Journal & Proceedings of the Royal Society of New South Wales, vol. 152, part 2, 2019, pp. 157–159. ISSN 0035-9173/18/020157-03

Editorial: "The Old One does not play at dice"

Robert Marks

Economics, University of New South Wales, Sydney

E-mail: robert.marks@gmail.com

This issue contains three submissions — papers by Rendsburg, Holman, and Anemaat — on, respectively, a Hebrew fragment found in an old book in the Fisher Library at Sydney University and how it was identified, the science of red meat in NSW, and surviving drawings made during the first days of the Colony at Botany Bay. As I have remarked before, the *Journal* is not the first choice for young academics, and so I look for possible submissions from older contributors. In this issue there are two commissioned papers: a long one by John Spence FRS on the history of measuring the speed of light and where that led to in 1905 and later, and a shorter one by Rob Burford FRSN on the history of plastics (aka polymers) over the past century or so. There is a paper by Barbara Gillam FRSN, reprinted from the journal *Leonardo*, where it is not very accessible. We hope that its appearance here results in greater exposure. There are five PhD abstracts, including one (by Tran) that should have appeared in the print version of the June issue, but did not. Finally, there is an obituary of Ann Moyal FRSN (1926–2019), who was the first recipient of the Royal Society's History and Philosophy of Science Medal in 2014. She was also a co-author of mine. I am grateful to Stuart Macintyre AO, a former Dean of the Faculty of Arts at the University of Melbourne, for agreeing to write the obituary.

David Attenborough tells us[1] that when he was a schoolboy in the 1930s, his science master showed them a marvellous new substance that had been invented, called plastic. It was light, it was cheap, and it could be used for a multitude of things. In centuries to come, the teacher said, people would look back in the twentieth century and say that was the plastic period! That was, Attenborough says, truer than the teacher knew, because, yes, it had all those advantages, but the mere fact that it was indestructible meant that it could not be thrown away. Plastics manufacturers advised that once it was used it should be thrown away. But there is no "away:" plastic is so permanent that it does not decay or rot. Hence our growing problem with plastic waste, on land and in the oceans. Although his paper focuses on the advances in polymer chemistry that have resulted in new plastics, Burford does make some suggestions about this issue, through changes in our behaviour and in new chemistry.

My old friend John Spence has recently published a book (2019) on the history of measuring the speed of light, and the consequences for our understanding of the Universe that ensued, over a hundred years ago, including Einstein's 1905 paper, and also indirectly to quantum physics. At my request, he has written a paper that summarises his book, published here. As Spence

[1] A message from naturalist Sir David Attenborough: Plastic Oceans, OceanVistaFilms, https://www.youtube.com/watch?v=cX1T79ZKJqM

recounts, in 1900, despite the achievements of Newton and Maxwell and many others, there were two puzzles in physics: the failure of the Michelson-Morley experiment and the black-body radiation problem. Solution of the first puzzle led to special relativity, and solution of the second led to quantum theory, with all its weirdness.

I recently came across a fascinating "life" of the Italian polymath, Jerome Cardano (1501–1576), who has variously been described as a gambler and blasphemer, inventor and chancer, astrologer and astronomer.[2] In notes he wrote in 1520 while still a student, much later posthumously published as a book, he was the first to attempt to derive a law of probability applied when a die is cast, as formulated in Cardano's Formula. This was over a hundred years before Leibnitz in 1676, and over two hundred years before Laplace's foundation of probability theory in 1774. As a gambler, Cardano was motivated to understand this to win at dice. As an inventor he invented the forerunner of the Cardon universal joint which facilitates the transmission of torque between two shafts positioned at various angles. And, in his pioneering work at solving cubic equations, he derived numbers that were multiples of the square root of minus one, at a time when even negative numbers were suspect.[3] He thought such entities (imaginary numbers) were useless rubbish. It's surprising to realise that the two basic ingredients of modern quantum theory, namely probability and complex numbers, were discovered by one man, four hundred years before quantum theory itself was developed.

Ekert (2008) asks whether we have to use Cardano's discoveries (probability and complex numbers) to describe the world. Predictive determinism is the view that, if at any time we knew the positions and velocities of all the particles in the universe, then, at least in principle, we could calculate their behaviour at any other time, past or future. This was the official dogma until quantum theory was developed a hundred years ago, which rules out sharp predictions of measurement outcomes. Instead, we must use probabilities. Moreover, causal determinism, in which every event is caused by, and hence determined by, previous events, does not always hold in a quantum world. After some discussion of the connection between complex numbers and probabilities, and how they unite in quantum theory, Ekert concludes that we cannot avoid probability and complex numbers in describing the world. We cannot avoid quantum theory.

In a letter to Max Born[4] in 1926, Einstein said "Quantum theory yields much, but it hardly brings us close to the Old One's secrets. I, in any case, am convinced He does not play dice with the universe." I believe that Einstein could not accept the abandonment of predictive determinism that occurs in quantum theory. He could not accept the probabilistic nature of the theory. And yet quantum theory is one of the pillars of modern physics and underlies so much of modern technology. It works.

[2] Brooks (2017), who expounds the non-intuitive behaviours at the quantum scale in an amusing way.

[3] Ekert (2008) tells a story about a mathematician sitting in a café and watching an abandoned house across the street. After a while two people enter the house and a little time later three people exit. How interesting, thinks the mathematician, if another person enters the house it will be empty again.

[4] Max Born was Dame Olivia Newton-John's maternal grandfather, and a pioneer of quantum theory. The letter is dated 4 December 1926 and was translated by Irene Born Newton-John. See https://physicstoday.scitation.org/doi/full/10.1063/1.1995729

One of the scientific highlights of the past year has been the publication on 10 April 2019 by the Event Horizon Telescope of the first ever direct image of a black hole and its vicinity, the supermassive black hole at the core of the supergiant elliptical galaxy Messier 87, 53 million light-years away. By nature, black holes do not themselves emit any electromagnetic radiation other than the hypothetical Hawking radiation, so astrophysicists searching for black holes must generally rely on indirect observations. This image took two years of processing data from eight radio observatories recorded over ten days in April 2017.

Denisovans, extinct cousins of Neanderthals, have been known only by scraps of fossils from a Siberian cave, yet their genetic traces are found in modern humans, especially in Melanesia and Australia.[5] This year, scientists used a new protein method to identify a jaw bone from the Tibetan Plateau as Denisovan — the first physical trace outside Siberia.

[5] Genetic traces of Neanderthals (up to 2.5% of DNA) are found in all modern humans outside Africa.

Dr Len Fisher FRSN has agreed to join the Editorial Board of the *Journal*. Welcome, Len. The Editorial Board have given me advice and I should also like to thank Ed Hibbert, Rory McGuire, and Jason Antony for their help in preparing this issue.

Balmain, 20 December 2019.

References

Brooks, M. (2017) *The Quantum Astrologer's Handbook*, Scribe, Melbourne.

Cardano, G. (1663, 2015) *The Book on Games of Chance: The 16th-Century Treatise on Probability* (*Liber de ludo aleæ*), Dover, New York.

Ekert, A (2008) Complex and unpredictable Cardano, *International Journal of Theoretical Physics*, 47(8): 2101–2119, August.

Spence, J. C. H. (2019) *Lightspeed: The Ghostly Aether and the Race to Measure the Speed of Light*. O.U.P., New York.