The Universe Speaks in Numbers: How Modern Maths Reveals Nature's Deepest Secrets

by Graham Farmelo, Faber & Faber, 2019, £20, US$30, ISBN: 978-0571321803

Review by Noel-Ann Bradshaw

Graham Farmelo has opened my eyes to the world of theoretical physics and, more importantly, its links with pure mathematics. As a teenager I loved maths, music and art. I was interested in chemistry and history, but physics left me cold; partly because I had endured the same teacher for five years and she had failed to inspire me. Since embarking on my academic career, I have become somewhat embarrassed by my aversion to all things physics-related, and consequently I saw the opportunity to review this book as a way of addressing this.

In true academic style Farmelo begins each chapter with a summary of what will be covered, but then each chapter unfolds into a beautiful historical account of the development of ideas and the relationships between those who created them. It reminds me of tracing the genealogy of intertwined family trees, showing where they overlap, come together and then separate for a time before coming back to create powerful new dynasties.

This book clearly depicts the development of mathematical physics, starting with a brief overview of the very early history of the subject. As an enthusiastic mathematical historian I enjoyed reading about Aristotle's rejection of Plato's view, that mathematics was fundamental to understanding science and the world. And also then about the impact of mathematical giants such as Euclid, Kepler, Galileo and Newton, who paved the way for the likes of Laplace and Maxwell (said by one of his teachers to practice maths with "exceeding uncouthness"). This journey and progression of ideas is important for mathematicians and physicists to understand and, in my opinion, should be taught in schools where the subjects are still presented very separately.

Farmelo's style of writing particularly brings alive the work of Maxwell, demonstrating how he linked electromagnetism and optics with his fascination for topology and knots. It is clear that he believed in the importance of mathematics for understanding the universe, whereas his friend and collaborator, Thomson, is described as seeing mathematics as a servant of physics rather than a guide.

Next on the scene is Einstein, who is reported as realising that advanced mathematics was a physicist's most valuable tool. There follows a delightful account of the relationship between Hilbert and Einstein as they race to complete the theory of gravity, coming at it with very different backgrounds. For me the book really starts to come alive with the entry of Dirac and his vision for the future of these distinct, but linked, disciplines.

Dirac proposed a new theory: the beauty of mathematics. As someone who has recently been told by a teacher not to mention the b-word in talks to school children because apparently this turns them off the subject, I was delighted to read that he mentioned the beauty of mathematics seventeen times in his talk on the relationship between mathematics and physics at the Royal Society of Edinburgh in 1939 – a talk which is crucial to Farmelo's book. Here he urged theoretical physicists to learn a lot of advanced mathematics, concluding that "big domains of pure mathematics will have to be brought in to deal with the advance in fundamental physics."

The history and theories discussed by Farmelo develop swiftly with much of the book understandably focussed on more recent developments, some of which are less easy for a non-physicist to understand. However, understanding the detailed theory is not essential as it is the accounts of the relationships and collaborations between the likes of Dyson and Feynman, Penrose and Hawking, Weyl and Wigner that are fascinating and thought-provoking. I defy any pure mathematician not to be moved as Farmelo's account becomes personal. He describes his conversations with Atiyah, Dyson, Langlands, Uhlenbeck and other modern day greats, demonstrating not only the link between mathematics and physics but also the desperate necessity for the two disciplines to collaborate and work together. As I am personally aware that the mathematical modeller needs ideas and problems from industry in order to perfect his/her craft, I appreciated seeing this echoed by Uhlenbeck, who is quoted as saying how "Research mathematicians need physicists' ideas."

I believe this is an important book that should be read by both mathematicians and physicists. It challenges, but yet is sympathetic, to the different histories, backgrounds and indeed prejudices of the two disciplines. Farmelo sometimes presents his own opinion but much more frequently uses the words, actions and works of others to put his point across. What makes his call for intimate collaboration more powerful is the acknowledgement that he was not of this opinion when he started out in his career. Over time, his experience has shown him the importance of working together to further developments in areas such as String Theory, Supersymmetry and the discovery of the Higgs particle.

In my opinion this book should be on the reading list for every mathematics and physics A-level student and every new undergraduate of both these disciplines. Wherever their interests in these subjects currently lie, they should be made aware of the overlap of mathematics and physics, the power of cooperation and where the sharing of ideas can lead.

Noel-Ann Bradshaw

Noel-Ann Bradshaw is Head of Computing and Digital Media at London Metropolitan University. She recently survived a brief foray into the world of Data Science at Sainsbury's Argos in 2018. In her spare time she enjoys the company of her two cats, skiing, making cocktails, sunbathing, learning Italian and taking holidays that combine as many of these as possible.