miss the distant mountains, physicists may find their theories, formulated for only a small, well-behaved piece of space-time, may not work on a larger scale.

Another striking feature of these exotic four-dimensional spaces is that they appear to become extremely complicated at great distances and infinitely complex at infinity. In other words, complexity increases as the scale increases. Such a picture may apply to the distribution of matter in the universe.

Indeed, as astronomers study the universe on larger and larger scales, some see hints that the distribution of galaxies and interstellar matter doesn't seem to even out. They detect evidence for irregular arrangements of giant structures, punctuated by large gaps, as far as the aided eye can probe. Astronomer R. Brent Tully of the University of Hawaii in Honolulu, in mapping the distribution of galactic clusters at cosmological distances, proposes that the local supercluster of galaxies in which our Milky Way galaxy resides is actually part of what he calls the Pisces-Cetus complex, a gargantuan grouping of superclusters extending more than a billion light-years.

But Tully's observations lie at the limit of observational work in astronomy, making measurements tough to interpret. It's also difficult to imagine how such an immense, irregularly distributed collection of galaxies could have formed through gravitational effects in the comparatively brief time available since the Big Bang.

Nevertheless, one might expect a universe like the one Tully sees — becoming increasingly convoluted and contorted as more distant regions are explored — if it were embedded in an exotic four-dimensional space rather than a space of the conventional Euclidean variety.

Mathematicians, too, are puzzled by what all this means. Four-dimensional space is indeed strange, with many mysteries yet awaiting solution. For instance, picturing exotic four-dimensional spaces, or four-spaces, remains a problem. "We know these exotic four-spaces exist, but we don't know how to construct them explicitly," Kirby says. "In a sense, they are extremely convoluted. You wouldn't want to do your several-variable calculus homework on such an exotic four-space."

Furthermore, mathematicians have not finished the task of classifying smooth, compact four-manifolds. These researchers have two different pictures of four-manifolds — one in terms of a construction procedure and the other in terms of Donaldson's mysterious invariants. But they haven't yet succeeded in bridging the gap between the two.

"The classification problem is wide open for smooth manifolds," Morgan says. "We now know that it's a very complicated, intricate and delicate classification, but we have no idea even of its general outline."

The methods used for studying four-manifolds also may have far-reaching consequences. Paradoxically, they show that the study of space in five and higher dimensions is simpler and easier to understand than is the study of space in three and four dimensions.

There seems to be a need for new and fundamental insights to aid in understanding four-manifolds. Donaldson's work in particular rests upon deep connections between mathematics and physics. "Nobody knows yet the full power of what Donaldson has done," Taubes says. "We really don't know what's missing."

Perhaps further progress will follow more exchanges between physics and mathematics. Recent work linking quantum field theories and knot theory may be a step in the right direction (SN: 3/18/89, p.174).

"It's a very exciting corner of mathematics," says Ronald J. Stern of the University of Utah in Salt Lake City. "There's a lot going on, and the dust has yet to settle."

"Dimension four is a bizarre dimension," Morgan adds. "But we're beginning to get used to it now." □

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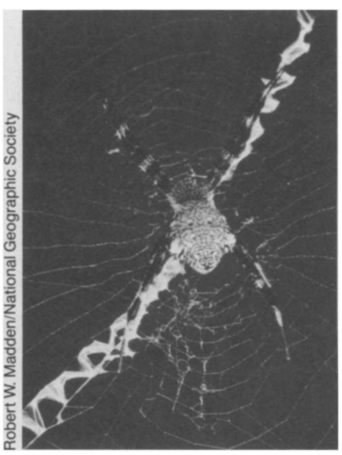
Spider webs: Luring light may be a trap

In the first studies of the spectral properties of spider silks, researchers have found that some of these silks reflect ultraviolet (UV) light and that this property lures insects to the webs, says coauthor Catherine L. Craig, evolutionary ecologist at Yale University in New Haven, Conn.

The work "provides an unexpected new insight into the factors that shape the evolution of spider web design," says biologist Stephen Nowicki of Duke University in Durham, N.C. Comparing webs from evolutionarily early and later species, the scientists found that the optical properties of spider webs change with the evolution of the web, Craig says.

In contrast to the traditional view of spiders as passive foragers, the studies also show that "spiders are doing more than we imagined to increase their probability of capturing prey," Nowicki says. Unlike humans, insects can see ultraviolet light and are known to use this sense to locate UV-reflecting flowers and liquids, which may be important food resources or mating sites, Craig explains. But, until now, no one realized that spiders' webs have UV-reflecting properties that turn their prey's UV-detecting ability into a liability — for the insect.

Craig and Gary D. Bernard at the Yale University School of Medicine studied the spectral properties of silks from different spider species by directing a monochromatic beam of light at the silk and measuring the relative amounts of the colors reflected back. They found that the silks from the earliest "ancestral" spiders, which spin silks for only domestic purposes such as lining burrows and covering eggs, selectively reflect ultraviolet light and that the prey-capturing silks of the more recently evolved primitive aerial web weavers, *Uloborus glomosus,* have an even more enhanced UV-reflectance peak.


Robert W. Madden/National Geographic Society

Spider on its web with UV-reflecting designs.

When drosophila fruit flies were given a choice between a *glomosus* web illuminated with white light containing a UV component and one brightened with non-UV-containing light, the majority flew to the ultraviolet-reflecting web. This work indicates that although UV reflectance in spider silk did not evolve for the purpose of capturing prey, its prey-luring advantage seems to have caused natural selection to preserve and enhance the property, Craig told SCIENCE NEWS.

When the researchers looked at the catching silks of the more recently derived garden spider, *Argiope argentata,* they found that the main portions of these webs do not reflect ultraviolet light, but that the decorations added to their webs do. They then discovered that, in nature, decorated webs capture 58 percent more insects than do undecorated webs, suggesting a novel, prey-attracting function for the designs.

Although other scientists have proposed mechanical functions for the designs and recent data from Nowicki and his team suggest that the features function to warn birds of a web's presence, "the strongest point about our hypothesis is that it applies to all situations where you find these [decorative] structures," Craig says. The new studies are scheduled to appear in a forthcoming issue of ECOLOGY. *— I. Wickelgren*