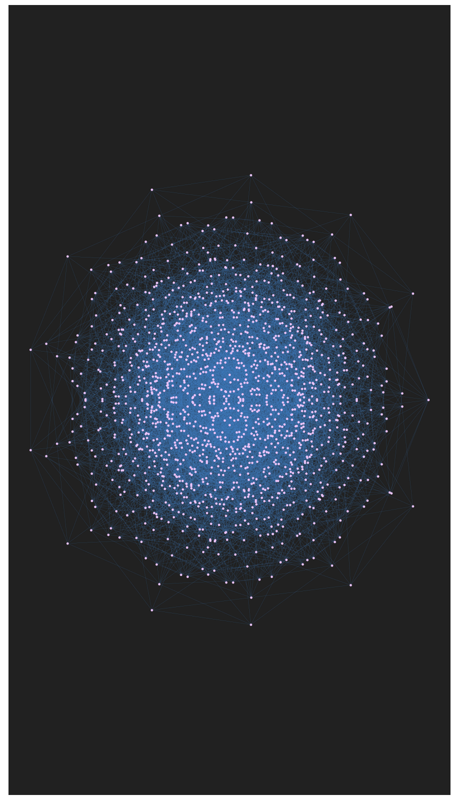
Newsletter

BELGIAN MATHEMATICAL SOCIETY

\# **118**, May 15, 2018

Comité National de Mathématique CNM

NCW Nationaal Comité voor Wiskunde



Newsletter of the Belgian Mathematical Society and the National Committee for Mathematics

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About the cover photo

It is always great to see people who are not professional mathematicians often get interested in certain mathematical problems and spend lots of energy to enthusiastically work on those problems. Unfortunately their lack of training often results in false theorems or flawed proofs. Sometimes, however, amateurs make significant progress on a long-standing open problem. In April this year Aubrey de Grey, a biologist, showed that the chromatic number of the unit-distance graph in the plane is at least 5.

The problem of coloring the unit-distance graph on the plane $\mathbb{R}^2$ has eluded many mathematicians for more than 60 years. The graph we are talking about is easy to define: the vertices are the points of the Euclidean plane and two vertices are adjacent if and only if their Euclidean distance is 1. In 1950 Edward Nelson asked how many colors (at least) are needed to color the vertices of this graph such that two adjacent vertices never have the same color. Since then this has been known as the *Hadwiger-Nelson problem*. Soon it was shown that the graph can be colored with no fewer than 4 and no more than 7 colors. But since then not much progress was made.

The fact that the unit-distance graph on the plane has an infinite number of vertices might seem scary at first but to improve the lower bound on the number of colors needed it is sufficient to come up with a (finite) subgraph which cannot be colored with 4 colors. That's exactly what de Grey did: he found a unit-distance graph with 1581 vertices needing 5 colors. That graph is shown on the front page of this Newsletter.

This discovery on its own is quite interesting but even more important is that it brought this old problem back in the spotlights. Like many problems involving (lower or upper) bounds and minimal examples in the past few years de Grey's example was picked up by the *Polymath project* (see https://polymathprojects.org/) and in a few weeks' time the number of vertices was reduced to 826. More details about this interesting discovery by an 'amateur mathematician' can be found in a recent Quanta Magazine article.

The highlight of this newsletter is the **BMS PhD-day**. As announced before this event will be organized in Gent on Friday May 25, 2018. The program of the day is now fixed and can be found further in this Newsletter. There will be talks by 7 PhD students about their research and 23 students opted for a poster presentation. We are very excited to discover the mathematics about which our PhD students are so passionate! They will all benefit from comments and suggestions form fellow PhD students and more senior participants. New in this PhD-day is the job fair. Private companies like KBC, PWC, Deloitte, ... are keen on hiring mathematicians and will be present on the PhD-day to show us what skills they are looking for and what kind of jobs they have to offer.

On the PhD-day Laure Saint-Raymond will deliver the BMS Godeaux lecture for this year. The Godeaux lecture is organized at least once every two years during a BMS event. These lectures honoring the memory of Lucien Godeaux are organized with the assets of the Belgian Center for Mathematical Studies which were transferred to the BMS after the dissolution of this Center. Lucien Godeaux (1887-1975) was one of the world's most prolific mathematicians (with 644 papers in Math Reviews but more than 1000 in total) and took many initiatives to encourage young mathematicians to communicate their research. He was the founder of the Belgian Center for Mathematical Studies in 1949.

Philippe Cara,
BMS president

1 News from the BMS & NCM

The Belgian Mathematical Society PhD Day

Your maths are made for talking!

Friday, May 25, 2018
Ghent University, Campus De Sterre, Building S9

Krijgslaan 281, 9000 Ghent

The Belgian Mathematical Society invites everybody to attend the PhD Day.

The PhD Day starts with the Godeaux lecture, and ends with a job fair where you can establish contacts with companies interested in mathematicians. In between, 23 PhD students present a poster and 7 PhD students present a talk on their research. Grab the opportunity to discuss with these PhD students, to meet each other, and exchange ideas. At the end of the PhD Day, there will also be the best poster award and a drink.

There is no registration fee for members of the BMS. For non-members of the BMS, the registration fee is 20€. There is the possibility to become a member of the BMS (also 20€) before the start of the PhD Day.

Please register for the PhD Day via the website http://bms.ulb.ac.be/phdday with your name and affiliation. All information will be made available on this website.

On behalf of the Belgian Mathematical Society.

The organizers: Els Goetghebeur, Leo Storme, Michèle Vanmaele, Jasson Vindas Diaz, Andreas Weiermann

Schedule

- 9u30: Welcome coffee (Aud. A3).
- 10u: Welcome to the participants (Aud. A1).
- 10u10: Godeaux lecture (Aud. A1): Prof. Laure Saint-Raymond (École normale supérieure de Lyon): Internal waves in a domain with topography.
- 11u: Poster storm sessions (Aud. A1).
- 11u15: Poster presentations (Aud. A3).
- 12u: Lunch (Aud. A3) (free for BMS members).
- 13u: Contributed talks (Lecture rooms 3.1 and 3.2).
- 14u35: Coffee break (Aud. A3).
- 15u: Poster presentations and Job fair (Aud. A3).
- 16u30: Drink and Best poster award (Aud. A3).

Contributed talks
Lecture rooms 3.1 and 3.2

The two lecture rooms 3.1 and 3.2 are opposite to each other on the third floor of the building S9. Contributed talks last 20 minutes to enable participants to change lecture rooms in between talks.

	Lecture room 3.1	Lecture room 3.2
13u00	A. Debrouwere (UGent): Topological properties of convolutor spaces via the short-time Fourier transform	S. Barbier (UGent): A minimal representation of the orthosymplectic Lie supergroup
13u25	G. Debruyne (UGent): Tauberian theory and the prime number theorem	Thibaut Grouy (ULB): Orbital integrals on Lorentzian symmetric spaces
13u50	M. Valvekens (KU Leuven): Combinatorics and diagrams in representations of quantum groups	L. Neyt (UGent): The structure of ultradistributional quasiasymptotics
14u15	W. van de Vijver (UGent): The higher rank Racah algebra	

Poster session PhD day

1. Lynn Boen (UA): Multivariate Financial Models with Sato Marginals and Linear Dependence
2. Niels Bonneux (KU Leuven): Wronskians of Appell polynomials
3. Lins Denaux (UGent): Small weight codewords arising from the incidence matrix of points and hyperplanes
4. Sander Devriendt (KU Leuven): Sparsity with multi-type Lasso penalties
5. Jozefien D'haeseleer (UGent): Cameron-Liebler sets
6. Anneleen De Schepper (UGent): Plane geometry on the line
7. Alfonso Garmendia (KU Leuven): Morita equivalence for singular foliations
8. Fatemeh Ghaderinezhad (UGent): Choose or Not to choose a prior. That's the question!
9. Jens Hemelaer (UA): Forget about addition
10. Lisa Hernandez Lucas (VUB): Subspaces with Constant Intersection Dimension
11. Jiawei Hu (ULB): Geometric partial coactions
12. Marjolein Leurs (KU Leuven): Jacobi-Angelesco multiple orthogonal polynomials on an r-star
13. Sam Mattheus (VUB): Non-orthogonal vectors in a finite vector space
14. Cheikh Mbaye (UCL): A subordinated CIR model wrong-way risk CVA
15. Julien Remy (ULB): Testing for Principal Component Directions under Weak Identifiability
16. François Renaud (UCL): A homotopy theory for quandles
17. Sofie Reyners (UCL): Gaussian process regression: fast approximation of derivative prices and Greeks

18. Jacob Snoeijer (UA): Efficient numerical pricing of basket options via partial differential equations
19. Florence Sterck (UCL & ULB): Crossed modules of Hopf algebras
20. Sam Tertooy (KU Leuven Campus Kulak): Reidemeister fixed-point theory on infra-nilmanifolds
21. Bert Verbeke (KU Leuven Campus Kulak): Almost inner derivations of Lie algebras
22. Sarah Vluymans (UGent & University of Granada): Fuzzy rough set based classification
23. Lena Vos (KU Leuven): The monodromy conjecture for ideals

2 Meetings, Conferences, Lectures, ...

2.1 May 2018

Methusalem Lecture Series: Lectures and Mini-Courses in Pure Mathematics

KU Leuven, Department of Mathematics

A series of colloquium talks for a broad pure mathematics audience and specialized mini-courses in algebra, analysis and geometry. Upcoming colloquium talks (Heverlee Campus in Leuven):

Erik Koelink (Radboud University Nijmegen)	May 17, 2018	16:15-17:15
Roland Speicher (University of Saarbrücken)	May 28, 2018	11:30-12:30

For titles and abstracts, room number and the full schedule, please visit

https://wis.kuleuven.be/methusalem-pure-math/activities

2.2 June 2018

14th **Belgian–Dutch Algebraic Geometry Seminar**

June 8, 2018

KU Leuven

The fourteenth edition of the rotating Belgian–Dutch Algebraic Geometry seminar will take place at KU Leuven on June 8, in the Jozef Heuts Auditorium (Landbouwinstituut, Kasteelpark Arenberg 20, 3001 Heverlee).

The schedule is as follows:

13:45–14:45	Arend Bayer (Edinburgh) *Families of hyperkähler varieties via families of stability conditions*
15:00–16:00	Christian Liedtke (München) *A Néron–Ogg–Shafarevich criterion for K3 surfaces*
16:30–17:30	Lionel Darondeau (Leuven) *Jet differentials and hyperbolicity*

For abstracts and more information, see the webpage of the seminar:

http://www.math.ru.nl/ bmoonen/BNL.html.

2.3 July 2018

Geometric PDEs in Freiburg 2018

July 23-27, 2018

Freiburg im Breisgau, Germany

See the website http://home.mathematik.uni-freiburg.de/gpde18/.

2.4 October 2018

The 11th International Statistics Days Conference (11th ISDC)

October 3-7, 2018

Bodrum, Turkey

The 11th International Statistics Days Conference (11th ISDC) is scheduled on October 3-7, 2018 at Kefaluka Hotel Bodrum/Turkey for the statisticians, researchers, scientists, scholars, students, and practitioners from all around the world is to present and share ongoing research activities. This conference provides opportunities for the participants to exchange ideas and discuss new theoretical and practical issues in their fields face to face, to establish new collaborations and to contact global partners for future collaboration.

The attendee will have the following benefits from the meeting in general;

1. Raise your profile through networking and engagement with researchers at all career stages
2. Publication opportunities in one of the conference associated journals
3. Showcase your research and develop research ideas through discussion and feedback from experienced colleagues
4. Connect with researchers and explore opportunities within and beyond your areas of expertise through discussion sessions and a variety of other activities
5. Opportunity to compete for the Best Presentation Award

The ISDC is a biannual conference organized regularly. The 11th ISDC2018 is organized by the Department of Statistics of Muğla Sıtkı Koçman University in Bodrum, Turkey. The meeting will be held at elegant Kefaluka Resort embracing the deep blue of Aegean Sea.

The Scientific Committee will evaluate your prospective, valuable contributions on the topics of the conference and the ones approved to be presented will be notified soon after submission. All abstract submissions are subject to a blind peer review process. Accepted submissions will be published in the Conference Proceedings, which will later be available online on the conference website with an ISSN number. Furthermore, selected papers will be published in high profile journals.

We will spend every effort and be pleased to generate an atmosphere where you can share your knowledge, expertise, and experiences with your colleagues.

Best Regards, 11th ISDC Organizing Committee

See also the website http://www.igs2018.mu.edu.tr/en.

2.5 April 2019

International Conference on Mathematical Methods in Physics

April 1-6, 2019

Marrakech, Morocco

See the announcement at the end of the newsletter.

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3 PhD theses

Common $\mathcal{A}$-hypercyclicity

Monia Mestiri, Université de Mons
June 22, 2018, at 16:00
UMons, campus Plaine de Nimy
auditorium Vésale 030

Thesis advisor: K. Grosse-Erdmann (UMons), Q. Menet (Université d'Artois)

Summary

In the last decades the notion of hypercyclicity has been subject to many investigations in linear dynamics. An operator T on a Fréchet space X is called hypercyclic if there exists some vector $x \in X$ such that the set $\{T^n(x) \mid n \geq 0\}$ is dense in X. In this case x is called hypercyclic for T. In other terms an operator is hypercyclic if there exists some vector that visits under this operator each non-empty open set. A fundamental theorem in linear dynamics is the transitivity theorem of Birkhoff. This ensures that the set of hypercyclic vectors of an operator is a dense G_δ-set and this provides an equivalent formulation of hypercyclicity. Later this result has been generalized for families of operators. Instead of studying the behaviour of an operator one then cares about a family of operators. In this context it is rather natural to study the existence of vectors which are hypercyclic for each operator of the family.

This yields the notion of common hypercyclicity. Most of the common hypercyclicity criteria are based on a generalization of the transitivity theorem of Birkhoff.

Recently Bès, Menet, Peris and Puig have defined a notion which generalizes hypercyclicity: the $\mathcal{A}$-hypercyclicity. This notion also includes upper frequent hypercyclicity. Intuitively an operator is upper frequently hypercyclic if it possesses a vector that visits 'very often' each non-empty open set. Imposing some conditions on the family $\mathcal{A}$, Bonilla and Grosse-Erdmann have found an analogue of the theorem of Birkhoff for $\mathcal{A}$-hypercyclicity.

In this thesis we study common $\mathcal{A}$-hypercyclicity. Relying on the arguments used in common hypercyclicity we establish a generalization of the theorem of Bonilla and Grosse-Erdmann for families of operators. In particular this allows us to obtain a common upper frequent hypercyclicity criterion. In addition to these positive results we develop an approach ensuring the nonexistence of common $\mathcal{A}$-hypercyclic vectors.

4 Job announcements

4.1 From KU Leuven

Position for a *Ph.D. student in Geometry*

The Geometry Section of the Department of Mathematics is doing research in differential geometry, in particular (pseudo-) Riemannian and symplectic geometry. About the project:

- You will do research in the Geometry Section of the Department of Mathematics, leading to a Ph.D. in mathematics.
- The research project will be related to Riemannian or pseudo-Riemannian submanifolds, in a broad sense.

Applying for this job should be done no later than June 16, 2018.

See more information and the announcement at

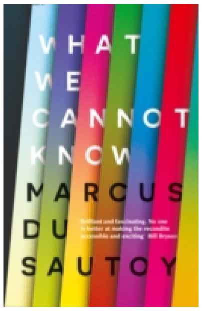
https://www.kuleuven.be/personeel/jobsite/jobs/54613295.

5 History, maths and art, fiction, jokes, quotations ...

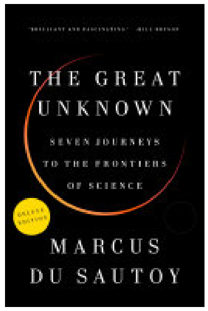
5.1 Adhemar's corner

To read during the summer holidays at the beach, in the mountain cabin or ... here are two reviews from Adhemar Bultheel.

What we cannot know, *Marcus du Sautoy*, Harper Collins (UK), (2016) ISBN 978-00075-7666-1 (hbk), 320 p. ≡ **The Great Unknown**, Viking (US) (2017) ISBN 978-07352-2180-2.



UK edition (2016)



US edition (2017)

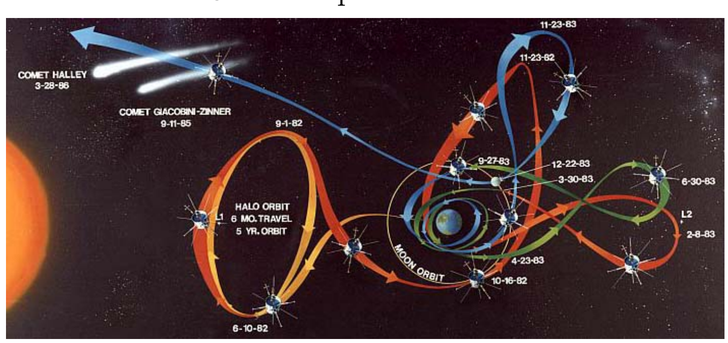
Marcus du Sautoy (2007)

Marcus du Sautoy is a mathematics professor from Oxford. He did excellent mathematical work mainly on group theory and number theory, but for a broader public he is well known because he appears regularly in the media and he wrote several books to popularize mathematics. Since 2009 he holds the chair of the *Simonyi Professorship for the Public Understanding of Science*. That was established in 1995 and 'the holder is expected to make important contributions to the public understanding of some scientific field', which du Sautoy rightfully does.

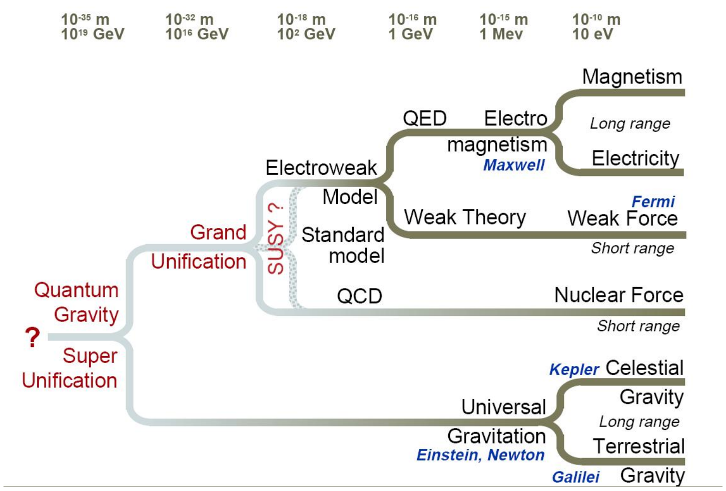
At the time of writing, the book under review is his most recent one. The original is from 2016 but in 2017 it was published under a different title for the US and also the Dutch (Uitg. Nieuwezijds) and French (Ed. Héloïse d'Ormesson) translations came out. As explained in a chapter zero, the idea is to explore where the boundaries of science are for the moment and whether we will ever be able to answer all the questions that are still open.

There are seven parts, each one consisting of two chapters. Du Sautoy calls these parts 'Edges' since they lead you to the boundary of where science meets its present limitations beyond which is the abyss of the 'great unknown'. Of course there is confidence that with further research these boundaries will be shifted forward in the future. However the main objective is to also discuss what will be attainable in the distant future and du Sautoy comes to the conclusion that there are certain targets for which we have to give up all hope to ever reach them.

Because of this Simonyi chair du Sautoy is supposed to know everything about science and he is regularly involved in discussions about religion. Ever since humans have explored the laws of the world surrounding them, there were phenomena that could not be explained with the limited knowledge of the moment. Where knowledge ended was often where religion began. God was an explanation of things that could not be explained. So one could define God as that what cannot be explained or known: the God of the gaps. Du Sautoy is a convinced atheist and in this book, when he arrives at those phenomena that we probably will never know, he spends some time contemplating whether or not this could be a definition of God or a proof of his existence.

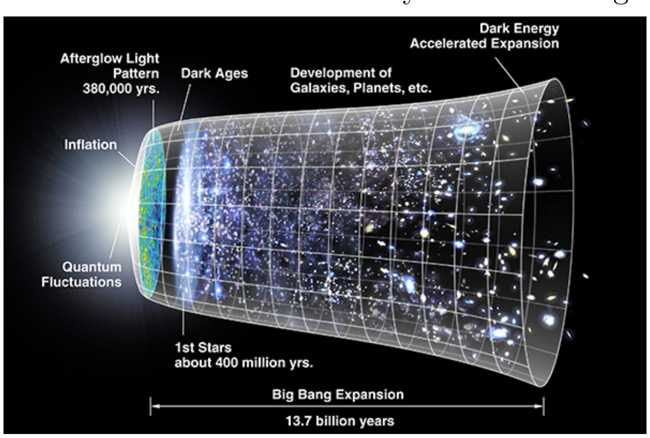


The distinction between the subjects populating the different edges is not very strict but every edge has its main focus. The first edge is about the theory of everything as it was conceived by Newton. Things happened according to strict physical laws, and everything was predictable. Our world and the planetary system was arranged like a clockwork. Sometimes, when the system is too complex to compute we have to recourse to statistics to predict the outcome of throwing a die, or to apply statistical mechanics to explain the behaviour of a gas. Until Poincaré threw the bat in the hen house and declared that actually our planetary system was not a clockwork but behaved in a very chaotic way. The tiniest change at one moment may give a completely different state of the system after a while. Long time weather forecasting is made impossible because of the nonlinear dynamics of the climate system. And as mathematics show, very simple laws can result in very complex fractal results. Even chaos is deterministic but every particle in the universe can influence every other particle. That is just too much information to deal with. Does it mean that free will is impossible? God doesn't play dice, so he must be the one who knows everything at every instance, or he must have conceived everything from the beginning.



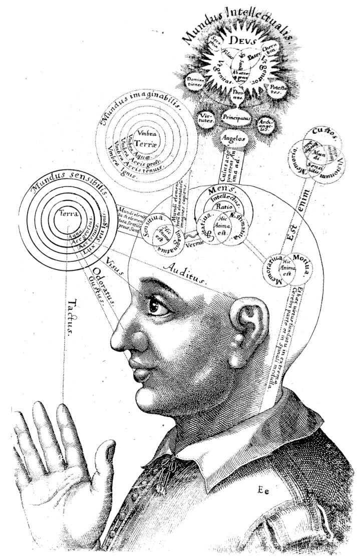
Edge number two is about the infinitely small. In mathematics, that has led us to the irrational numbers. Although there are infinitely many digits, we can still prove things about them. When physicists were looking for smaller and smaller particles that make up the physical world they ended up with an unmanageable zoo of quarks and leptons. Some order could be brought by introducing symmetry and SU(3) was the mathematical tool that saved them from chaos. Experiments at this scale are seemingly impossible, but we conceived indirect ways of making observations that tell us something about the properties of these particles that are not directly observable. Whether we will ever be able to reach a time scale of 10^{-22} is unlikely, but it cannot be proved impossible.

The next edge is about quantum physics which comes with the intrinsic limit of the Heisenberg uncertainty relation putting a theoretical restriction on what we can ever know about the state of a quantum object. Moreover, our observation is an act of creation because by Bell's theorem, it changes the properties of what we observe and our very observation may create a random outcome. But is this really random? Is this where God can interact with our world? The Planck length (10^{-35}m) seems to be the absolute limit. Points at a smaller distance are indistinguishable. That is where quantum physics and general relativity do not match and where we have to enter the abstract mathematical fantasy world of strings and quantum gravity.



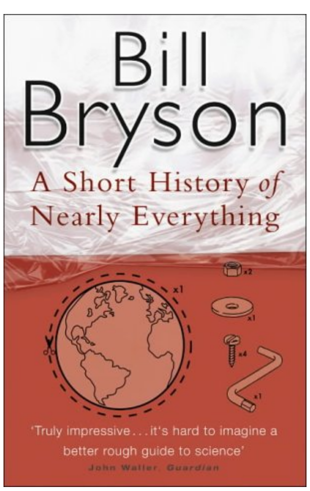
Stopped at the infinitely small, the next edge switches to the infinitely large and tackles cosmology. Several theories were proposed looking for the origin of the universe. All of them based on observations. This has given us the Big Bang theory of Lemaître. But the standard model can only explain 4.9% of matter-energy. The remaining 95.1% is dark matter and dark energy. There are theoretical horizons for what we can observe, both in time and in space. We cannot see further in time than we do because light could not make it through the plasma some 378.000 years after the Big Bang but we can observe the neutrinos that could. In multiverse theories it is conjectured that just like the bubble of our universe inflated in 10^{-36} seconds to 10^{78} times its size, similarly other universes may have been created with different physical constants and by definition there is no way we can interact with them. True of not, this is definitely something we shall never know.

Edge number five is introducing relativity theory and explains how space and time are related and how gravity can deform the space-time configuration. In extreme cases gravity creates a black hole singularity preventing even light to escape beyond an event horizon. However Hawking conjectured that some radiation is still possible. That is related to information that is leaking because the entropy inside does not really represent perfect order. Recall that the increase of entropy defines time. According to Penrose, our universe is just a sequence of big bangs each one seamlessly starting a new aeon. Is God something like mathematics that exists outside of our universe of time and space and is this the reason for the 'unreasonable effectiveness of mathematics'? According to du Sautoy this may well be, but he does not go as far as Tegmark to define our physical universe as a finite discrete mathematical abstraction.



Then du Sautoy engages in the problem of defining consciousness. Traditionally a less mathematical subject, although it is close to the study of (artificial) intelligence. After all, the problem of knowing what we cannot know, only exists because we humans are conscious. This requires an exploration of the brain, and a discussion of the mind-body problem. And yet there is the neuroscientist Tononi who defined a mathematical quantity Φ that can be assigned to any network, thus also to the neural network of our brain, to define the amount of its consciousness. The philosopher John Searle is strongly opposing this idea. It is not because a machine can follow the rules defining how a conscious entity would act that it would be conscious itself. And yet statements are uttered about the Internet being alive and when you ask Google about 'conscious networks' you get a several organizations and companies using it as part of their brand name.

And that brings us to the last edge of what we can never know in mathematics. While (physical) science is constantly evolving depending on the observations, one might hope that mathematics is fairly static. However, new geometries are possible when the axioms change. We can prove things about things that can never be verified experimentally because it would need an infinite amount of time like for example Fermat's Last Theorem. On the other hand ample experimental evidence like for the Riemann Hypothesis for example does not prove it. And then there are Cantor's uncountable infinities and Gödel's incompleteness theorems to definitely limit the mathematical possibilities to prove everything. But at least we know and we can prove that we shall never know whether a certain theorem will be true or false.



Du Sautoy brings here a survey that is almost as broad as the 2003 Bill Bryson's classic *A Short History of Nearly Everything*, but more focused on the edges mentioned above. Knowing the unknown is a popular subject and several scientists have written so-called popularizing books about their domain of expertise, which are often circling the ideas of the infinite small, the infinite large or the functioning of our brain. Some examples are listed below. They were mostly theoretical physicists or scientists on the edge of mathematics, and it is not always easy reading, even for a mathematician that is not expert in the material. Du Sautoy is more of a mathematical outsider and his view on these topics is closer to how an average mathematician looks at this stuff.

He has quite some experience with science communication and so he brings his account in an entertaining way. The dice he has on his desk are a recurring gadget he uses throughout the book and also playing the trumpet and the cello is used to illustrate discrete versus continuous phenomena.

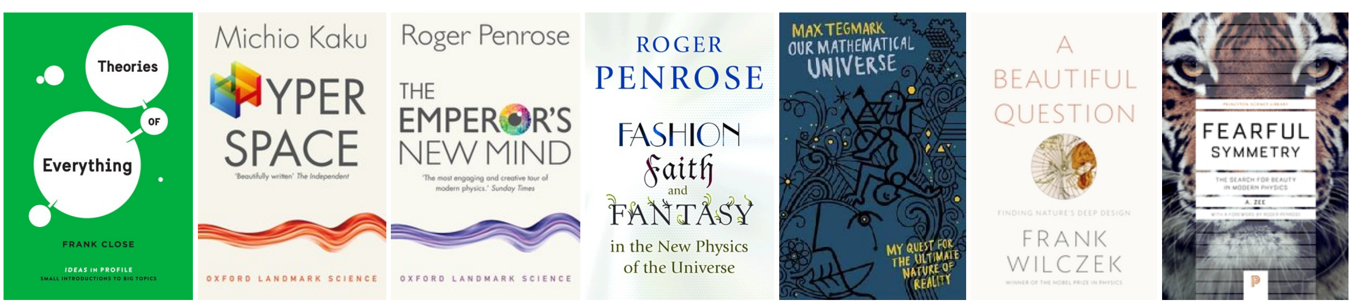
It is also clear that he went though a lot of research. He did several interviews for example with Bob May (nonlinear dynamics), Melissa Franklin (particle physics), John Polkinghorne (theoretical physics and theology), John Barrow (cosmology), Roger Penrose (mathematical physics; his office in Oxford is just downstairs of du Sautoy's), and Christof Koch (neuroscience). The interviews are not really formal and written down in the book in a casual way as part of the meandering of du Sautoy's account.

R. May M. Franklin J. Polkinghorne J. Barrow R. Penrose C. Koch

He even has put himself through experiments such as fMRI scans. In the first case he was being anaesthetised with propofol (the drug that probably killed Michael Jackson). In a second fMRI experiment he was given two buttons that he could push randomly at will. It was shown that one could see by his brain activity which one of two buttons he was going to push 6 seconds before he actually pushed it. So if a computer can predict what you will do before you actually do it, what does this say about free will?

Although du Sautoy is entertaining, I cannot say that he is particularly funny, but neither is he boring. His views are those of a mathematician, but formal mathematics are never used. So for example the reader can understand that symmetry is important to solve equations and to get some order in the quark zoo, and that SU(3) is very helpful, but it is not really explained what SU(3) actually is. The symmetry of a die cube is used to explain S4, but SU(3) is described as 'the object that can describe the symmetries of a range of different geometrical objects in different dimensions'. But the reader should have caught the idea that it is some sort of generalization of what S4 does for the cube.

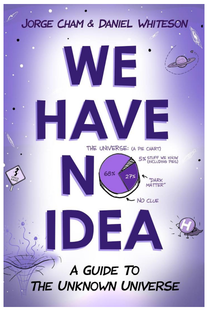
Some related or similar books:

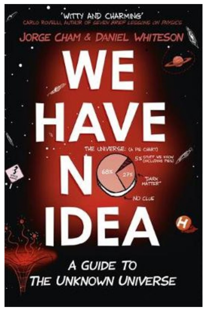


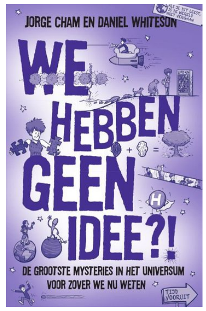
- Frank Close, Theories of Everything Ideas in Profile, (2017)
- Michio Kaku, Hyperspace A Scientific Odyssey through Parallel Universes, Time Warps, and the Tenth Dimension (1994)
- Roger Penrose, The Emperor's New Mind. Concerning Computers, Minds, and the Laws of Physics (1989)
- Roger Penrose, Fashion, Faith, and Fantasy in the New Physics of the Universe. (2016)
- Ian Stewart, Calculating the Cosmos. How Mathematics Unveils the Universe (2016)
- Max Tegmark, Our mathematical universe. My quest for the ultimate nature of reality (2014).
- Frank Wilczek, A Beautiful Question. Finding Nature's Deep Design (2015).
- Anthony Zee, Fearful Symmetry. The Search for Beauty in Modern Physics (1986).

Adhemar Bultheel

We have no idea, *Jorge Cham and Daniel Whiteson*, Riverhead Books / Penguin Random House, (2017) ISBN 978-0-7352-1151-3 (hbk), 368 pp.








Jorge Cham


Daniel Whiteson

If you think du Sautoy's *What we cannot know* is too boring, too much philosophy and too much about God, and if you are in for a fun-approach, this book is exactly what you need.

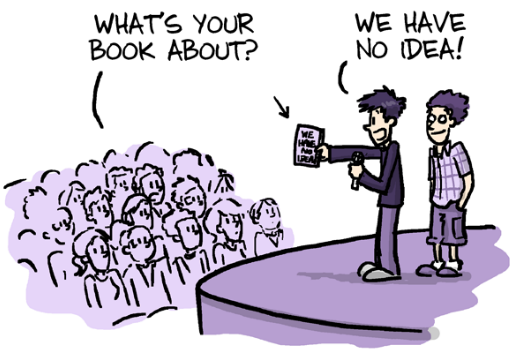
Jorge Cham has a PhD in robotics from Stanford but he is now free-lance cartoonist and science entertainer while Daniel Whiteson is professor in physics and astronomy at the UC Berkeley. Cham is creator of phdcomics.com where you find more of his work, a link to two PhD movies, and also links to YouTube for animated cartoons related to this book.

Many of the topics discussed by du Sautoy or by other authors of popular books on particle physics and cosmology, appear also in this strip, or whatever you call a book containing text amply illustrated with cartoons. It is brought like a comedian would bring it in a show, but nevertheless, it discusses all the appropriate subjects and the right questions are asked. In fact the title of every chapter is a question: What is the Universe made of? What is dark matter and dark energy? What is the most basic element of matter and what mysteries does it entail? Why is gravity so different from the other three fundamental forces? What is space, and what is time? How many dimensions are there? Why is there a speed limit for light? Who is shooting superfast particles at us? What is the Big Bang and how big is the universe? The shortest chapter is chapter 13. It is entitled "What happened to chapter 13?" and it has only one sentence: "We have no idea". This is also the most recurrent answer to many of the questions asked as you may have guessed from the title.

Of course there is no mathematics here, but for a lay person, I think this is the clearest possible introduction to the subject you may wish for. The strong point is that the authors are well aware of how a lay person will think about these matters. They keep repeating the question an 8-year old keeps asking: Why is it like this? The answer is most of the time the usual one: We have no idea. But while trying to answer, they explain all that we do know.

One of the more confusing chapters in other books that I read about these topics was the one on particles. That subject is introduced here by saying that any atom of matter we can observe (although that is only 5% of what the universe contains) can be made of only three particles: the electron which has a negative charge while the kernel needs up and down quarks to form positrons and neutrinos. Gradually these are extended to 6 quarks and 6 leptons, all of them called fermions. Only then enter the force carriers or bosons like photon, gluon, the Higgs boson, and the yet unconfirmed graviton.

The authors also bust some stereotype ideas most people have like imagining the kernel or the electrons as little balls. They carry some charge but we do not think of charge as being located at a particular place in the electron. It is more like a property, a label, attached to it. In fact this is also how we should think about mass. The kernel and electron are like dimensionless points that have properties like a charge and a mass. So how come we feel resistance when hitting a table? Why can't we walk through walls? What do we measure when we weigh something? We do not add the sum of the masses of the electrons, but we actually measure the force that is binding everything together.



In this way we are introduced to all the elements of particle physics, relativity theory, and cosmology, and of course the holy grail of theoretical physicists: the Theory of Everything. It is not only explained what this ToE is, but also why it is so freakingly difficult to link general relativity and quantum mechanics into a common package and have a theory of quantum gravity.

Most of all the book is just fun. Lots of fun, cartoons and gags. Animals, pets and marshmallows are returning fun elements. The problem of weight mentioned above is illustrated as follows. When cutting up a llama in pieces, then the weight of the llama is the sum of the weight of the pieces, unless you cut the llama into 10^{23} pieces. Then you have to add to the mass of all the pieces also the binding energy. Ferrets are employed dropping water balloons to explain some aspects of relativity theory and Bertha the hamster is using two photon guns (a.k.a. flashlights) pointing in opposite directions standing on the Earth while Larry the cat is flying by approaching the speed of light and you are floating in space and you all observe the same speed for the photons from the flashlights. That is until the hamster's arms are getting tired.
A quote from early in the book to illustrate the kind of language used:

> If there is a fundamental equation of the universe —whatever it is— we can be sure it doesn't have a variable Nllamas because llamas, like atoms, are not a fundamental element in the universe. They don't define its essential nature; they are just the aggregate result (the emergent phenomenon) of the deeper reality (sorry, llamas) the same way tornados are an emergent phenomenon of wind or stars an emergent phenomenon of gas and gravity.

Of course the cartoons are funny elements too and there are usually several per page. And there are many footnotes which are fun remarks like this example:

> Scientists hundred years from now might think that we had the clues staring us in the face, that it was *so bloody obvious*, but currently it is a mystery.*
>
> ---
>
> *Future physicists apparently have a condescending British accent.

In short I can recommend this book strongly. You may read it just for the fun of it, and you will probably learn something on top.

Adhemar Bultheel

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