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'Warped Passages': The Secret Universe

By TIM FOLGER

IN 1900, the British physicist Lord Kelvin assured a gathering of his colleagues, "There is nothing new to be discovered in physics now." What a difference a century makes. Physicists today are all too aware of the holes in their theories. Lordly smugness isn't an option, not when physicists readily concede that more than 95 percent of the mass of the universe apparently consists of an unknown substance that, lacking any better description, they simply call dark matter. And just a few years ago astronomers discovered that the expansion of the cosmos is accelerating, driven by who knows what. Most vexing of all, physicists know that the two masterpieces of their discipline, quantum mechanics and general relativity, are incompatible and cannot in themselves be the final word on the nature of reality.

Lisa Randall's chronicle of physicists' latest efforts to make sense of a universe that gets stranger with every new discovery makes for mind-bending reading. In "Warped Passages," she gives an engaging and remarkably clear account of how the existence of dimensions beyond the familiar three (or four, if you include time) may resolve a host of cosmic quandaries. The discovery of extra dimensions - and Randall believes there's at least a fair chance that evidence for them might be found within the next few years - would utterly transform our view of the universe.

Randall, a theoretical physicist at Harvard, writes from the trenches: she's been working on higher-dimensional models of the universe for several years now. Her work is a departure from mainstream physics, in particular from string theory, which has its own take on extra dimensions.

According to string theory, the most fundamental constituents of matter and energy are not particles, but infinitesimally small strings and loops that vibrate in 10 dimensions. The extra dimensions, string theorists contend, are so small and tightly curled that they are beyond the reach of any conceivable particle accelerator. Many physicists are willing to overlook the lack of experimental evidence because they believe that string theory will eventually reconcile quantum mechanics, which governs atoms and all other particles, with general relativity, which describes how matter and gravity interact on the very largest scales.

Randall, though, argues that without any experimental feedback, string theorists may never reach their goal. She prefers a different strategy, called model building. Rather than seeking to create an all-encompassing theory, she develops models - mini-theories that target specific testable problems and that might then point the way to a more general theory.

The models that Randall and her collaborator Raman Sundrum have been building may explain one of the greatest mysteries in physics: why is gravity so weak compared with the other forces in the universe? Gravity's weakness may not seem obvious, but as Randall writes, "A tiny magnet can lift a paper clip, even though all the mass of the earth is pulling it in the opposite direction." The electromagnetic force is a trillion trillion trillion times as powerful as gravity.

To account for gravity's feebleness, Randall and Sundrum borrow some ideas from string theory but add their own twist. What if, they ask, higher dimensions are not small and curled up but large, perhaps infinite in size? Would there be any observable consequences? So they build models of what the universe might look like if it consisted of objects called branes (short for "membranes"). Branes, a creation of string theory, are surfaces that exist in higher-dimensional space. In Randall and Sundrum's various models, our universe is a four-dimensional brane (three dimensions of space and one of time) that exists on the surface of a five-dimensional space, much as a two-dimensional layer of water covers a three-dimensional sea.

Their models, it turns out, produce a weakened gravitational force. But most important, they predict the existence of particles that may be detectable when a giant new particle accelerator called the Large Hadron Collider, under construction near Geneva, begins smashing protons together in 2007. The expectation is that the collider will discover a group of new particles, and perhaps even miniature black holes. If Randall and Sundrum's predictions pan out, and the existence of extra dimensions is confirmed, it would be one of the biggest advances in physics in decades.

To set the stage for all this, Randall has to recap nearly a century of physics, which she accomplishes with extraordinary clarity. Her explanation of the uncertainty principle, a central tenet of quantum mechanics, is the best I have ever read. Along the way she includes some surprising historical sidelights. Dalí's "Crucifixion," she points out, depicts a four-dimensional cube. The full lyrics of "As Time Goes By" include a reference to Einstein and the fourth dimension. Einstein's calculus teacher, Hermann Minkowski, called his most famous pupil a "lazy dog." And Randall's perspective as a woman in a field where men hold 90 percent of all faculty positions makes for some wry comments. I doubt it would occur to most physicists to observe, "If, however, you lived inside a black hole, your travel opportunities would be far more severely constrained, more restricted even than those of women in Saudi Arabia."

Some of her devices are a bit silly - for example, she opens each chapter with the adventures of time-and-interbranal-traveling characters named Athena and Ike Rushmore. Perhaps it's an occupational hazard: physicists who write for the general public often seem not to trust their own material. But a little silliness in a book that's freighted with discussions of gauge bosons, supersymmetry and D-branes is not necessarily a bad thing. In any case, none of her words are sillier than Lord Kelvin's.

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