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Science Focus

THE BIG QUESTIONS SPECIAL ISSUE

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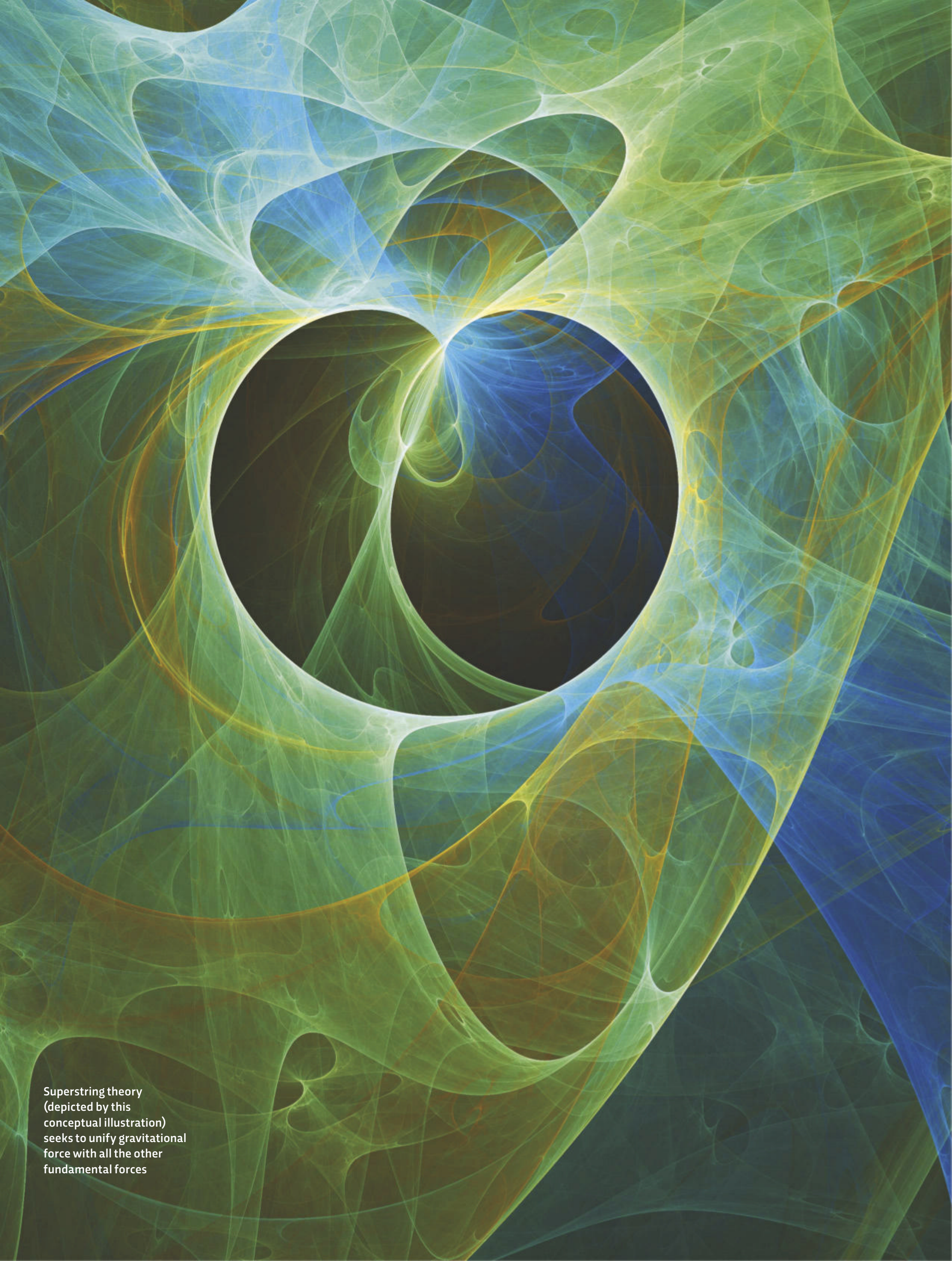

Superstring theory (depicted by this conceptual illustration) seeks to unify gravitational force with all the other fundamental forces

WHAT'S INSIDE THE FIFTH DIMENSION?

What else could there be beyond the three dimensions of space and one of time? And how can we begin to conceive of it? MARCUS CHOWN **delves into the mind-warping possibilities...**

In 1905, Albert Einstein showed in his Special Theory of Relativity that space is intimately connected to time via the cosmic speed limit of light and so, strictly speaking, we live in a Universe with four dimensions of space-time. For everyday purposes however, we think of the Universe in three dimensions of space (north-south, east-west, up-down) and one dimension of time (past-future). In that case, a fifth dimension would be an extra dimension of space.

Such a dimension was proposed independently by physicists Oskar Klein and Theodor Kaluza in the 1920s. They were inspired by Einstein's theory of gravity, which showed that energy, most commonly mass-energy, warped four-dimensional space-time. Since we're unable to perceive these four dimensions, we attribute motion in the presence of a massive body, such as a planet, not to this curvature but to a 'force' of gravity. Could the other force known at the time (the electromagnetic force) be explained by the curvature of an extra dimension of space? Kaluza and Klein found it could. But since the electromagnetic force was 1,040 times stronger than gravity, the curvature of the extra dimension had to be so great that it was rolled up much smaller than an atom and would be impossible to notice. When a particle, such as an electron, travelled through space, invisible to us it would be going round and round the fifth dimension, like a hamster in a wheel.

Kaluza and Klein's five-dimensional theory was dealt a serious blow by the discovery of two more fundamental forces that operated in the realm of the atomic nucleus: the weak and strong nuclear forces. But the idea that extra dimensions explain forces was revived half a century later by proponents of 'string theory' in which the fundamental building blocks of the Universe are viewed not as particles, but tiny 'strings' of mass-energy. To mimic all four forces, the strings vibrate in 10-dimensional space-time, with six space dimensions rolled up far smaller than an atom.

STRINGS, ISLANDS AND MATTER FROM THE FUTURE

String theory gave rise to the idea that our Universe might be a three-dimensional island, or 'brane', floating in 10-dimensional space-time. This raised the intriguing possibility of explaining why gravity is so extraordinarily weak compared with the other three fundamental forces. While they're pinned to the brane, goes the idea, gravity leaks out into the six extra space dimensions, enormously diluting its strength on the brane.

There is a way to have a bigger fifth dimension, which is curved in such a way that we don't see it, and this was suggested by the physicists Lisa Randall and Raman Sundrum in 1999. An extra space dimension might even explain one of the great cosmic mysteries: the identity of 'dark matter', the invisible stuff that appears to outweigh the visible stars and galaxies by a factor of six. This year, a group of physicists from Johannes Gutenberg University in Mainz, Germany, proposed that the gravity of hitherto unknown particles propagating in a hidden fifth dimension could manifest itself in our four-dimensional Universe as the extra gravity we currently attribute to dark matter. Though an exciting possibility, it's worth pointing out that there's no shortage of possible candidates for dark matter, including subatomic particles known as axions, black holes and reverse-time matter from the future! SF

"An extra space dimension might even explain one of the great cosmic mysteries: the identity of 'dark matter'"

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