Blackholes, Wormholes and the Tenth Dimension

Will these concepts be proven by a theory of everything?

Last June, astronomers were toasting each other with champagne glasses in laboratories around the world, savoring their latest discovery. The repaired $2 billion Hubble Space Telescope, once the laughing stock of the scientific community, had snared its most elusive prize: a black hole. But the discovery of the Holy Grail of astrophysics may also rekindle a long simmering debate within the physics community. What lies on the other side of a black hole? If someone foolishly fell into a black hole, will they be crushed by its immense gravity, as most physicists believe, or will they be propelled into a parallel universe or emerge in another time era? To solve this complex question, physicists are opening up one of the most bizarre and tantalizing chapters in modern physics. They have to navigate a minefield of potentially explosive theories, such as the possibility of “wormholes,” “white holes,” time machines, and even the 10th dimension! This controversy may well validate J.B.S. Haldane’s wry observation that the universe is “not only queerer than we sup-pose, it is queerer than we can suppose.” This delicious controversy, which delights theoretical physicists but boggles the mind of mere mortals, is the subject of my recent book, Hyperspace.

Black Holes: Collapsed Stars

A black hole, simply put, is a massive, dead star whose gravity is so intense than even light cannot escape, hence its name. By definition, it can’t be seen, so NASA scientists focused instead on the tiny core of the galaxy M87, a super massive “cosmic engine” 50 million light years from earth. Astronomers then showed that the core of M87 consisted of a ferocious, swirling maelstrom of superhot hydrogen gas spinning at l.2 million miles per hour. To keep this spinning disk of gas from violently flying apart in all directions, there had to be a colossal mass concentrated at its center, weighing as much as 2 to 3 billion suns! An object with that staggering mass would be massive enough to prevent light from escaping. Ergo, a black hole.

The Einstein-Rosen Bridge

But this also revives an ongoing controversy surrounding black holes. The best description of a spinning black hole was given in 1963 by the New Zealand mathematician Roy Kerr, using Einstein’s equations of gravity. But there is a quirky feature to his solution. It predicts that if one fell into a black hole, one might be sucked down a tunnel (called the “Einstein-Rosen bridge”) and shot out a “white hole” in a parallel universe! Kerr showed that a spinning black hole would collapse not into a point, but to a “ring of fire.” Because the ring was spinning rapidly, centrifugal forces would keep it from collapsing. Remarkably, a space probe fired directly through the ring would not be crushed into oblivion, but might actually emerge unscratched on the other side of the Einstein-Rosen bridge, in a parallel universe. This “wormhole” may connect two parallel universes, or even distant parts of the same universe.

Through the Looking Glass

The simplest way to visualize a Kerr wormhole is to think of Alice’s Looking Glass. Anyone walking through the Looking Glass would be transported instantly into Wonderland, a world where animals talked in riddles and common sense wasn’t so common.

The rim of the Looking Glass corresponds to the Kerr ring. Anyone walking through the Kerr ring might be transported to the other side of the universe or even the past. Like two Siamese twins joined at the hip, we now have two universes joined via the Looking Glass. Some physicists have wondered whether black holes or worm- holes might someday be used as shortcuts to another sector of our universe, or even as a time machine to the distant past (making possible the swashbuckling exploits in Star Wars). However, we caution that there are skeptics. The critics concede that hundreds of wormhole solutions have now been found to Einstein’s equations, and hence they cannot be lightly dismissed as the ravings of crack pots. But they point out that wormholes might be unstable, or that intense radiation and sub-atomic forces surrounding the entrance to the wormhole would kill anyone who dared to enter. Spirited debates have erupted between physicists concerning these wormholes. Unfortunately, this controversy cannot be re- solved, because Einstein’s equations break down at the center of black holes or wormholes, where radiation and sub-atomic forces might be ferocious enough to collapse the entrance. The problem is Einstein’s theory only works for gravity, not the quantum forces which govern radiation and sub-atomic particles. What is needed is a theory which embraces both the quantum theory of radiation and gravity simultaneously. In a word, to solve the problem of quantum black holes, we need a “theory of everything!”

A Theory of Everything?

One of the crowning achievements of 20th century science is that all the laws of physics, at a fundamental level, can be summarized by just two formalisms: (1) Einstein’s theory of gravity, which gives us a cosmic description of the very large, i.e. galaxies, black holes and the Big Bang, and (2) the quantum theory, which gives us a microscopic description of the very small, i.e. the microcosm of sub-atomic particles and radiation. But the supreme irony, and surely one of Nature’s cosmic jokes, is that they look bewilderingly different; even the world’s greatest physicists, including Einstein and Heisenberg, have failed to unify these into one. The two theories use different mathematics and different physical principles to describe the universe in their respective domains, the cosmic and the microscopic. Fortunately, we now have a candidate for this theory. (In fact, it is the only candidate. Scores of rival proposals have all been shown to be inconsistent.) It's called "superstring theory," and almost effortlessly unites gravity with a theory of radiation, which is required to solve the problem of quantum wormholes. The superstring theory can explain the mysterious quantum laws of sub-atomic physics by postulating that sub-atomic particles are really just resonances or vibrations of a tiny string. The vibrations of a violin string correspond to musical notes; likewise the vibrations of a superstring correspond to the particles found in nature. The universe is then a symphony of vibrating strings. An added bonus is that, as a string moves in time, it warps the fabric of space around it, producing black holes, wormholes, and other exotic solutions of Einstein's equations. Thus, in one stroke, the superstring theory unites both the theory of Einstein and quantum physics into one coherent, compelling picture.

A 10 Dimensional Universe

The curious feature of superstrings, however, is that they can only vibrate in 10 dimensions. This is, in fact, one of the reasons why it can unify the known forces of the universe: in 10 dimensions there is "more room" to accommodate both Einstein's theory of gravity as well as sub-atomic physics. In some sense, previous attempts at unifying the forces of nature failed because a standard four dimensional theory is "too small" to jam all the forces into one mathematical framework. To visualize higher dimensions, consider a Japanese tea garden, where carp spend their entire lives swimming on the bottom of a shallow pond. The carp are only vaguely aware of a world beyond the surface. To a carp "scientist," the universe only consists of two dimensions, length and width. There is no such thing as "height." In fact, they are incapable of imagining a third dimension beyond the pond. The word "up" has no meaning for them. (Imagine their distress if we were to suddenly lift them out of their two dimensional universe into "hyperspace," i.e. our world!) However, if it rains, then the surface of their pond becomes rippled. Although the third dimension is beyond their comprehension, they can clearly see the waves traveling on the pond's surface. Likewise, although we earthlings cannot "see" these higher dimensions, we can see their ripples when they vibrate. According to this theory, "light" is nothing but vibrations rippling along the 5th dimension. By adding higher dimensions, we can easily accommodate more and more forces, including the nuclear forces. In a nutshell: the more dimensions we have, the more forces we can accommodate. One persistent criticism of this theory, however, is that we do not see these higher dimensions in the laboratory. At present, every event in the universe, from the tiniest sub-atomic decay to exploding galaxies, can be described by 4 numbers (length, width, depth, and time), not 10 numbers. To answer this criticism, many physicists believe (but cannot yet prove) that the universe at the instant of the Big Bang was in fact fully 10 dimensional. Only after the instant of creation did 6 of the 10 dimensions "curled up" into a ball too tiny to observe. In a real sense, this theory is really a theory of creation, when the full power of 10 dimensional space-time was manifest.

21st Century Physics

Not surprisingly, the mathematics of the 10th dimensional superstring is breathtakingly beautiful as well as brutally complex, and has sent shock waves through the mathematics community. Entirely new areas of mathematics have been opened up by this theory. Unfortunately, at present no one is smart enough to solve the problem of a quantum black hole. As Edward Witten of the Institute for Advanced Study at Princeton has claimed, “String theory is 21st century physics that fell accidentally into the 20th century.” However, 21st century mathematics necessary to solve quantum black holes has not yet been discovered! However, since the stakes are so high, that hasn’t stopped teams of enterprising physicists from trying to solve superstring theory. Already, over 5,000 papers have been written on the subject. As Nobel laureate Steve Weinberg said, “how can anyone expect that many of the brightest young theorists would not work on it?” Progress has been slow but steady. Last year, a significant breakthrough was announced. Several groups of physicists independently announced that string theory can completely solve the problem of a quantum black hole. (However, the calculation was so fiendishly difficult it could only be performed in two, not 10, dimensions.) So that’s where we stand today. Many physicists now feel that it’s only a matter of time before some enterprising physicist completely cracks this ticklish problem. The equations, although difficult, are well-defined. So until then, it’s still a bit premature to buy tickets to the nearest wormhole to visit the next galaxy or hunt dinosaurs!