manifest themselves or how an ethologist could demonstrate their existence. However, the idea surely applies to the activity of scientific research, and perhaps even to the writing of a book. ■

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To infinity and beyond!

Parallel Worlds: The Science of Alternative Universes and Our Future in the Cosmos
by Michio Kaku
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David Lindley

Michio Kaku is an enthusiast. In the breathless introductory chapters of *Parallel Worlds*, he speeds through the history of cosmology and fundamental physics to persuade us that science has never been as thrilling as it is now. Edmund Halley may have been "shocked beyond belief" and "staggered" by Newton's calculation of planetary orbits, but that's small potatoes compared with the staggering science that goes on nowadays. String theory is staggering; quantum computers are truly staggering; the recent discovery of accelerating cosmic expansion left scientists dumbfounded; their minds reel at the idea of parallel universes. And when they're not reeling and staggering, they have to contend with the "insane conclusions of quantum theory".

Melodrama aside, Kaku's book provides a sprightly and generally efficient account of our present understanding of the Universe, in which astronomical observation and elementary physics combine to give a coherent, if rather bizarre, picture of the cosmos. Plain ordinary matter, such as we are made of, is tame stuff. The Universe is mostly dark matter and dark energy, both revealed by the dynamics of galaxies. As yet there is no convincing explanation for either.

But string theory will take care of that. Beginning with the now familiar idea that all particles are in fact little wiggly loops inhabiting extra dimensions, Kaku sketches how gravity may one day be unified with quantum mechanics. Then we will understand space-time and all the matter and forces in it. There was a time when string theory seemed unique: only one version of it could possibly work. But more versions appeared, to be subsumed some years later into M-theory, which unifies string theories at the cost of introducing fundamental surfaces of higher dimensions (called 'branes').

It is a little unsettling now to learn that physicists are drowning in branes, as Kaku puts it, and that they are beginning to think that M-theory itself must be part of some yet more basic theory that is awaiting discovery. This is progress, Kaku assures us.

J. BAUM/SPL

Brane teaser: if parallel universes exist, they might take the form of bubbles in different dimensions.

Although he has every confidence that the quest for a theory of everything will succeed, perhaps in just a few decades, Kaku is vague about what success will look like. He describes how observations of gravitational waves or of temperature fluctuations in the cosmic microwave background, or perhaps experiments at CERN's upcoming Large Hadron Collider, might reveal tiny signs of M-theory seeping from higher dimensions into our own poor world. Then again, they might not, in which case we have to fall back on neopythagorean arguments of pure mathematical consistency to let us know which is the right theory. If that theory is unique, we would "know the mind of God", says Kaku, borrowing a favourite phrase of Einstein's. Or there could be lots of legitimate theories, so that our Universe would be merely one of many possible universes. (I suppose this means that even God couldn't make his mind up.)

Whatever universe we live in, it is bound to end badly. Stars die and cosmic expansion can only lead to a cold, utterly attenuated emptiness. But we can escape this dreary fate, Kaku says. Once physicists have figured out the theory of everything, they will be able to manipulate space-time to create a wormhole through which we can pass to a new universe and start over again. Or maybe, if it is too difficult to send our physical selves to another universe, we can capture our civilization's entire sum of information and convey it down the wormhole in the memory of a quantum nanobot. This is the big payoff: by fully understanding physics, intelligence can escape its cosmic doom.

Parallel Worlds slides from even-handed discussion of what physicists and cosmologists are actually doing into areas that are, shall we say, a touch speculative. Kaku mentions problems and difficulties along the way, but he gives the distinct impression that the prospects described in his final chapters are, if not exactly within our grasp, at least reasonable extrapolations. Some readers will no doubt be entranced by the grand vision, the great sweep of imagination. For me, the parade of mind-boggling ideas breezily portrayed here — the Big Bang as a collision of branes, time travel around massive rotating cylinders, matter as holographic projection from higher to lower dimensions — created a different cumulative impression. The great enterprise of fundamental physics began to seem larky, whimsical and not quite serious.

String theory and its cosmological implications embody, for the moment, a research programme much more than a genuine theory of physics. Getting from one to the other demands detailed and diligent effort. There is no guarantee that it will all work out as desired. But Kaku takes the truth of the big ideas more or less for granted, and races ahead to the most far-reaching and literally cosmic conclusions. This is intellectual entertainment — brane candy, if you like — but will it ever be more than that? ■

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