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Move Over, Black Holes

Here Come Those Curious Cosmic Strings

When first confronted in the 1930's with the startling notion of stars contracting into black holes, Sir Arthur Eddington was quick to respond. There should be a law of nature, the noted astrophysicist declared, to prevent stars from behaving in such absurd ways. But as it turns out, black holes are hardly the strangest entity postulated to exist in the heavens.

Astronomy's latest theoretical plaything, cosmic strings, would surely have left Eddington speechless. Cosmic strings are conceived as infinitesimal cracks or flaws in space-time—bits of the original Big Bang fireball frozen in place during the rapid expansion and cooling of the universe in the first few instants of its existence. These threads of intense energy might be spread, like an unraveled skein of yarn, throughout the length and breadth of the cosmos. And they would be enormously massive, with a gravitational pull that perhaps attracted matter together to form galaxies and that might today still act as gravitational lenses that alter the path of passing light. Clearly, cosmic strings, if they exist, are very different from any other beast in the celestial menagerie.

Although it now seems likely that black holes reside at the center of every galaxy, it took many years for astronomers to fully accept the possibility of their existence. Cosmic strings will likewise require rigorous observational proof before they are considered anything more than a madcap theoretical fantasy. The exotic filaments haven't even garnered a separate listing in scientific indexes and are often confused with superstrings—a very different theoretical entity devised in an attempt to unify the basic forces of matter.

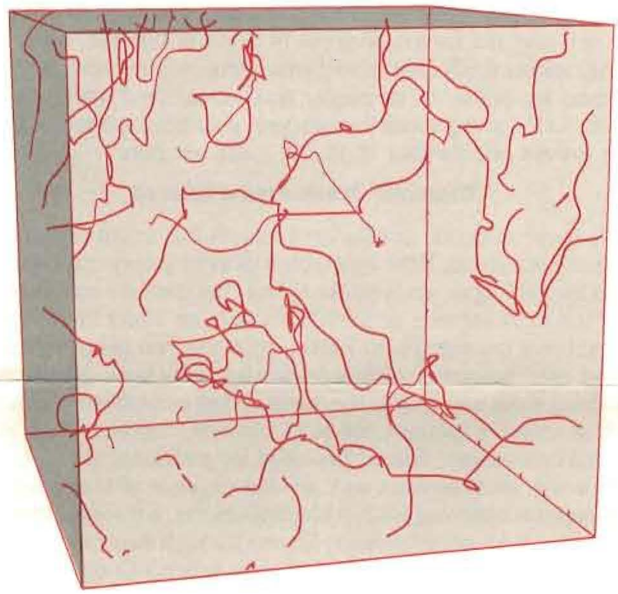
Convenient Solutions to Cosmic Mysteries

Yet, an ever-increasing number of physicists and astronomers are becoming quite enamored with cosmic strings: they might prove—as black holes once did—convenient solutions to a host of nagging cosmological mysteries.

The idea of a cosmic string originated in the 1970s as theorists began to contemplate how their latest particle physics theories might affect our understanding of the universe's birth, which occurred some 15 billion years ago in that primordial explosion playfully dubbed the Big Bang. Tom Kibble of the Imperial College in London was particularly interested in the first few moments of creation, when temperatures in the primeval plasma dropped below 1,000 trillion trillion degrees. This is the moment in which three of nature's major forces, joined as one during a fleeting period of "grand unification," began to assume their separate identities, now known as electromagnetism and the strong and weak nuclear forces.

Physicists like to visualize this process as a sort of "crystallization," but it was likely a flawed congealing. Just as water freezing into ice can develop imperfections, the newborn cosmos, too, could have generated some defects as it cooled and expanded outward. Kibble postulated in 1976 that slender strands of highly concentrated mass-energy—remnants of the original fireball—could have endured, weaving a network of cracks in the topology of space-time that survive to this day.

Physicists envision two configurations for cosmic strings. Some of the strands, though tangled and curled, would be virtually endless, stretching across the visible universe. But kinks in the long strings could also pinch off to produce a multitude of closed loops in assorted lengths—from microscopic to astronomic, rings hundreds of thousand of light-years around. It's estimated that the average distance between large loops today is about 300 million light-years.



Computer simulations of cosmic strings in an evolving universe. Strings may have shaped the large scale structure of the universe, pulling together matter into clumps that became galaxies.

More compelling is a string's off-beat characteristics, which have been called particle physics' most entertaining contribution to cosmology. "Black holes are mild by comparison," exclaims Neil Turok of the Fermi National Accelerator Laboratory and a protege of Kibble's.

A cosmic string would certainly be the thinnest structure in the known universe; its calculated width is 100,000,000,000,000,000 times smaller than an atomic particle. To put it another way, if an atom were blown up to the size of our solar system, a cosmic string would still be no thicker than a virus. Yet, each and every centimeter of this stringy stuff would weigh billions of tons. "Several miles of string would outweigh the Earth," notes Fermilab theorist Andreas Albrecht.

Vibrating Away Gravity Waves

And each string would be terribly restless, moving through space at near-light speeds. Moreover, the loops would vibrate wildly and consequently decay away by emitting a steady stream of gravity waves, actual ripples in space-time. The smaller the loop, the quicker its disappearance. "But the long strings just chop off more loops," notes Turk, "to maintain a steady supply."

One way to check for string-produced gravity fluctuations is to monitor the fastest spinning neutron stars. Called millisecond pulsars, they emit blips of radio energy, with amazing precision, hundreds of times each second. "The gravity waves should cause the pulsar to either speed up or slow down very slightly," says Turok. Astronomers are maintaining a close surveillance.

Space would be so distorted near a string that if you circled completely around a tube of string, you would travel less than 360 degrees, as if a wedge of space had been mysteriously cut out. But you may not be too desirous to perform this act. While a string, anorectically thin, could whiz through your body without bumping into one atom, its intense gravitational field would wreak havoc: As the string sliced through you, your head and feet would rush toward one another at 10,000 miles per hour.

Dramatic Gravitational Effects

It's these dramatic gravitational effects that could reveal the presence of a string. If the light from a faraway galaxy or quasar were to come upon an invisible string, the photons would get diverted to either side of the obstruction, an effect known as gravitational lensing. From Earth, we'd see two objects instead of just one. A number of double quasars have been discovered, but string is not necessarily the cause. Other celestial obstacles, such as massive galaxies and large clusters, can also act a as gravitational lenses; hence, the need for additional tests.

Although most astronomers are not eager to devote precious telescope time hunting for hypothetical objects, a few systematic string searches are underway. Sifting through maps of the sky photographed at Steward Observatory in Arizona, Craig Hogan is on the lookout for a particular pattern. "A chain of galaxy pairs across the sky would be a strong signature of a string," he says.

Interest is also being focused on four sets of twin galaxies—nestled close together in an extraordinary grouping—sighted by two University of Hawaii astronomers (see *Science Impact*, July, 1987). A big convoluted string loop, situated a billion light-years out twixt Earth and the galaxies, could conceivably have split each galaxy's image in two.

More evidence would come by examining the microwave background around a candidate string. (These microwaves, which bathe the entire universe, are the residual heat left over from the Big Bang.) "There would be a jump in temperature across the string," explains Turok. "On one side the microwave radiation would be slightly hotter than on the other side."

Cosmic-string experts are hardly unquestioning converts. Albrecht, for one, maintains a healthy skepticism when dealing with the fanciful object. But all are agreed that the idea is well worth pursuing. Theories on grand unification, that moment in the early universe when nature's forces were identical, cannot be directly tested with current technologies. Finding a string may be the only way to prove such conjectures.

Causing Galaxies To Form

Most exciting to string devotees is the ability of the strand to solve one of astronomy's longstanding puzzles: how galaxies formed. It's well established that the Big Bang disgorged a very smooth ocean of plasma. So, how did the universe get so clumpy over time? Current galaxy-formation models are fraught with problems; string, on the other hand, can handle the job with comparative ease.

Tufts University physicist Alexander Vilenkin was one other first to suggest that stringy loops of the proper size, abut 100 light-years wide, could have attracted vast assemblages of matter around themselves in the early universe, serving as the seeds of future galaxies.

Slowly shrinking as it oscillates and releases gravitational energy, each string would eventually vanish, leaving a galaxy behind as its calling card. At the same time, larger loops could have corralled clusters of galaxies. And lastly, long strings, briskly racing through the primeval soup, could have set the stage for future superclusters.

A new twist to this scenario was recently added by Edward Witten and two of his colleagues at Princeton University. Witten figures that cosmic strings might also be superconducting. Sitting in a primordial magnetic field, a newborn string could start an immense current, perhaps as much as a hundred million trillion amperes, endlessly flowing within it. Flopping around like a rubber band, this superconducting string would emit overwhelming amounts of electromagnetic radiation, which pushes on the surrounding plasma and scours out bubbles of space. In this way, matter would get swept up into the walls of the bubbles. Recent maps of the universe do tend to exhibit a sort of frothiness, with galaxies arranged in sheets and bubble-like structures. Could string be the reason?

"Strings are so unusual," says Vilenkin, "that we're always trying to connect them to phenomena equally as unusual." Vilenkin and George Field of the Harvard-Smithsonian Center for Astrophysics, for instance, have suggested that a superconducting string loop, vigorously oscillating in the heart of a quasar, might be generating the jets of energy spewing from the bright young galaxies. Others have wondered whether gamma-ray bursts, mysterious events that sporadically pop off in the sky, have a similar origin.

Of course, such speculations can be carried too far. Black holes were once blamed for every quirk in the heavens. Turok and others doubt that cosmic strings would be superconducting at all. "Most of these models will probably turn out to be wrong," admits Vilenkin. He and others continue to speculate, however, because "it is curiosity that drives us."

Like black holes before them, the tantalizing tendrils offer myriad and fascinating possibilities. If found to be real, string would bring cosmologists closer to a complete understanding of our cosmic beginnings. And black holes would have to give up their title as nature's most bizarre concoctions.

UPDATE

Progress on AIDS Drugs. Medical scientists have found a drug that shows promise of combating a form of pneumonia that attacks many AIDS sufferers. The drug, pentamidine isethionate, is not new, but its toxicity when injected into patients had discouraged many doctors. Now two research groups in New York and San Francisco have shown that the drug works better and is far less toxic when patients inhale it directly into their lungs in aerosol form.

A second drug, fusidic acid, has entered clinical trials in several countries after a Danish doctor tried it—almost as a last resort—on an AIDS patient who also had tuberculosis. The patient got better. Preliminary research at a British research center seems to show that the drug, normally used against bacteria, inhibits the AIDS virus from reproducing.

Clinical trials have also begun in California for a third compound, peptide T, that seems in laboratory tests to inhibit the AIDS virus from entering human cells (*Science Impact*, June, 1987). Although early research with peptide T generated a lot of controversy, the Food and Drug Administration recently approved human trials with the compound.