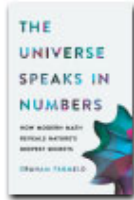


***The Universe Speaks in Numbers: How Modern Math Reveals Nature's Deepest Secrets*  
By Graham Farmelo, ISBN 978-0-465-05665-1**



In *The Universe Speaks in Numbers*, Graham Farmelo presents a concise version of the history of the relationship between mathematics and physics. As Farmelo explains in his book, the relationship, though perhaps a natural one, has not always been an easy one. He even goes so far as to describe it as one that has gone through a long divorce and subsequent reconciliation.

Farmelo begins by describing Einstein's philosophy, that a purely mathematical and theoretical approach to the study of physics could wield meaningful insights into the natural world, as opposed to a purely experimental one. Even though Einstein's genius was celebrated in his own time as it is now, such an approach was considered laughable by many of his peers and fellow physicists. A young Robert Oppenheimer once described Einstein as "completely cuckoo," Farmelo explains. And Oppenheimer wasn't the only one.

But, as with many great minds, Einstein was simply ahead of his time. A significant amount of scientific research up to that point was observation- and experiment-based. Now, the use of mathematics to study and describe physics on a theoretical level is widely practiced—string theory comes to mind as perhaps the most famous example of theoretical physics in the forefront of the zeitgeist.

After beginning with Einstein, Farmelo goes back to the basics—classical physics. It's a field that Isaac Newton—a mathematician by practice and title—helped describe. Newton, despite being well-known in high school and college physics courses today for his Laws of Motion, would not have considered himself a physicist in his own time. Newton described his use of mathematics to explain what he saw in nature in his *Principia*—now considered a foundational text of calculus. Today, calculus and physics are essentially married subjects—but, in Newton's time, the idea of wedding mathematical calculations with experimental insights to support theoretical observations was revolutionary, to say the least. His work catalyzed the integrated study of mathematics and science in an unprecedented way that would culminate in the invention of modern physics in the twentieth century.

Farmelo makes sure to pay his respects to some of Newton's "giant" predecessors, upon whose shoulders Newton stood to see further. These include Aristotle and Galileo, amongst others. But the main focus of Farmelo's first chapter is Newton. After Newton, he details James Clerk Maxwell's mathematical investigations into electromagnetism—the culmination of which is a series of equations that bear his name. From there, Farmelo moves on to the two revolutionary discoveries that define modern physics: basic relativity and quantum mechanics.

Then, Farmelo comes to the aforementioned long divorce. In the mid-twentieth century, many physicists, Freeman Dyson among them, felt physics stood alone from mathematics. Experimentation and observation were the foundations of the field. Dyson and his fellow physicists viewed the mathematical foundations of theoretical physics with skepticism. Now 92, Dyson—along with others in the field—have changed their tune. It's intriguing to read *The Universe Speaks in Numbers* not long after reading Dyson's memoir *Maker of Patterns: An Autobiography through Letters*. He's gone from being the narrator to the narrated, so to speak—from the director of the show to an actor in it, and it's an interesting transition. If you want more on Dyson after reading *The Universe Speaks in Numbers*, or even if you want a scientist's immediate perspective on the events Farmelo describes in his own book, I recommend checking out Dyson's memoir.



It's humbling to note, as Farnelo does, that it took three centuries to get from Newton to the Standard Model of particle physics, and only four decades to get from the Standard Model to where we are today. The last four decades occupy the second half of *The Universe Speaks in Numbers* and, as you might expect, more modern characters like Stephen Hawking make an appearance, while Dyson continues to pop up as the fields of theoretical physics and mathematics begin to repair their relationship and reconcile. If you want to learn how, you'll have to read it for yourself.

Farnelo is both a professor of physics and a skilled science writer—and it shows. He demonstrates a firm command of the subject matter, which coupled with his accessible language and writing style makes *The Universe Speaks in Numbers* a delightful and insightful read.

*Review by Jeanette S. Ferrara, MA*