathematics, Mechanics, and Morphogenesis

“How far even then mathematics will suffice to describe, and physics to explain, the fabric of the body, no man can foresee.” –D’Arcy Thompson

L. MAHADEVAN OF HARVARD has a natural curiosity for biological phenomena which can be described by mathematical or physical frameworks. His work is guided by an aesthetic developed in D’Arcy Thompson’s *On Growth and Form*, a classical text portraying the importance of a structural rather than genetic understanding of biological forms. Flow connects the two concepts of growth and form. Mahadevan studies flow in various biological contexts using techniques from applied mathematics. His models give a structural understanding of the biological form in question offering an explanation, using mathematics and physics, for how and why these forms came to exist.



Hyperbolic surface.

Mahadevan’s visiting lecture to the Fields’ showcased some of his most recent work. In particular he showed how he used techniques from fluid dynamics to study the growth of pollen tubes, elasticity theory to determine how leaves will change structure in different environments,

and stability theory to understand why the brain folds into the same macro-level structure for all humans. In other words Mahadevan uses applied mathematics to understand why these forms appear in nature and also to understand why they always appear. An aim for this type of research is to use an understanding of a certain biological features of an organism and predict how those features may change or emerge, given a change in environment.

Mahadevan first explains the shape of single celled plant organs. At the Applied Math Lab, along with Post-doc Otger Campas, they examined the growth process of pollen tubes. His principle focus is to understand the dynamics of the shape of the pollen tube as determined by size, thickness, speed and stability of the structure. Each of these parameters varies with changes of internal cellular pressure, composition of cell walls, and flow of material through the cell. These parameters come together into a model characterizing growth at the tip, which is the primary location where new material is being added to the cell.

The model describes how the various tubular shapes are characterized by mean and Gaussian curvatures and related by a simple generalization of Laplace’s Law. Growth at the tip occurs because new material is being added to the plant organ, causing the internal pressure of the cell to increase and since the tip is less rigid, this causes growth to occur in the direction of least rigidity. Mahadevan and Campas have set up the model in such a way that the overall shape of the pollen tube is characterized by two functional equations with three

unknown quantities. Fluid dynamics and asymptotic methods allow for understanding of the overall growth of the pollen tube as described by the model. With this model, Mahadevan is able to simulate different cellular conditions and predict the shape of these specific single celled organs. These simulations guide other researchers to do experiments and also to explain data from past scientific experiments.

For multi-celled plant organs, Mahadevan chooses another specific scenario to unravel. Using experiments conducted by Mimi Koehl at Berkeley, he studied the emergence of ruffles in large kelp. Ruffles in plant leaves are designed by nature to increase dispersion of nutrients in the neighbourhood of the plant. In slow moving water, the appearance of ruffles and increases in width will allow for mixing nutrients in the surrounding environment while in fast moving water, sharper and narrower blades are better for mixing. Koehl’s technique for producing this phenomenon experimentally is to transplant the plant from a slow water environment to fast. Holes are poked in the leaves before the transplantation and then measured after some time when the plant has adapted to its new environment. This produces data explaining how the leaf becomes either narrower or wider based on location on the plant. It also explains how the structure of ruffled leaves is determined by environmental changes. Biologically it is already well understood how much the kelp will grow or shrink, but the ruffling of the leaf edges remains to be understood quantitatively.

Mahadevan along with past

A MATHEMATICAL LOOK INTO THE GENE REGULATORY NETWORK

graduate student Haiyi Liang have decided to tackle this biological phenomenon using elasticity theory and differential geometry. They would like to explain elastic buckling, which is the appearance of ruffles with increases in the environmental flow around the plant. There are two principle forces which are modulated within the ambient environments. These are bending forces and stretching forces. It is possible to have incompatibility of intrinsic curvature of a surface and ruffles on the edges and so these must be modeled separately and superimposed on each other to produce a result. This gives rise to two separate scaling laws describing how the width and ruffles vary with flow measurements. The specific leaf in question has negative Gaussian curvature everywhere and this corresponds to the intrinsic curvature. However, the ruffles can be described by a generalization of minimal surfaces called Willmore surfaces that correspond to minimization of area integrals and mean curvature functionals over the surface. The two surfaces are then intersected with each other to produce the predicted leaf shape.

An interesting question mentioned was given a metric on the intersection of the surfaces is it possible to embed a patch of the hyperbolic plane in Euclidean Space. These patches would correspond to biological organisms called crotches which have a beautiful but poorly understood physical form.

Mahadevan also talked briefly about his approach to understanding the folding of the brain using stability theory and homologies.

Richard Cerezo (Toronto)

QUAID MORRIS IS THE PRINCIPAL INVESTIGATOR AT THE Morris Lab of the University of Toronto Banting and Best Department of Medical Research. Recently, he spoke to the Centre for Mathematical Medicine about his work with mathematical models that determine the dynamic biological functionality of RNA binding proteins (RBPs) as regulators of gene expression.

Through a series of complex processes, DNA undergoes transcription into RNA. It is then translated into proteins, a process that may be regulated by RNA binding proteins. During translation, messenger RNA (mRNA) produced during transcription are decoded to produce an amino acid chain, or polypeptide, that later folds into an active protein. Polypeptides are comprised of a specific sequence of the 22 amino acids found in proteins, and can be thought of as an alphabet. Proteins that regulate transcription of DNA to RNA are called transcription factors, and the amount of RNA produced during transcription is controlled by transcriptional regulation. For double-stranded DNA, transcriptional regulation is better understood than post-transcriptional regulation. Morris is studying the latter and how it is influenced by RBPs and their choice of binding sites. RNA binding proteins recognize signals encoded in mRNA by binding to them, ultimately determining what happens to RNA after transcription. Prediction of where RBPs will bind could give insight into the mechanisms of the underlying regulatory process.

Mathematical models used to study how DNA or RNA signals are recognized by proteins that bind to particular sequences are called motif models. Constructing a motif model for DNA was easier than for RNA, as the structure of DNA is well-characterized—such knowledge of RNA structures does not exist. However, by using a polynomial-time algorithm, a probability distribution of the possible secondary structure of RNA can be computed based on thermodynamic characteristics of the molecule. Fortunately, the secondary structure gives a useful approximation of the complete structure, which can be utilized for development of an mRNA-processing motif model.

Morris' ultimate goal is to computationally predict the regulatory fate of an arbitrary mRNA sequence, given cellular conditions. As a primary step towards that goal, Morris' team has developed an experimental assay called RNAcompete, which determines preferential pairings between recombinant RBPs and constructed RNA sequences. Morris and his collaborators at the Banting and Best Department of Medical Research have also developed a motif model called RNAcontext that takes these preferential pairings as inputs and learns a motif model. RNAcontext uses a structural annotation scheme to score potential binding sites based on their RNA sequence and secondary structure. The secondary structure context of RNA bases is divided into four groups (paired, loops, unpaired, and miscellaneous, or PLUM) and continuous scoring is used against other structural motif models to represent RBP structure preference. RNAcontext performs better in eight out of nine cases, successfully describing historical *in vivo* and *in vitro* data.

Richard Cerezo (Toronto)

Review: Ottawa lectures on admissible representations of reductive p -adic groups

THIS MONOGRAPH CONSISTS OF NOTES BASED on mini-courses given at two Fields Institute Workshops that were held at the University of Ottawa in May 2004 and January 2007. These notes contain introductions to a variety of topics in the representation theory of reductive p -adic groups. The emphasis is on delivering the basic ideas and avoiding technicalities. The articles illustrate different, but interrelated, perspectives on the study of admissible representations of reductive p -adic groups. In addition to describing fundamental concepts and results, some of the articles give historical background, and several provide an overview of techniques and theories currently used by researchers. The monograph is a highly accessible and valuable introductory reference to the area.

The first few pages contain a brief summary of background concerning fields, algebraic groups, representations of p -adic groups, and the local Langlands program. This material will be especially helpful for beginning students.

In the first chapter, Alan Roche gives a beautiful exposé of the Bernstein decomposition and the Bernstein centre. The Bernstein decomposition, which expresses the category of smooth complex representations of a reductive p -adic group as a product of indecomposable subcategories, is one of the basic foundations of the theory of smooth representations. The theory of the Bernstein centre describes the centre of the category of smooth representations.

Bruhat-Tits theory has played a crucial role in many advances in the representation theory and the character theory of reductive p -adic groups. The second chapter, written by Jiu-Kang Yu, provides hints for those who want to understand how Bruhat-Tits theory is applied to representation theory. Yu makes useful suggestions for readers interested in passing between the well-known survey article of Tits and the highly detailed, technical and extremely general papers of Bruhat and Tits. This article is a valuable complement to Tits' survey article.

The importance of supercuspidal representations of reductive p -adic groups is a consequence of the fact that all irreducible admissible representations may be obtained as subquotients of representations arising via parabolic induction from supercuspidal representations of Levi subgroups. Ju-Lee Kim gives an elementary introduction to supercuspidal representations in the third chapter. After a brief discussion of the history of the classification of supercuspidal representations, Kim gives an overview of Yu's construction of tame supercuspidal representations,

followed by a description of the general ideas used in proving that for certain classes of groups Yu's supercuspidal representations exhaust all of the supercuspidal representations.

In the fourth chapter, Paul Sally and Loren Spice give a brief introduction to the character theory of reductive p -adic groups. After recalling the definition of the character of an irreducible admissible representation and discussing the history of character computations, they give explicit examples of character formulas for certain supercuspidal representations of general linear and special linear groups.

Julia Gordon and Yoav Yaffe give an elementary introduction to the theory of arithmetic motivic integration in the fifth chapter. They also discuss applications of this theory to harmonic analysis on reductive p -adic groups, including the use of motivic integration to study orbital integrals and values of characters of representations. The appendices to the article contain a description of relationships between various theories of motivic integration, and an example of a calculation of a motivic volume.

If F is a p -adic field and G is the F -rational points of a connected reductive F -adic group, the non-archimedean local Langlands correspondence relates the set of conjugacy classes of homomorphisms from the Weil-Deligne group of F to the L -group of G and the set of equivalence classes of irreducible admissible representations of G . In the sixth chapter, Paul Mezo reviews background on Galois groups, local class field theory, the Weil and Weil-Deligne groups of F , and representations of the Weil-Deligne group of F . Then he discusses the local Langlands correspondence for general linear groups and L -groups for split groups, concluding with comments about features of the local Langlands correspondence in particular examples.

In the final chapter, Jiu-Kang Yu gives an elementary and explicit presentation of the local Langlands correspondence for tori in the non-archimedean setting. In other references, the local Langlands correspondence for tori is obtained as a special case of a general cohomological isomorphism theorem. Yu's more straightforward approach to this topic requires less background and may be easier for students to digest. At the end of the article, Yu proves that the local Langlands correspondence for tori is depth-preserving for tori that split over tamely ramified extensions of the base field.

The extensive bibliography at the end of the book serves not only as references for the articles, but also as a general bibliography for the field.

Fiona McHaffey (Toronto)

COXETER LECTURE SERIES

Nicole El Karoui speaks about backward stochastic differential equations

EACH YEAR THE COXETER LECTURES SEE A world-renowned mathematician deliver a series of three lectures, in connection with that year's thematic program. For this term's *Quantitative Finance* program, Fields was fortunate to have, as Coxeter lecturer, Nicole El Karoui, former head of the Financial Modeling group at Paris's École Polytechnique.

Following a distinguished body of work on Markov processes and stochastic control theory, El Karoui moved into mathematical finance in 1989. As one of the founders of the premiere European graduate programs in mathematical finance, at the École Polytechnique and Paris VI, she went on to train a generation of French "quants," profoundly influencing the development of the field. She is a Chevalier de l'ordre de la légion d'honneur.

But what exactly are backward stochastic differential equations (BSDEs), the topic of her lectures? Back in the 1940s, Kiyoshi Itô had introduced (forward) stochastic differential equations such as

$$dX_t = a(X_t) dt + b(X_t) dW_t, \quad t \geq 0$$
$$X_0 = x,$$

work for which he went on to receive the inaugural Gauss prize. Here W_t is a Brownian motion, or Wiener process. The idea is that there are two components to how X_t changes: a systematic component (the dt term above) and a noisy one (the dW_t term). If there were no noise, X_t would satisfy an ODE and be perfectly smooth. But including noise implies that solutions have no derivatives at all (and have unbounded variation), so the normal rules of calculus

no longer apply. Itô modified those rules and succeeded in developing a calculus for noisy/non-smooth functions. His *stochastic calculus* has since become the cornerstone of fields as diverse as option pricing in finance, and signal processing in electrical engineering.

A key feature of Itô's theory is that none of the processes involved peek ahead into the future; they are *non-anticipating*. So in this context, the initial value problem posed above is very natural; we fix X_0 and solve forward in time. In finance however (as discovered by Black, Scholes, and Merton), the natural problems involve terminal values, not initial ones.

Financial engineers work with prices determined by the absence of arbitrage. These are particularly convenient to calculate using a *risk-neutral* model, for example, a market where stocks evolve as

$$dS_t = rS_t dt + \sigma S_t dW_t.$$

Here r is the risk-free interest rate and σ is the stock's volatility. Likewise, a money-market account evolves as $dR_t = rR_t dt$. It follows that the value Y_t of any "self-financing" portfolio, obtained by trading between the stock and the money-market account, satisfies an equation

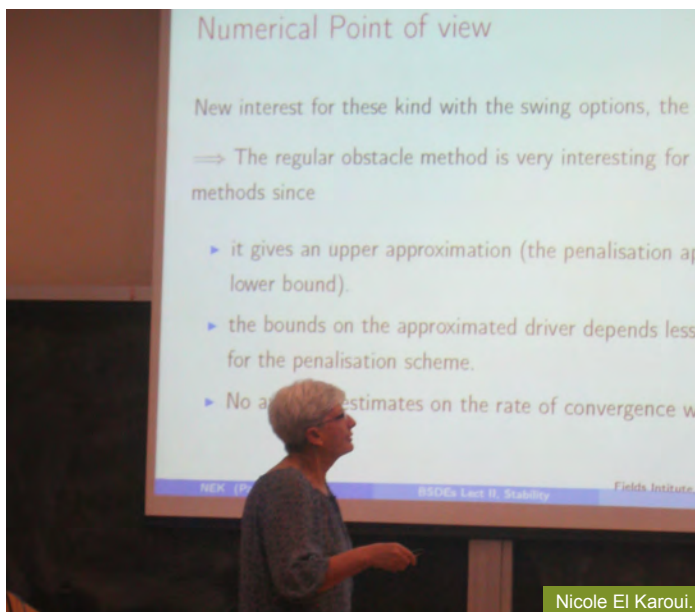
$$dY_t = rY_t dt + dM_t$$

where M_t is a (risk-neutral) martingale. In fact, this property essentially characterizes such portfolios. The martingale representation theorem then shows that $dM_t = Z_t dW_t$ for some stochastic process Z_t (E.g. $Z_t = 0$ for the pure money-market account, and $Z_t = \sigma S_t$ for the pure stock).

The classic hedging problem is to find such a portfolio that matches some liability ξ_T at a given time T . That is, to find a portfolio process Y_t , $0 \leq t \leq T$ of the above form such that $Y_T = \xi_T$. Then the no-arbitrage price is the cost Y_0 of initiating the hedge. For example, a European call option with strike price K is the case $\xi_T = (S_T - K)_+$, and the price Y_0 is then given by the famous (and Nobel prize-winning) Black-Scholes-Merton formula.

The point to emphasize is that one now has a terminal condition (at time T) rather than an initial condition (at time 0). One traditional way of actually computing the price is to write $Y_t = u(t, S_t)$ for some function $u(t, x)$ to be determined, and then use Itô's lemma to obtain a PDE whose solution gives u (in which case $Z_t = \sigma S_t \partial u(t, S_t) / \partial x$). Another approach is to use the martingale property of M_t to write Y_0 as the risk-neutral expectation $e^{-rT} E[\xi_T]$, and then to compute this directly.

'Coxeter' continued on page 17



COMPUTATIONAL

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incorporating the views of a portfolio manager into the execution problem. Since views reflect information, and since information leaks into price over time, he found that traditional execution policies are generally sub-optimal and determined that rebalancing should be done more often than traditionally suggested. From the talks, it became clear that this is a fast-growing area in the literature, with much work remaining to be done.

During the last morning talk, Chris Rogers reverted back to numerical methods and introduced a way to solve optimal stopping problems using convex approximations to a convex value function. As Rogers pointed out, there could be benefits to such an approach, although his preliminary numerical results did not appear to indicate a large advantage for the new method.

In an informal presentation after lunch, Mike Giles gave an overview of the use of the graphic processing unit (GPU) in quantitative finance. GPUs have tremendous potential in speeding up computer code that can be executed in parallel, but imply additional effort in software development. It was highly entertaining to hear that banks in Canary Wharf have exhausted the energy capacity available, since any new power generation will be committed to the 2012 Olympic Games. Thus, banks face the choice of either migrating to less power-hungry GPUs—and having to rewrite all their code—or building new data centres on the periphery of London.

Following Giles' talk, Kay Giesecke showed how to use importance sampling, in the context of portfolio credit risk, to efficiently simulate rare events and calculate several risk measures. Liming Feng concluded the day by introducing a discrete Hilbert transform to calculate option prices for several exotic options in a variety of Levy models with surprisingly good error estimates.

The last day of the workshop opened with a second presentation by Mike Giles, who described a Monte Carlo method implemented on different levels of resolution in order to achieve a prescribed accuracy and showed how to apply it to challenging exotic option pricing and sensitivity calculations. Peter Forsyth discussed how to price guaranteed minimum withdraw benefits contracts using a penalty method. Such contracts became popular in Canada during the past ten years, and led to large losses for insurance companies. Forsyth showed that the contracts had been underpriced, perhaps because insurers were betting on consumers acting suboptimally. Nizar Touzi described a probabilistic approach for solving fully nonlinear PDEs. As is well known, probabilistic methods can be used to solve second order linear parabolic PDEs via the Feynman-Kac

formula, which can then be approximated by Monte Carlo. For quasi-linear PDEs, a similar approach leads to a numerical scheme for solving backward stochastic differential equations. Touzi demonstrated how to generalize to the fully nonlinear case, in a scheme that involves both Monte Carlo and finite-differences. Phillip Protter ended the workshop with a talk on absolutely continuous compensators, which show up in the study of totally inaccessible stopping times such as those used in reduced-form credit risk models.

Stathis Tompaidis (Texas)

CALABI-YAU

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The workshops

The subjects covered in the workshops range widely from arithmetic and algebraic geometry, Galois representations, complex geometry, to mathematical aspects of string theory. These workshops are well attended with about 25 to 30 participants from all over. They comprise well-established recognized leaders working at the forefront of the subject, a promising next generation of younger researchers (including graduate students and postdoctoral fellows), and leading experts in closely related areas where fruitful interactions are deemed likely. The workshops are generally self-supporting, and are of an informal character. The organizers solicit speakers in advance, and postdoctoral fellows and graduate students (who are supported by their supervisors) are especially encouraged to participate by giving talks.

The pedagogical aspects of the workshops are emphasized in the choice of topics so that every participant can benefit from talks and informal discussions. The workshops provided a forum for young participants to get first-hand opportunities to discuss their problems and results with mid-career and senior researchers. They also serve as a useful forum for researchers to present new ideas that often lead to future fruitful collaborations. As in the past, this formula worked well in the recent March 2010 workshop. After a full day of lectures on a Saturday, the participants shared stories over dinner, thus winding down from a busy and interesting day. The workshop ended around noon Sunday, allowing time for some to continue their discussions and for others to spend the afternoon exploring the city of Toronto. The feeling one has about these workshops is one of inspiration. They are an enormous success!

Noriko Yui (Queen's) and James D. Lewis (Alberta)

COXETER

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Starting with the work of Pardoux and Peng in 1990, a new approach emerged, via BSDEs. These are equations of the form

$$dY_t = f(t, Y_t, Z_t) dt + Z_t dW_t, \quad 0 \leq t \leq T$$
$$Y_T = \zeta$$

for which one seeks a non-anticipating solution pair (Y_t, Z_t) , typically unique. Including the second process Z_t explicitly is the tradeoff for naturally imposing a terminal condition. Alternatively, one can think of Z as a control variable that is used to guide Y towards its future target. The case $f(t, y, z) = ry$ is our example above, for the risk-neutral model. One immediate payoff from the BSDE approach is that the same formulation turns out to work for the physical “real world” model, if we use $f(t, y, z) = ry + \lambda z$ (where λ is the *risk premium*).

Since their introduction, a substantial theory for BSDEs has emerged, along with many natural applications to finance. El Karoui's first lecture introduced this subject, and gave a broad range of financial applications, including duality, option pricing in incomplete markets, and portfolio optimization. Her second lecture expanded on the underlying mathematical theory, treating existence, uniqueness, stability, reflecting BSDEs, and introducing some numerical techniques. Her third and final lecture discussed these numerical methods further, analyzing errors and giving relations to the Malliavin calculus. She finished the lecture by returning to finance, defining convex risk measures and connecting them to BSDEs using Peng's notion of g -expectations. The latter treat BSDE solutions as operators and study the functional dependence of the solution on its terminal value.

As one of the principal architects of many of these developments, El Karoui brought a unique perspective to her lectures. Her demonstration of how much can be accomplished by judiciously switching between the forward and backward approaches left the audience with a truly memorable experience.

Tom Salisbury (York)

GENERAL SCIENTIFIC ACTIVITIES

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JULY 20–23, 2010

Fields Institute-Carleton Finite Fields Workshop
at Carleton University

JULY 29–31, 2010

Workshop on Hybrid Dynamic Systems
at University of Waterloo

AUGUST 2–6, 2010

Workshop on Discrete and Computational Geometry
at Carleton University

AUGUST 9–11, 2010

Canadian Conference on Computational Geometry
at University of Manitoba

AUGUST 9–13, 2010

Workshop on Fluid Motion Driven by Immersed Structures

AUGUST 12–13, 2010

Selected Areas in Cryptography (SAC) Workshop
at University of Waterloo

AUGUST 12–15, 2010

CIAA 2010, 15th International Conference on Implementation and Application of Automata
at University of Manitoba

AUGUST 15–18, 2010

Research Meeting and School on Distributed Computing by Mobile Robots
at Carleton University

AUGUST 16–20, 2010

Fields-MITACS Industrial Problem-Solving Workshop (FMIPW10)

AUGUST 17–20, 2010

14th Developments of Language Theory
at University of Western Ontario

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Call for Proposals, Nominations, and Applications

For detailed information on making proposals or nominations, please see the website: www.fields.utoronto.ca/proposals

General Scientific Activities

Proposals for short scientific events in the mathematical sciences should be submitted by October 15, February 15 or June 15 of each year, with a lead time of at least one year recommended. Activities supported include workshops, conferences, seminars, and summer schools. If you are considering a proposal, we recommend that you contact the Director or Deputy Director (proposals@fields.utoronto.ca). For further details, visit www.fields.utoronto.ca/proposals/other_activity.html.

Thematic Programs

Letters of intent and proposals for semester long programs at the Fields Institute are considered in the spring and fall each year and should be submitted, preferably by March 15 or September 30. Organizers are advised that a lead time of several years is required, and are encouraged to submit a letter of intent prior to preparing a complete proposal. The Fields Institute has started a new series of two-month long summer thematic programs focusing on interdisciplinary themes. Organizers should consult the directorate about their projects in advance to help structure their proposal.

Fields Research Immersion Fellowship

This program supports individuals with high potential to re-enter an active research career after an interruption for special personal reasons. To qualify, candidates must have been in a postdoctoral or faculty position at the time their active research career was interrupted. The duration of the career interruption should be at least one year and no more than eight years. Examples of qualifying interruptions include a complete or partial hiatus from research activities for child rearing; an incapacitating illness or injury of the candidate, spouse, partner, or a member of the immediate family; or relocation to accommodate a spouse, partner, and/or other close family member. The RIF will participate fully in the thematic program, in the expectation that this will allow her or him to enhance her or his research capabilities and to establish or re-establish a career as a productive, competitive researcher. The award is to be held at the Fields Institute, but there are no restrictions on the nationality or country of employment of the re-entry candidate.

For programs in a given program year (which runs July to June) the closing date will be the preceding March 31. Applications should be sent by email to the Director. Late applications will be considered if the position has not yet been filled. For further details, visit www.fields.utoronto.ca/proposals/research_immersion.html.

CRM-Fields-PIMS Prize

Nominations for this joint prize in recognition of exceptional achievement in the mathematical sciences are solicited. The candidate's research should have been conducted primarily in Canada or in affiliation with a Canadian university. Please send nominations to crm-pims-fields-prize@fields.utoronto.ca. Nominations for the CRM-Fields-PIMS Prize should reach Fields by November 1, 2010.

Call for Outreach Proposals

The Fields Institute occasionally provides support for projects whose goal is to promote mathematical culture at all levels and bring mathematics to a wider audience. Faculty at Fields sponsoring universities or affiliates considering organizing such an activity and seeking Fields Institute support are invited to submit a proposal to the Fields Outreach Competition. There will be two deadlines each year for such submissions, June 1 and December 1, with the first competition scheduled for June 1, 2010. Proposals should include a detailed description of the proposed activity as well as of the target audience. A budget indicating other sources of support is also required. Submissions should be sent to proposals@fields.utoronto.ca. Questions about this program may be directed to the Director or Deputy Director.

FIELDS ACTIVITIES

Bridging Research, Education, and Industry



MAY TO SEPTEMBER 2010

FIELDS

Thematic Programs

THEMATIC PROGRAM ON THE MATHEMATICS OF DRUG RESISTANCE IN INFECTIOUS DISEASES, SUMMER 2010
Organizing Committee: Troy Day (Queen's), David Fisman (Toronto), Jianhong Wu (York)

JULY 5–16, 2010

Emergence and Spread of Drug Resistance

JULY 19–30, 2010

Mathematical Immunology

AUGUST 3–13, 2010

Transmission Heterogeneity

AUGUST 4–6, 2010

Coxeter Lecture Series: Neil M. Ferguson (Imperial College)

THEMATIC PROGRAM ON ASYMPTOTIC GEOMETRIC ANALYSIS, JULY–DECEMBER 2010
Organizing Committee: Vitali Milman (Tel Aviv), Vladimir Pestov (Ottawa), Nicole Tomczak-Jaegermann (Alberta)

SEPTEMBER 13–17, 2010

Workshop on Asymptotic Geometric Analysis and Convexity

WEEK OF SEPTEMBER 13, 2010

Distinguished Lecture Series: Avi Wigderson (IAS)

OCTOBER 12–16, 2010

Workshop on the Concentration Phenomenon, Transformation Groups and Ramsey Theory

NOVEMBER 1–5, 2010

Workshop on Geometry Probability and Optimal Transportation

FALL/WINTER 2010

Coxeter Lecture Series: Shiri Artstein-Avidan (Tel Aviv)

General Scientific Activities

Activities take place at Fields unless otherwise indicated. Detailed information: www.fields.utoronto.ca/programs

MAY 31–JUNE 4, 2010

Harmonic Analysis: A Retrospective Workshop

JUNE 11–12, 2010

Workshop on Optimization and Data Analysis in Biomedical Informatics

JUNE 17–19, 2010

14th International Congress on Insurance: Mathematics and Economics
at University of Toronto

JUNE 21, 2010

Industrial-Academic Forum on Financial Engineering and Insurance Mathematics

JUNE 22–26, 2010

6th World Congress of the Bachelier Finance Society
at the Toronto Hilton Hotel

JULY 4–6, 2010

Joint Fields-Perimeter Workshop on Random Matrix Techniques in Quantum Information Theory
at Perimeter Institute

JULY 5–9, 2010

Iwasawa 2010 Conference

JULY 6–10, 2010

Canadian Undergraduate Mathematics Conference
at University of Waterloo

JULY 7–10, 2010

Schubert Calculus Summer School

JULY 12–15, 2010

Schubert Calculus Workshop

JULY 12–16, 2010

Workshop on Groups and Group Actions in Operator Theory
at University of Ottawa

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FIELDS WELCOMES MATTHIAS NEUFANG AS DEPUTY DIRECTOR

IN LATE MARCH, THE BOARD OF DIRECTORS appointed Matthias Neufang Deputy Director of the Fields Institute for a three-year term beginning July 1, 2010. Matthias Neufang comes to the Institute from Carleton University, where he has won awards for teaching and served as Associate Dean of Graduate Studies and Director of the Ottawa-Carleton Institute. He is well-known at Fields, and Fields is well known to him—in the past he organized programs at the Institute and served as Acting Deputy Director from January to July 2009.

Many things about Neufang are perhaps less well-known. His undergraduate degree, which he took at Lille, was in French Literature and Mathematics, and he has continued his interest in literature ever since. His favourite writer is Austrian novelist, Robert Musil (1880–1942), and his favourite book by Musil is *The Man without Qualities* (*Der Mann ohne Eigenschaften*). Neufang describes Musil's book as philosophical and likens it to works by Thomas Mann, Marcel Proust, and James Joyce, all contemporaries of Musil. His work, like theirs, has been termed “modernist.” Set in Vienna during the period between World War I and II, the novel revolves around discussions between the central character (who, incidentally, is a mathematician on his way to becoming a philosopher) and a number of friends and acquaintances. It is a large novel. The first section of about 1,000 pages is complete, but the second section of roughly the same size consists of fragments resembling an unfinished puzzle. When he reads the incomplete section, Neufang wonders if all the components simply outgrew the author, who was unable to bring them together. “*The Breath of a Summer Day*” (*Atemzüge eines Sommertags*), is Neufang's favourite fragment, which he often rereads. Written in his garden on a summer day, Musil set aside his pen, returned to his house and died.

Neufang will live in Toronto during his term as Deputy Director, and knows the city well from previous visits. A native of Germany, he brings with him language fluency that will be useful for his work in welcoming guests to the Institute.

He has some ideas in mind as possible directions for the Fields Institute. One is for mini-interdisciplinary thematic

programs—interdisciplinary within mathematics—in fields such as topology, operator algebras, harmonic analysis, and quantum information theory. As an example he noted the particular success of the 2007 workshop on Operator Spaces and Quantum Groups that brought together mathematicians working with different tools in similar fields. Mini-thematic programs might be interspersed among the longer six-month thematic programs.

A second area of interest for Neufang concerns the public representation of the Institute itself. He suggests that it use new platforms available now for communications. He has in mind *Fields Notes* and the website as ways of bringing people into events and taking the Institute out to mathematicians everywhere in the many ways that are possible in the twenty-first century. As the Fields Institute will soon celebrate its twentieth birthday, it may be timely to review its public connections.

When asked if he would have to give up time for his own research when he takes on the duties of Deputy Director, Neufang replied that the only thing he would be giving up for three years is teaching. When all Ontario universities were expanding their graduate programs radically, he was Associate Dean of Graduate Studies at Carleton. Neufang was responsible for overseeing a budget of \$23 million, a process of juggling the quality of graduate students, their likely acceptance of Carleton programs at a time of fierce inter-university competition for students, and the various needs of all departments at the university. This involved decisions about disciplines he knew little about. At least at Fields, he says, the territory is all mathematics. Under these more familiar circumstances, Neufang anticipates he will be able to maintain his research program.

That this is active can be seen in the fact that he will be giving a plenary address at the ICM Satellite Conference on Harmonic Analysis in Bhubaneswar, India, in August 2010. He will speak on Harmonic Analysis on Quantum Groups.

Elaine McKinnon Riehm (Fields)

