

Spacetime, Warped Branes, and Hidden Dimensions

Look around—how many dimensions are you aware of? Of course, you know the answer is four: three spatial dimensions and one time dimension. Four numbers are enough to locate and catalog anything that happens anywhere in the universe, for as long as the universe lasts. But why four? Where did they come from? Until fairly recently, the best minds in history had to settle for “that’s just the way it is.” Then, a mere 87 years ago, Albert Einstein introduced his Theory of General Relativity, which rolls the four dimensions together into the concept of a spacetime. Suddenly the universe became tractable, malleable, an object with dynamic topology and geometry. Physicists realized that it could fluctuate, curve, and even warp in on itself to form exotic astronomical objects such as black holes. Millennia of speculation gave way to a pair of much more productive questions about the universe itself: What is its structure, and how did that structure develop?

Addressing the first of those questions in this special issue on spacetime, Tegmark (p. 1427) reviews the physical structure of the universe—the structure and distribution of galaxies, the formation of astronomical objects, the cosmic microwave background, gravitational lensing, and other topics—from the latest measurements made from ground- and space-based observatories, satellites, and telescopes. He also provides the experimental data that put constraints on the theoretical models proposed to describe spacetime.

In tackling the second question, cosmologists go back to basics. After all, they can argue, there is no a priori reason for having four dimensions. Extra dimensions are easy to describe mathematically; why shouldn’t they exist? Indeed, counterintuitive though the idea might seem, theorists have presented a slew of mathematical equations that show that extra dimensions are not only possible but necessary for a consistent description of spacetime.

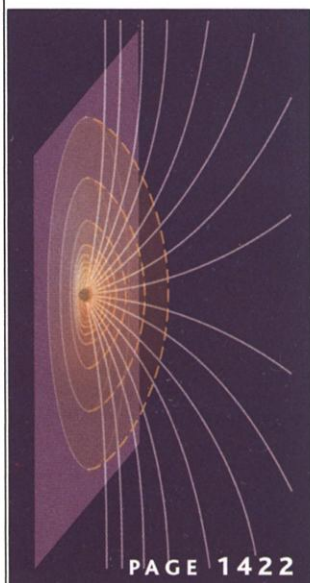
In the 1970s, for example, theorists working to reconcile gravity and quantum theory developed an elegant model in which the fundamental particles of our universe are viewed as excitations of a tiny subatomic species called strings. To be mathematically coherent, however, string theory needed dimensions well beyond the standard four. An obvious question arises: If these extra dimensions do exist, where are they? Randall (p. 1422) provides an overview of the latest developments in string theory and extra dimensions and explores possible reasons for their being hidden from view.

In particular, theory reveals that our “field of view” may be limited to a lower dimensional membrane, or brane, embedded in the higher dimensional spacetime and that collisions or interactions between branes can manifest themselves as gravitational excitations. The theory raises the

humbling possibility that remnants of these collisions pave the way for the development of the structure of the universe we observe. Steinhardt elaborates on this idea in a Research Article (p. 1436). His pulsating-universe model posits that pairs of branes may trigger series of big bangs as they collide again and again like sheets drying in a strong wind.

If all this sounds intimidating, have no fear. News writer Charles Seife opens the section with a nontechnical history explaining how the cosmic fabric wove itself into physicists’ awareness of the universe and how it can enhance your own.

—IAN OSBORNE, LINDA ROWAN, AND ROBERT COONTZ



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