"Tesla unveiled the first radio tube in this second month of 1892". This is followed by a description of electrical discharges in a vacuum and a quotation with a footnote. But the source cited does not refer to the material in this paragraph, nor is the quotation there.

I wish I could have written a positive review. In this 542-page work there is a good 200-page book struggling to get out. All the requisite material is there. What is needed is a ruthless editor and the two professional and critical readers that most academic publishers require. □

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House of cards

The Fabric of Reality
by David Deutsch
Allen Lane: 1997. Pp. 390. £25. To be published in the United States on 1 August at $29.95

Peter T. Landsberg

The great outpouring of 'popular science' books continues unabated. Often they deal with modern physics and provide an introduction to recent progress. Sometimes they suggest a new philosophy or world view. This book is in the second category. Knowledgeable, fiercely outspoken and quite partisan, David Deutsch aims to introduce us to his view of reality. He has written about this before, but this book presents a more systematic development.

His four strands are quantum theory, the theory of computation, the theory of evolution and the theory of knowledge. He concludes that scientists have not taken their own theories sufficiently seriously; they are instead "clinging irrationally to what could be called 'paradigms'". For example, optical interference experiments involve photons we can detect, and others whose presence we infer merely from their interference effects on the observable photons ("tangible" and "shadow" photons respectively). Take this seriously, Deutsch advises, and call the tangible particles our universe and each shadow particle a part of a parallel universe.

This raises a terminological point. Deutsch drops the term "universe" as a description of the whole of physical reality, because what we see and study would then be merely a portion of it, and so would require a new name. He uses "universe" to denote only the part of physical reality that we normally study. And the rest — the physical reality as a whole? Well, just call that a "multiverse", and we have got our nomenclature. There seems to be no difference between the multiverse and the notion of parallel universes.

Things analogous to each other are supposed to happen in the parallel universes. In one of his few lighter touches, Deutsch speaks of variants of himself in these parallel universes: "Many of those Davids are at the moment writing these very words. Some are putting it better. Others have gone for a cup of tea."

How can one understand these ideas? When an electron goes through two slits (in the double-slit experiment) there results a superposition of states, and one might talk about a plurality of potential electron states. The next step is to associate possible worlds in which these states are realized individually. This is done here. But it will come as no surprise that there is resistance to the phrase "many worlds", for it can conjure up "ontological profligacy gone mad".

Another terminological point, not made by the author, is elementary but important. When physicists talk about "the universe" that occurs in their theories, they always mean some model universe, not the actual universe we observe, to which the model is, at best, a good approximation.

A reader may well want to hurry on to quantum computers, which are associated with some seminal papers by Deutsch. Indeed, here we find a reference to Peter Shor's algorithm — a way of factorizing numbers of the order of 1 followed by 500 zeros. These are huge numbers, if we recall that the number of particles in the observable universe is estimated to be 'only' 1 followed by 80 zeros. The factorization, asserts Deutsch, uses the resources of the parallel universes. His challenge is: "Explain the algorithm on a single-universe world view." I hope that computer scientists can and will take up this challenge.

Here, as in other places, I was disappointed that the author could not give a briefer and more incisive introduction to basic ideas. Must one really still also go to articles in *Science* or *Physics World* to find out about quantum computers when one has this book? I have a feeling that Deutsch is so keen to propagate his ideas that he sometimes neglects a more straightforward exposition. He does not warn us, for example, that there could be obstacles to the construction of quantum computers that may not be overcome for many years. The main difficulties will arise from the nature of the error correction needed and from quantum mechanical decoherence problems.

There is some fun to be had in the chapter on time travel. The most interesting type is travel into the past, and there is still some doubt whether this is 'allowed' by our scientific laws. If it is, one may expect messages from the future. But visitors from the future "cannot know our future any more than we can, for they did not come from there". Deutsch engages us in various speculations, some of which, as he admits, would not be out of place in science fiction.

To whet appetites, here are some memorable quotations: "While most mathematicians and computer scientists take the certainty of mathematical intuition for granted, they do not take seriously the problem of

... nor any drop to drink

Floods come quickly upon villagers in the Ganges and Brahmaputra delta, particularly when dams on the other side of Bangladesh's land borders are opened without warning. People seek refuge on roofs, only to be at risk from deadly bites of water-shy snakes. From *Delta: The Perils, Profits and Politics of Water in South and Southeast Asia*, a photographic survey by Daniel Schwartz of life in these impoverished yet resourceful delta regions. Thames and Hudson, £28.

In retrospect chosen by Euan Nisbet

Emma
by Jane Austen
(1816)
The Climate of London
by Luke Howard
(1833)

Austen: acute observer of the weather

Why choose *Emma*? *Emma* is weather. Meteorology shapes the novel. This is a work of science, seamlessly woven into art. *Emma* is perfect. The slightest change would disrupt the book. How did Jane Austen create a work without flaw? Literati will have their explanations and doubtless many learned theses. But, to this illiterate from the numerati, the science perfects the art.

Emma herself is in full bloom, lovely, ready for marriage, as the spring of life passes to high summer. Day by day, the plot twists with the weather report. Is it bright? All is cheerful. Is it drizzling? Misery abounds. Or, beware, is it hot and sultry? Romance and danger loom. No doubt there is a learned tome on this somewhere, but it is a fascinating game to read *Emma* alongside one of the founding texts of meteorology, Luke Howard's *The Climate of London*.

Emma is set not far from London, near Cobham in Surrey, perhaps at Painshill, where the eccentric Mr Hamilton, related by marriage to Admiral Nelson's Emma, had created an experimental garden-farm, a ruined 'abbey' and artistic 'mill'. There was "a sweet view, sweet to the eye and the mind". The gardens are now modernized by electricity pylons so obtrusive that the observer may be permitted to suspect the hand of a planner.

Howard, a chemist and close friend of John Dalton, named the clouds: stratus, cumulus, cirrus, nimbus. He helped to lead the Bible Society and the fight against slavery. After the devastation of the Napoleonic wars, Howard and his friends in the United Kingdom and United States collected a vast sum, equal to many millions today — and took it to help the distressed people of Germany. Even Goethe, who wrote *In Honour of Howard*, addressed him as 'master'.

On the warm evening of 22 July 1813, Howard records his visit to Alton, Hampshire. As he travelled through Chawton, just before Alton, he would have passed before Austen's dining room window, the outlook of one who was his equal in meticulous observation. Whether they met that day we do not know but it seems possible. Howard was a campaigning celebrity with links to the Lloyd and Barclay families, Quaker bankers. There were Barclays in Alton, and Austen's brother was a banker. After this time, Austen's letters seem full of weather.

Austen wrote *Emma* in 1814–15. It is nice to imagine that the crux of the book, the trip to Box Hill, dates from summer 1814. The lesser details may have been filled in as she wrote. Suppose then that the book records the weather of summer 1814 and winter 1814–15, day by day as she wrote, although the calendar may be 1813–14, when she began the plotting. With these assumptions, the course of the book fits beautifully with the weather recorded in *The Climate of London*. If so, the story may begin on 25 September, pass through autumn to snow at Christmas (now a rare event, but it did occur at Christmas 1814), then to a post-Christmas period between frost and thaw (32–41 °F in Howard's record), and the late winter weather of early 1815.

The crisis in the book occurs just before midsummer's day. Austen makes the fascinating observation of an "orchard in blossom", her famous 'error'. What are apple trees doing in flower in mid-June? But is this error — or clue? The weather was unusual in 1814. The annual mean temperature was one of the coldest in Howard's record, and in May and June the means were colder than 1816, the 'year without a summer' after the eruption of the Tambora volcano in what is now Indonesia. In the cool spring of 1996, mild in comparison to 1814, apple trees flowered as late as early June.

Perhaps Austen herself saw apple blossom on two hot days, 14 June (85 °F) and 15 June (78 °F), at Painshill and Box Hill. Then the weather broke. On 21–23 June, Howard notes that a "fire in the grate has been again acceptable", an observation worthy of Mr Woodhouse himself. Only as June ended did summer reappear. In July came clouds of uncommon beauty. In *Emma* "it cleared; the wind changed into a softer quarter; the clouds were carried off, the sun appeared; it was summer again". Did Mr Knightley come to call on Wednesday 6 July 1814?

Is it presumptuous to attempt to match the weather to the novel? Possibly — an author has the right of imagination. But Austen is accurate. If she says the orchard was in bloom, then it surely was in bloom. Her meteorological sense is acute, accurately recording the passage of fronts. The perfection of the book comes from the quality of the observation; the science makes the art. Each graduate student should be set to read an Austen novel before starting a thesis.

Austen painted in miniature on two inches of ivory, but she wrote on large issues. In 1772, Judge Mansfield's far-reaching judgment ended slavery in England, helping to create modern individual liberty; in *Mansfield Park* the rich, cultured society can save itself only if it is cleansed of its Caribbean evil. The Prince Regent, to his credit, greatly liked that book. He would have seen the point. We should not forget it today. *Sanditon*, her last work, has a black subsidiary heroine: was Austen going to tackle racism?

In her tiny theatre, Austen took on the greatest of themes. Is it too much to see in her masterpiece, *Emma*, an allegory on *Nature* herself? Perhaps this is imagining too far — or may it be allowable in this journal? But it is a good excuse to follow her commendation and pour a glass of Constantia in her honour this July.

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reconciling this with a scientific world view"; "mathematical knowledge is inherently derivative, depending entirely on our knowledge of physics"; "Plato was a very competent philosopher who believed in telling ennobling lies to the public"; "Let us start by imagining some parallel universes stacked like a pack of cards, with the pack as a whole representing the multiverse".

Even wider horizons are explored in the concluding chapter. Deutsch suggests that his four strands together provide an explanation of reality. The fourth strand is knowledge, "which seems a parochial concept until we consider it from a multiverse perspective". Regarding ourselves as primarily knowledge-creating beings, we would welcome an unlimited supply of energy and hence the availability of an enormous number of computational steps. How can this be achieved?

Here Deutsch makes contact with Frank Tipler's "omega-point" theory. The omega-point is supposed to be the end-point of the gravitational collapses after many cycles. The many-cycle concept does not seem as far-fetched as I once feared. Just before the end-point is reached, the energy generated may well be such that "an infinite number of memory accesses" and an unlimited memory capacity are feasible. So we can then march forward into what future is left for us. It is a huge extrapolation! I am worried about the impression it creates among sensible nonscientists. There is more to life than the creation of knowledge, as also pointed out by Deutsch (somewhat belatedly) in his exposition.

This is a highly stimulating book, full of ideas and spurring us on to greater efforts of imagination; indeed, it lifts the veil that separates science and science fiction. Some of the arguments are hard to follow and some seem quite unconvincing. But they are always striking. □

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