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IMTech Newsletter

Issue 5, Advances 5c, May 2023

НЕТ ВОЙНЕ – No War!

Contents

Editorial

This issue, NL05c, contains May advances of the NL05 (January-August 2023).

It features two interviews: with Xavier Fernández-Real Girona and with Juanjo Ruét.

Fernández-Real and Xavier Ros-Oton (he was interviewed in NL05a, pages 2-3) are the winners of the 2023 Ferran Sunyer i Balaguer Prize awarded by the Ferran Sunyer i Balaguer Foundation. The title of the winning memoir is Integro-Differential Elliptic Equations and we offer a short review in these pages.

Juanjo Ruét is the winner of the Albert Dou Prize for Mathematical Dissemination awarded by the SCM. The title of the winning essay is (in Catalan) *De la teoria de grafs clàssica a l'anàlisi de les grans xarxes* (English: *From classical graph theory to the analysis of large networks*).

The Hardy Tour of Eva Miranda is gaining momentum and we continue reporting about it by including an image of the London Mathematical Society poster and English translations of excerpts of her recent interview with Toni Pou in the **Ara** newspaper. Her mathematical achievements, which are and have been attracting much international media attention, are regularly reported in this NL. In particular, about the Hardy Lectures, in NL05a, page 1, and NL05b, pages 1 and 20.

Interviews

Xavier Fernández-Real Girona pursued a CFIS double degree in Mathematics and Engineering Physics (his bachelor thesis in Mathematics, *Boundary regularity for the fractional heat equation*, was worked up in the academic year 2013/14 under the advise of Xavier Ros-Oton and Xavier Cabré Vilagut). Then he earned a Master's degree in Advanced Study in Mathematics (Part III of the Mathematical Tripos) from the University of Cambridge and a PhD in Mathematics from the ETH Zürich on *Regularity Theory for Thin Obstacle Problems* under the advise of Alessio Figalli. For his postdoc research, he joined the Maria Colombo group at EPFL. Since January 2023 he is a Bernoulli Instructor in this school, a position that will change next September to an Ambizione Fellow. His research interests focus on partial differential equations (PDEs) and calculus of variations, and more specifically on elliptic and parabolic PDEs, integro-differential operators, free boundary problems, and optimal transport and transport equations. Among the honors and awards he has received there are: Evariste Galois Prize 2016 from the Societat Catalana de Matemàtiques (SCM); Spanish National Award for Excellence in Academic Performance 2013-14, First Prize, 2018; ETH Medal for outstanding doctoral theses, 2021; Vicent Caselles Prize 2021 for best PhD Theses in Mathematics awarded by the Real Sociedad Matemática Española (RSME) and the BBVA Foundation; Dimitris N. Chorafas Prize 2021 for best doctoral students in the Hard Sciences; XXVI SeMA "Antonio Valle" Young Researcher Award 2023; Ferran Sunyer i Balaguer Prize 2023 for the book *Integro-Differential Elliptic Equations* (co-authored with Xavier Ros-Oton).

NL. ***To begin with, we would like to know when and how your interest for the "exact sciences" was ignited. Did it have to compete with other interests?***

My interest in the exact sciences was most likely ignited through the Cangur competitions that have been organized in Catalonia for many years. It was then consolidated through the mathematical Olympiads, which I was introduced to by Prof. Josep Grané Manlleu and Prof. José L. Díaz Barrero from UPC.

And yes, it has always had to compete with other interests, even to this day. I have always been interested in all sciences, and it was never easy for me to restrict myself to just one discipline. That's why I chose to study at CFIS, and it also influenced my choice of master, and even my choice of area within mathematics.

You took part in the Mathematical Olympiads and other similar contests, culminating with your winning a gold medal in the Spanish MO and hence taking part in 2010 in the IMO as a member of the Spanish delegation. Could you share your more salient memories of those experiences? Did they influence your choices when you entered the university?

The Mathematical Olympiads were probably the main reason why I chose Mathematics as my preferred degree when entering university. These competitions showed me what it really means to do math, and they also revealed how much there was to learn about it.

I have many fond memories of those days; the teachers at the Mathematical Olympiads were incredibly motivated, and we always felt fortunate and grateful to be there. Additionally, it was fascinating to meet people from all over the world who shared similar interests but had vastly different stories.

Your bachelor thesis shows that you had already a strong research drive as an undergraduate. What circumstances contributed to inspire you to follow that call?

I would say that I always knew I wanted to pursue basic research, but I was unsure of the specific area I would choose. My father is a researcher in medicine, and that undoubtedly influenced how I viewed researchers and their work. It was something that always fascinated me.

During my final year of my bachelor's degree, I was greatly inspired by Prof. Xavier Cabré and then-PhD student Xavier Ros Oton. They encouraged me to explore more advanced topics, and they were always patient and supportive. They helped me appreciate the beauty of PDEs and their connections with the world.

In 2015 you earned a master's degree from Cambridge University (Part III of the Mathematical Tripos), with distinction. How did this accomplishment unfold? What did it add to your research training?

I chose to pursue my master's degree at Cambridge University, specifically the Part III of the Mathematical Tripos program, for several reasons. One of the primary reasons was that it allowed me to postpone my decision on a specific research area. The program offered over 100 advanced courses in mathematics and physics, which provided me with the opportunity to study a diverse range of subjects such as Cosmology, Elliptic PDE, and Semigroups of Operators.

The program was intense, and there was a lot to learn in a short amount of time. However, it provided me with a solid foundation in the topics that would later be integral to my PhD thesis. I still consult some of my notes from my time at Cambridge today.

Your next major academic achievement was earning a PhD from ETH Zürich under the advise of Alessio Figalli. Could you please sketch the story of this outstanding experience?

Choosing where to pursue a PhD is always a difficult decision, and my experience was no different. At the time, Alessio Figalli was a professor at UT Austin, and I was applying to several universities in the US as a clueless master's student. I got very nice offers from some places, and I was full of doubts for some months. But Alessio (who at the moment hadn't yet won the Fields medal) seemed very approachable and very active, and this eased my decision to go to UT Austin (after one year, Figalli's group moved to ETH Zurich, where I finished my PhD). Looking back, it was one of the best academic decisions I've

ever made, as Alessio proved to be an outstanding advisor who was always available and patient with my many questions.

Since 2016 you have published a remarkable number of works, with the last few still as arXiv manuscripts. Could you try to summarize the main questions you have probed, often with one or more collaborators?

I have worked on various topics, since the beginning of my PhD. I have studied the regularity of solutions to integro-differential equations, and my PhD thesis focused mostly on free boundary problems, and more precisely, on the thin obstacle problem. Roughly speaking, this problem attempts to understand the shape of a membrane that lives above a given fixed obstacle that is defined on a lower-dimensional set (a "thin obstacle"); and it has surprising connections in many different areas: from finance to ecology, biology, industry, physics, and to other areas of mathematics themselves. One of my favorite results, which I worked on with Joaquim Serra (currently a professor at ETH Zurich), was proving that minimizers of the area constrained to be above a thin obstacle are regular around contact points in all dimensions. This is in contrast to minimizers of the area without an obstacle, for which the Simons' cone is a counter-example to regularity from dimension 8 and higher.

Aside from my work on the thin obstacle problem, I have also been interested in transport equations and more recently, their relation to neural networks.

In your list of publications there are two recent books written in collaboration with Xavier Ros-Oton: Regularity Theory for Elliptic PDE (2022) and Integro-Differential Elliptic Equations (2023), which is the winner of the Ferran Sunyer i Balaguer Prize 2023. Could you comment on the genesis of these memoirs and broadly describe their goals and distinguishing features?

In both cases, the original seeds for the corresponding books were graduate courses that Xavier Ros-Oton gave some years ago both at UT Austin and at the University of Zurich. And in both cases, the books contain some of the things I learned from different places during my graduate studies; they are both books that I would have liked to have available when I started my PhD, and will be hopefully useful to other prospective PhD students.

The first book, *Regularity Theory for Elliptic PDE* is more "basic" in content, and in some settings, it could even be used in advanced master-level courses. This book contains a selection of fundamental results and techniques that we believe are essential in the understanding of Linear Elliptic PDE, but it also introduces, from an elementary viewpoint, some important nonlinear PDE problems.

The second book, *Integro-Differential Elliptic Equations*, is deeper in content, and with much more recent results, almost all of them obtained during the 21st century. The book is more advanced and covers, for the first time, an area that was until now contained in many different papers from the last 20 years. In this way, we try to give a first comprehensive understanding of the subject, we have simplified proofs and unified approaches, and in doing so we are even able to prove some new results that complement well the existing theory.

One aspect I particularly like about both books is that they are completely self-contained, which means that they can be used both as a reference and as a learning tool. We hope that they will be widely used by researchers and students interested in the topics covered in them.

With the Bernoulli instructorship and especially with the coming Ambizione Fellowship at EPFL it seems that you are going to have much freedom to undertake more enterprising research plans. Could you portray what is your vision about these plans and what aims you would like to achieve with them?

These fellowships are truly invaluable, as they offer a rare opportunity for intellectual freedom during a critical juncture in a researcher's career when such opportunities are hard to come by. Rather than constantly seeking out new postdoctoral positions and worrying about where to go next, I will have the stability of a fixed institution and my own research money for the next four years.

Thanks to the Ambizione Grant, I will have the opportunity to conduct research without the burden of heavy bureaucracy or extensive teaching obligations. Additionally, the grant provides substantial funding, allowing me to hire a PhD student and establish my own research group. Through this, I will be able to expand my collaborations with researchers from around the world. In my opinion, it is crucial to have research-focused positions at universities, and grants such as this one promote exactly that.

Looking at the panoply of your awards, prizes and distinctions, we would like to know your appraisal on their effectiveness to bolster research careers, and also to promote visibility of mathematics in the society.

Awards, prizes, and distinctions are undoubtedly valuable for researchers, especially those in the early stages of their careers. They can provide recognition and validation of one's work, and in some cases, they can even provide financial support to continue research. Moreover, they can also serve as a springboard for further career opportunities and collaborations.

I personally believe that major prizes and awards, such as the Fields Medal or the Abel Prize, can help highlight the importance and relevance of mathematics in various fields, as well as showcase the achievements of mathematicians to the wider public. They can also inspire younger generations to pursue mathematics and show that it can lead to meaningful and impactful contributions to society.

However, as with any form of recognition, it's important to remember that prizes can create an overemphasis on individual achievement and potentially overshadow the work of others. Therefore, it's crucial to maintain a balanced perspective and acknowledge the contributions of all researchers, regardless of whether they have received awards or not. Furthermore, I think it's important to ensure that resources are distributed fairly and that access to funding and opportunities are not tied solely to previous prizes or recognitions. Ultimately, research merits should be the sole consideration for such cases.

This year we have rejoiced with the awarding of the Abel Prize to Luis Ángel Caffarelli. How have you lived this memorable event?

It has now been some years that the researchers in the field have been wondering when (and not if) he would get the prize; so in a way, it has been to no one's surprise! Luis Caffarelli's work is one of the most influential contributions to mathematics in the 20th and 21st centuries, and having grown (mathematically) with his results and ideas I can only feel pride and admiration for him! His work in PDEs has greatly influenced many areas of mathematics and has had a profound impact on the development of the field.

This award is also a recognition of the importance of his field and its impact on mathematics and other disciplines. I believe that it will have a positive effect on all researchers in the area and that we are all very lucky to have someone like him working on the topics of our interest. (Of course, one could also argue that these topics are interesting to us thanks to his contributions!)

Congratulations for the FSB Prize, also to Xavier Ros-Oton. Does this prize have any special significance for you?

It is always special and meaningful to receive a prize, even more so when the prize is given by a Catalan foundation, named (and created) after a mathematician who worked in Analysis and was originally from the province of Girona (both traits that I share with him!). During my PhD studies, I looked up to this prize as a symbol of international recognition and prestige, and it is with great joy that I now find myself as a contributor to a book that has been awarded this honor!

Interviews

Juanjo Rue is Associate Professor at the Department of Mathematics (**DMAT**), member of **IMTech**, member of the research group Geometric, Algebraic and Probabilistic Combinatorics (GAPCOMB) and researcher attached to Centre de Recerca Matemàtica (CRM). His research field is in the area of discrete mathematics, in a broad sense, including enumerative combinatorics, asymptotic enumeration, additive combinatorics and extremal combinatorics. In this context, he has been the Principal Researcher of two international projects: A Marie Curie Career Integration Grant, on *Enumeration of discrete structures: algebraic, analytic, probabilistic and algorithmic methods for enriched planar graphs and planar maps* (2014.3-2018.2) and a Bilateral project between Germany and France on *Analytic, probabilistic and geometric Methods for Random Constrained graphs* (2015.1-2016.12).

He received a degree in Mathematics from the **FME** (2005) and a degree in Telecommunications Engineering from the **ETSETB** (2007), a double degree program supervised by the then just created **CFIS**. Then he worked up a PhD thesis on *Enumeration and Limit Laws of Topological Graphs* under the advice of Prof. Marc Noy. After that, he was an ERC postdoctoral researcher at École Polytechnique (2009-2010) and a JAE-DOC postdoctoral researcher at ICMAT (2010-2013). Before joining **UPC**, he was a Professor–W1 in Discrete Mathematics group at the Freie Universität Berlin and member of the Berlin Mathematical School (2013-2016). On the administrative side, he has been Vice-dean of the **FME** (2019-2023) and since March 2023 he has been appointed its Academic Secretary.

J. Rué is also a steady outreach and dissemination writer, including several books. A faint gleam of this activities can already be perceived in the **IMTech** NLs published so far: NL01, *How to visit two million stars in the shortest time*, p. 14; NL02, a chronicle, co-authored with Guillem Perarnau, on *The European Conference on Combinatorics, Graph Theory and Applications* (Eurocomb'21), p. 18; a review of the paper *On a density conjecture about unit fractions*, by T. Bloom, in NL03, p. 24; and the chronicle James Maynard*: a Fields Medal for major advances in Analytic Number Theory* in NL04, p. 20. Recently he has been the winner of the Albert Dou Prize for Mathematical Dissemination awarded by the SCM.

NL. ***You have been the winner of the 2023 Albert Dou Prize awarded by the SCM. Would you please let us know the title of the essay you submitted, and describe its main features? What significance does this prize have for you?***

The essay is written in Catalan and its title is *De la teoria de grafs clàssica a l'anàlisi de les grans xarxes* (*From classical graph theory to the analysis of large networks*). My idea on writing this essay was to follow an historical path from a selection of very important and already classical results in graph theory (starting by the well known Euler's solution of the Königsberg bridge problem, but covering also Kuratowski's Theorem, Erdös probabilistic construction of graphs with large girth and large chromatic number, ...) until the recent developments in the context of graph limits. In particular I wanted to show that the first results in the area were a mixture of apparently disconnected results and tricks, which have evolved into an area in mathematics (and, of course, in theoretical computer science) with its own agenda and techniques. Hence, receiving this prize was a great satisfaction for me, as it also rewards my field of study.

The Albert Dou Prize is the last link in chain of mathematical dissemination writings, for example in the daily press. Could you summarize the main highlights of this outreach activity?

I am very happy to have received this prize. I believe that the figure of Albert Dou is not well-recognized and it deserves some words. He was a Jesuit (a member of the Society of Jesus), and as such, he received a very comprehensive education outside Spain (which is important to remark considering how was Spain after the Civil War). In short, he was a great promoter of mathematics in Spain when doing research in mathematics was a very challenging matter. Returning to your question, I like to collaborate from time to time with general media (such as El País) by explaining (as simply as I can) recent developments in the areas of mathematics I know a little. In these articles I have talked, for instance, about Ramsey Theory, prime numbers and (maybe the article I am happier) about the 2021 Abel prize awarded to Laslo Lovász and Avi Wigderson.

Less ephemeral than the daily press, you have published the books [1], [3], [4], [5] ***and*** [6] ***aimed at a rather general public, with the latter two covering applications of mathematics, and the book*** [2] ***that is more specialized. Could you explain what profiles of readers were you having in mind and describe what kind of comments from them would please you most?***

In general terms almost all these books are addressed to people who have some minimal background in mathematics (secondary school) but who have not pursued technical studies. My philosophy is that they should be comfortable with some (small) degree of abstraction and, more importantly, to have a little predisposition to liking mathematics. However, for my book on transcendental numbers, written together with Javier Fresan, one needs to have some extra background (maybe 1-2 years of a bachelor in mathematics), as at the end we talk about modular forms, elliptic curves and other related number theoretical objects. Of course the idea with these books is to "hear the music" and not enter in the technical details.

The book [7] ***has a pedagogical character, but it is special in view of the problem solving approach to real analysis in a mathematics***

bachelor degree. In what context did it arise? What reception does it have on the part of the students?

This is a joint project with Santiago Boza from DMAT and Oscar Rivero, who was the living force of this project. The fact was that we were teaching this course at the **FME** just when pandemics started, and during the semester we prepared tons of ad hoc material for students. Oscar had the idea to use all this material to create a book, and the result happily ended with a nice publication. This is the first academic year the book is available, so we do not yet have feedback from the students, but I hope it will be useful to understand this course (which acts as a bridge between elementary calculus and a more abstract one).

It may be a good moment to ask you for your teaching record in terms of institutions, programs, and the specific subjects?

This is quite diverse. I have lectured bachelor, master and advanced courses in several countries and institutions, including of course Spain, but also France, Germany, Colombia and Peru. This goes from basic courses on linear algebra/calculus to advanced courses in extremal combinatorics or quantum computing. I like to change from time to time the courses I lecture. Typically, each year I take a course which I have not taught in the previous years.

Along your career you have also been committed to several administrative responsibilities. Can you specify what they have been in general, and at the FME in particular?

During the last years I have had some responsibilities at the **FME**. From march 2019 up to very recently (march 2023) I was Vicedean at **FME**, coordinating the **UPC** doctoral program in Applied mathematics as well as the master's degree in Mathematics. I had the chance to work with Jaume Franch [interviewed in NL05b, page 2], who was a wonderful Dean and a great colleague, especially during the COVID confinement period (which was definitely new for everybody and we needed to use creativity to solve issues). Right now I am acting as Academic Secretary of the **FME** for the new managing team led by Jordi Guardia [interviewed in NL04, pages 6-8]. I thank him for the trust he put on me by making this proposal. Finally, apart from that, I have had several different administrative tasks in different institutions (for instance, inside the CRM and the BGSMath). Maybe the funnier one occurred some years ago, while in Paris, where I was the President of the Spanish researchers at the Cité Universitaire. Someone told me (I do not know if this is true, most likely not) that this job had an institutional status in France (10 or 12 levels below the ambassador), and this is why during that time I had meetings with, for instance, Ángel Gabilondo (who was at that time Minister of Education) to talk about the situation of Spanish expats researchers in France (2010 was an specially bad moment for researchers who were finishing their graduate studies).

Now we would like to turn to your mathematical pursuit. Can you share your memories about what sparked your mathematical vocation?

There is a funny story about that. As many people at a young age I liked most of all subjects during primary and secondary school. At 1st BUP (now this would be 3rd ESO) our Biology class had to make a visit to Delta de l'Ebre. The same day there was the Math Kangaroo contest [Cangur] and students had to decide what to do. I do not know why, but I chose to stay and participate at the Cangur. I got some good results and so I had to go from my hometown (Lleida) to the Institut d'Estudis Catalans to get the prize (which is something a little intimidating for someone coming from an small town). From this experience I saw that I liked mathematics, and so I wanted to learn more. I have to thank here the selfless work of many people specially around the **FME**, and among whom Josep Grané undoubtedly stands out.

What circumstances concurred in your decision about what to study at the university? Was it an easy choice? How do you value your university education?

I had the chance to move from Lleida to Barcelona to study at **UPC** thanks to the economic support of my family. I was trained at **UPC**, in what today is **CFIS**. Although **CFIS** was not yet created, I belonged to one of the first cohorts pursuing a double degree at **UPC**. I have to say that the level of studies I received at both **FME** and **ETSETB** was wonderful. At **FME**, which is the school I know best, I have to say that my impression is that the level we are offering has not gone down, and in fact that is has increased. In general, we can feel proud of the education level we are providing to our students.

We would also like to know about your research training, fundamentally about your doctoral and postdoctoral work.

I started my PhD under the guidance of Marc Noy here at **UPC** in the area of enumerative combinatorics, and more precisely on the study of random planar graphs (and related families). After defending my PhD in 2009 I started my first postdoc in Paris, under the guidance of Gilles Schaeffer, who is one of the top leading researchers in map enumeration and had at that time one of the first ERC projects. After that I moved to Madrid for 3 years to work with Javier Cilleruelo. During this 3 wonderful years at ICMAT I changed my main topic of research and started working on additive combinatorics. Finally, before moving to Barcelona in 2016, I was a Professor–W1 (Junior professor, which was essentially an 6-year assistant professorship in the Germany level but without tenure track at that time) at Freie Universität Berlin. The city was incredible and the German system was very interesting; I had lots of academic experiences during my stay in Berlin that definitely afforded me some perspective on how to manage research.

Can you summarize the main results of your research so far?

This is difficult to say, because I have worked in very different types of problems. Maybe the two results I am proudest of are a proof obtained with Javier Cilleruelo in 2008 (still during my PhD) solving a long-standing question in additive combinatorics (from 1992) of Vera Sós and András Sárközy. Also, in this "hungarian type" mathematics, jointly with Marc Noy and Vlady Ravelomanana from Paris we solved an even longer standing question posted by Paul Erdös and Alfréd Rényi in their seminal paper *On the evolution of random graphs*: we got the very precise expression for the probability of planarity of a random graph when taken inside the critical window. No such exact expression was known until our result appeared.

Looking ahead, how do you see your research in the next few years? What problems would you like to see solved?

The more I work, the more I see that I have to study more, and the more I note that there is a big sea still to learn. But in order to give one general idea, a very important trend nowadays in discrete mathematics is the study of limiting objects of discrete structures, which in many situations are continuous objects. This fact is an important leivmotiv in random discrete structures and I would like to explore a little more these type of results in the next years. In fact, the content of my Dou Prize essay goes in this direction!

Closing somehow a loop, we would like to know your experience in tutoring and advising students at all levels. Along with research and teaching, perhaps also some administration, it is generally regarded as one of the important roles a university professor has to play.

Definitely, and one of the most enjoyable activities in our job. Discussing with younger researchers, with more energy, is always a source of satisfaction. And of course, later these students become friends and colleagues. For instance, very recently, jointly with Oriol Serra and

Miquel Ortega (who started his PhD at **UPC** this year) we have solved a conjecture on product-free sets on the free group. Sharing ideas with them and the very fresh contributions of Miquel have been very pleasant!

Finally, we would appreciate if you could speak about IMTech and put forward ideas and strategies that would enhance its positive future evolution.

IMTech has been a very important and transversal initiative at **UPC** level that I really appreciate, which it brings together the mathematical activity at **UPC**. I think this is a very crucial point that must be remarked. I do not have much good advice and suggestions, but maybe **IMTech** could be the catalyst of the interplay between researchers and industry: this is specially challenging in the case of pure mathematicians.

Thank you so much for your time and insights, and congratulations for the Albert Dou prize.

Thanks for your time, and for your work preparing this material.

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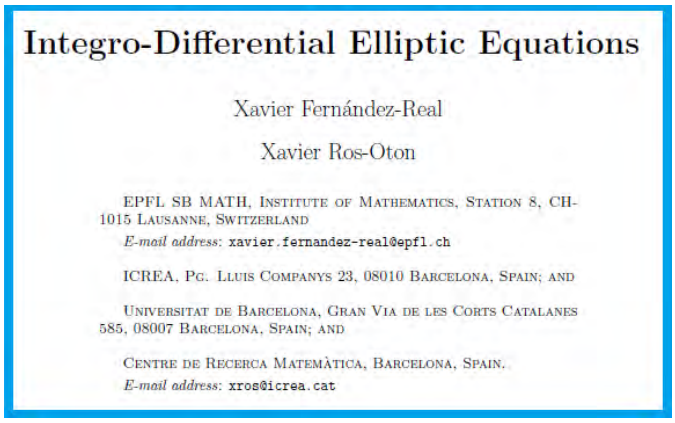
Reviews

Books

Integro-Differential Elliptic Equations

by Xavier Fernández-Real Girona and Xavier Ros-Oton.
Reviewed by Sebastià Xambó.



This memoir, henceforth named IDEE, is the winner of the Ferran Sunyer i Balaguer Prize 2023. This prestigious prize is awarded yearly by the Ferran Sunyer i Balaguer Foundation since 1993 (except the years 1995, 2015, 2019) and the winning memoirs are published in the Birkhäuser book series Progress in Mathematics. About the authors, see the interviews with Xavier Ros-Oton in NL05a (page 2), and in this issue with ▷ Xavier Fernández-Real Girona. For a biography of FSiB, see [1].


Ferran Sunyer i Balaguer (1912-1967)
Credit: FSB Foundation

The members of the Scientific Committee appointed to decide this edition of the FSB Prize were Antoine Chambert-Loir (winner of the 2017 edition [2]), Ruth Kellerhals, Marta Sanz-Solé, Kristian Seip, and Yuri Tschinkel. They had to consider nine candidates and their report on IDEE says:

"This book presents a deep and solid study about the existence and regularity theory for nonlocal elliptic equations. This type of equations somehow extends the PDE notion to a more general setting, in which the underlying operators are integral (instead of purely differential) operators. The study of nonlocal equations is motivated by several applications within Mathematics (in Probability, Geometry, or Fluid Mechanics) and in other sciences (Physics, Biology, or Finance). This is a quite young subject, central in the PDE theory, in which the authors have contributed with breakthroughs, and are among the world leaders."

The authors' back-cover summary of the book is also very informative about its aims and nature:

"This book aims to provide a self-contained introduction to the regularity theory for integro-differential elliptic equations, mostly developed in the 21st century. Such a class of equations often arises in analysis, probability theory, mathematical physics, and in several contexts in applied sciences. The authors give a detailed presentation of all the necessary techniques, primarily focusing on the main ideas rather than proving all results in their greatest generality. The book starts from the very basics, studying the square root of the Laplacian and weak solutions to linear equations. Then, the authors develop the theory of viscosity solutions to nonlinear equations and prove the main known results in this context. Finally, they study obstacle problems for integro-differential operators and establish the regularity of solutions and free boundaries. Almost all the covered material appears in book form for the first time, and several proofs are different (and shorter) than those in the original papers. Moreover, several open problems are listed throughout the book."

IDEE appears to be germane of [3], by the same authors. The sequential treatment is similar in both: linear equations first, then nonlinear equations, and finally the application to obstacle problems. The main difference lies in the kind of operators used: while in [3] they are "classical" local operators, in IDEE they are 'integro-differential" operators, a more involved breed whose study has taken off in recent times. In any case, they are remarkably self-contained and comprehensive, and are thus the sort of materials that should be useful to researchers, and even more to PhD students wishing to enter the realm of integro-differential operators. These books, and especially IDEE, also supply bibliographic references for results that are scattered in papers published in the last two decades, often with trimmed down proofs and with a good many new results. The technical aspects are dealt with thoroughly and efficiently, with a clear and engaging writing style.

To end, let us describe briefly IDEE's contents. The focus of the first chapter is the square root of the Laplacian, which is used to present a fairly basic introduction to nonlocal operators. The second chapter is about general linear integro-differential operators. After a motivating discussion about their origin and their probabilistic interpretation, the theory of interior and boundary regularity is presented. To note that the authors use, and prove, the optimal ellipticity hypotheses, a move not covered before in the literature. In the third chapter, "fully nonlinear" equations are studied and the complete general theory of viscosity solutions for "fully nonlinear nonlocal" operators is developed. Finally, in the last chapter the "obstacle problem" is presented as an example of "free boundary problems" with integro-differential operators.

Acknowledgments. The reviewer is thankful to the authors for sharing the prized memoir and other materials, and also for their readiness to provide helpful feedback on various aspects of their work. Thanks also to the FSB Foundation for the permission to reproduce the verdict on IDEE.

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LMS Hardy Lecture Tour 2023

G.H. Hardy, LMS President
1926–1928 and 1939–1941
Photo Courtesy of Master and Fellows of
Trinity College Cambridge

Eva Miranda (UPC-Barcelona)
Hardy Lecturer 2023

The Hardy Lectureship was founded in 1967 in memory of G.H. Hardy in recognition of outstanding contribution to both mathematics and to the Society. The Hardy Lectureship is a lecture tour of the UK by a mathematician with a high reputation in research. The 2023 LMS Hardy Fellow is Professor Eva Miranda (UPC-Barcelona).

Professor Miranda will visit the UK in May, June, July and September 2023 and she will give talks at:

Cambridge 30 May;
Counting periodic orbits
Organiser: Maciej Dunajski

Royal Institute, London 1 June;
From Alan Turing to contact geometry: towards a "Fluid computer"
Organiser: Saksham Sharma

Birmingham 26 June;
Desingularizing singular symplectic structures
Organiser: Marta Mazzocco

Warwick 28 June;
Euler flows as universal models for dynamical systems
Organiser: José Rodrigo

Mary Ward House, London 30 June;
From Alan Turing to fluid computers: Explored and unexplored paths
Organiser: London Mathematical Society

Oxford 4 July;
Singular Hamiltonian and Reeb Dynamics: First steps
Organisers: Andrew Dancer and Vivat Nanda

Loughborough 6 July;
Action-angle coordinates and toric actions on singular symplectic manifolds
Organisers: Sasha Veselov and Alexey Bolsinov

Edinburgh 19 September;
From Symplectic to Poisson manifolds and back
Organiser: José Figueroa-O'Farrill

Glasgow 21 September;
Quantizing via Polytope counting: Old and new
Organiser: Ian Strachan

For further information on attending each lecture, please visit the LMS website here:
lms.ac.uk/events/lectures/hardy-lectureship#Hardy%20Current
For general enquiries about the Hardy Lectures, please contact (lmsmeetings@lms.ac.uk).

Hardy lectureship. General Meeting of the LMS, 30 June

The LMS Hardy Lecture 2023 on June 30 will be preceded by a key-note lecture by Sir Roger Penrose (Oxford). Title TBA.

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CIÈNCIA

Eva Miranda, la matemàtica més guardonada

"La bellesa de les matemàtiques consisteix en captar l'essència de les coses"

On Saturday, May 13, 2023, the front page of the newspaper Ara featured the headline Eva Miranda, the most awarded mathematician, pointing to the two pages of the Science section dedicated to an interview with her. The interview of Prof. Eva Miranda (**IMTech**, full professor at UPC, and ICREA Academia) was conducted by the journalist Toni Pou. Her mathematical achievements, which are and have been attracting much international media attention, are regularly reported in this NL: Hardy tour: NL05a, page 1, and NL05b, pages 1 and 20, and the update in this advance; Distinctions: NL01, pages 1, 2, 21 and NL03, page 1 and page 20; Research focus: NL01, pages 9-11 (with Robert Cardona and Daniel Peralta-Salas).

In the interview, various topics about Mathematics of great interest to the general public were discussed, and Professor Miranda provided her personal view of them. Here is a summary gleaned by this NL. From an early age, Eva Miranda found solace and fascination in the world of mathematics. It provided her with a platform to solve problems within defined parameters and explore the depths of her own imagination. Describing mathematics as a means to solve equations and a discipline that allows us to model and address problems using formulas, she believes it encompasses a wide range of applications.

Prof. Miranda acknowledges the often-intimidating reputation that mathematics holds and attributes it to the way the subject is taught. She draws a charming parallel to writing a book, explaining that to truly appreciate mathematics, one must learn its language and engage with its internal rules and structures. She emphasizes that mathematics, much like literature, possesses a creative aspect. While there are rules to follow, mathematicians venture into uncharted territories to solve problems, a process she finds endlessly captivating. She admits that teaching mathematics is a formidable challenge, as conveying its creative dimension can be difficult, particularly when students have varying levels of interest, and she concedes that efforts have been made to highlight the creative aspects of mathematics and improve teaching methods to make it more engaging.

Prof. Miranda often tries to persuade those who have struggled with mathematics that it is a fascinating subject by emphasizing its presence in everyday life. From the coordination of traffic lights to the functioning of computers, mathematics permeates our surroundings. She is convinced that, by recognizing mathematics as an integral part of daily life, the fear associated with the subject can be overcome, transforming it into an exciting and empowering experience.

Prof. Miranda discusses the social recognition of mathematicians in Catalonia and its disparity when compared to that of countries like France, where mathematicians enjoy significantly higher prestige. She cites examples of accomplished mathematicians who receive little attention in the media, which connotes a low social recognition of the field.

The aesthetic and elegance found in mathematical procedures are qualities often mentioned by mathematicians. Prof. Miranda draws a parallel between mathematics and art, highlighting that mathematicians, like poets or painters, work with patterns made of ideas rather than words or colours. The beauty lies in capturing the essence of things and distilling complex concepts into simple and elegant explanations. Prof. Miranda textually asserts: "I lay claim to this aesthetic part of mathematics and science because, in a way, it humanizes us and makes us closer to art and creativity."

Mathematics has both theoretical and practical applications. While society increasingly demands immediate practical applications for everything, Prof. Miranda emphasizes that mathematics may not always provide immediate utility, but often yields applications in the long run. As an illustration, she considers the example of computers, which emerged from Alan Turing's abstract definition of computation during his doctoral thesis, initially without any apparent practical use.

Prof. Miranda's research explores various areas, often seeking interdisciplinary connections. She mentions a recent project related to fluid dynamics equations, motivated by a question of the renowned mathematician Terence Tao related to one of the Millennium Prize problems, which led to insights in geometry and has applications in studying ocean currents and meteorology.

In addressing the ethical implications of mathematics, Prof. Miranda highlights the significance of algorithms and artificial intelligence (AI). She recognizes that algorithms shape the information we receive and that AI can influence people's opinions, emphasizing the need for ethical guidelines in their development and usage. Prof. Miranda suggests involving ethics committees and taking a responsible approach to ensure these technologies benefit society as a whole.

Overall, Eva Miranda's journey in mathematics is characterized by her passion for abstract structures, her drive to uncover creative dimensions within the discipline, and her commitment to making mathematics accessible and recognized in society.

Sir Roger Penrose's quotations

- My own way of thinking is to ponder long and I hope deeply on problems and for a long time which I keep away for years and years and I never really let them go.
- Sometimes it's the detours which turn out to be the fruitful ideas.
- Some people take the view that the universe is simply there, and it runs along—it's a bit as though it just sort of computes, and we happen by accident to find ourselves in this thing. I don't think that's a very fruitful or helpful way of looking at the universe.
- The image of Stephen Hawking—who has died aged 76—in his motorised wheelchair, with head contorted slightly to one side and hands crossed over to work the controls, caught the public imagination as a true symbol of the triumph of mind over matter.

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