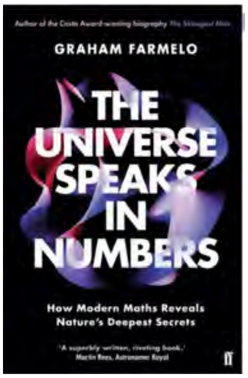
Notes of a Numerical Analyst

The Universe Speaks in Numbers?

NICK TREFETHEN FRS

Not long ago Graham Farmelo gave a public lecture in our Mathematical Institute about his book *The Universe Speaks in Numbers: How Modern Maths Reveals Nature's Deepest Secrets*. I've just finished reading this book with great pleasure, and I want to share with you the results of a rather quirky literature search it has prompted.



My subject isn't Farmelo's book *per se*, but the view it compellingly represents, which is a widespread one these days. Mathematics and physics drifted apart in the mid-20th century, according to this view, but something big has happened since then. The two fields are now extraordinarily close, with influences in both directions between some of the most exciting mathematics and some of the most exciting physics. Two of the leaders of this new synergy have been Ed Witten in physics and Michael Atiyah in mathematics.

But then there is controversy. The physics in question is string theory in its many forms. Is string theory physics? Is it mathematics?

Farmelo's title got me thinking. Of course, he doesn't mean "numbers" literally; this is a colourful way of referring to mathematics. Yet the question I found myself asking was, what actual numbers appear in some of the great works of theoretical physics?

So I've taken a sample. It turns out many papers mention the integers from 0 to 10, as well as e, π, i and ∞. I will exclude these from the tallies, just as Desert Island Discs grants everyone the Bible and the complete works of Shakespeare. What follows are exact lists of all the other numbers that appear in seven special papers.

Maxwell's great paper on electromagnetism (1865) contains these numbers: 10^{-50}, 0.0008, 0.00083, 1/1000, 0.00126, 1/500, 0.01841, 0.02010, 0.0236, 0.158194, 0.22437, 1/4, 1/2, 1.0618, 4.13, 13, 16, 24, 27, 32, 45, 48, 77, 100, 193, 313, 475, 7345, 13000, 44997, 410000, 430165, 436440, 456748, 60000000, 298000000, 308000000 and 310740000.

Einstein's Nobel Prize-winning paper on the photoelectric effect (1905): $6.10\cdot10^{-56}$, $1.62\cdot10^{-24}$, $4.866\cdot10^{-11}$, 10^{-8}, $1.9\cdot10^{-5}$, 2/3, 3/2, 1.7, 4.3, $9.6\cdot10^{3}$, 10^{7}, $6.4\cdot10^{12}$, $9.6\cdot10^{12}$, $1.03\cdot10^{15}$ and $6.17\cdot10^{23}$.

Einstein's 3-page announcement of $E = mc^2$ (1905): $9\cdot10^{20}$. (That's right! — just $9\cdot10^{20}$, along with 1 and 2. Einstein wrote the equation as Mass = L/V^2.)

Einstein's main paper on general relativity (1916): $1.87\cdot10^{-27}$, $6.7\cdot10^{-8}$, 1/4, 1/2, 0.02, 1.7, 11, 12, 24 and 43.

Schrödinger's Nobel Prize-winning theory of quantum mechanics (1926): 10^{-18}, 0.0004849, 0.0008312, 0.001573, 0.003433, 0.04418, 0.08975, 5/36, 3/16, 21/100, 2/9, 0.2386, 1/4, 1/2, 1.281, $\sqrt{2}$, 4.5, 11–20, 22, 26, 28, 30, 32, 64, 10000 and 100000, plus four tables of data.

Penrose's Nobel Prize-winning proof of stability of black holes (1969): 1/2, 0.7, 1.3, 10^8, $3\cdot10^{10}$, 10^{11} and $4\cdot10^{38}$.

Finally, the joint paper by Atiyah and Witten, a work of 106 pages.

Atiyah and Witten, "M-theory dynamics on a manifold of G_2 holonomy" (2001): $\sqrt{6}$, 11, 24, 27, 36, 48, 72 and 144.

Nick Trefethen
Trefethen is Professor of Numerical Analysis and head of the Numerical Analysis Group at the University of Oxford.