They trigger the formation of galaxies. The gravitational field of cosmic string is a little strange, as the tension along it cancels some ordinary gravitational effects. A straight string, or a piece of a loop so close as to amount to the same thing, will not attract nearby objects, it merely deflects their trajectories to the side. However, for objects far enough from a loop that they see it whole, so to speak, the ordinary sort of gravitational attraction occurs.

Thus, strings moving through space can collect assemblages of matter surrounding them, but residing at some distance from them. These assemblages could become the star-forming disks of galaxies. Meanwhile, the loops would be slowed by the drag of the assembling matter to a point where they could assemble second collections of matter much closer to themselves. These second agglomerations could become the dense, energetic centers of galaxies. The string loops would eventually disappear but they would leave behind galaxies.

Could there be string in the universe today? Vilenkin says only the largest loops at the time of formation could survive until now. String's ability to bend trajectories of light beams could make its presence apparent by a gravitational lens effect, producing several images of a single object. Five examples of gravitational lens effect are known, in the form of double images of quasars. This does not prove the existence of cosmic string, as galaxies and black holes can also produce this effect. Vilenkin suggests looking for lines of double images of galaxies, tracing out the extent of a string. Another test might be the observation of strong gravitational radiation from no visible source, but that has to wait until gravitational radiation is detected.

Finally the question of what happens to human beings near strings. Vilenkin says the head and feet of such a person would move toward each other at a speed of 10 kilometers a second, "which is unhealthy. So avoid these things if you possibly can."

—D.E. Thomsen

Ozone and light accelerate corrosion

The corrosive effects of sulfur-containing atmospheric pollutants, such as hydrogen sulfide (H_2S), are well known. But the magnitude of their impact on the environment now appears to be a function of the company they keep, according to new research by three chemists at AT&T Bell Laboratories in Murray Hill, N.J. The scientists have shown that the ability of these compounds to corrode copper, for instance — forming copper sulfide — can be doubled when exposure to them occurs in the presence of sunlight, and tripled if exposure to the gases occurs in the presence of ozone. Of course, it is virtually impossible to avoid exposure to either or both of these corrosion enhancers.

"The thing that is a little puzzling," notes Thomas Graedel, one of the experimenters, "is that when we have them both at once, we don't see an additive effect" — that is, a quintupling in corrosion. Instead, he says, "we see an effect that's about equal to what we see with the ozone by itself. That suggests to us that there's some process that limits the amount of corrosion that can occur."

Levels of H_2S and ozone used in their experiments were high but within the range of recorded values for polluted regions. The researchers chose these levels to speed up their results since earlier work had shown that lower concentrations over longer exposure periods would ultimately produce comparable corrosion.

Ozone is a potent oxidizer, that is, it readily enters into chemical reactions that involve the exchange of electrons. What's not clear, the researchers say, is whether the corrosion enhancement they witnessed with ozone was due to that chemical or reactive products, such as hydroxyl radicals (OH), that form when ozone reacts with water. "Corrosive processes are very much less efficient where it is dry," notes Graedel. And except where it is extremely dry, metal surfaces in the environment tend to be covered with a thin film of water.

Graedel says "reaction centers" appear to develop within this liquid film; it is here the reactive chemicals combine. These "may not end up being the sites that are corroded," he explains, "but sites that contemporarily grab molecules and assist in their transformation."

In a report of their work in the May 11 SCIENCE, the researchers speculate that ozone may also contribute to the development of structural defects in the metal's surface that somehow enhance the diffusion of copper ions up from the solid metal to these reaction sites. However, though they have studied the surface with electron microscopy, they still haven't identified the suspected defects.

They also found indications that the corrosion rate was limited by the rate at which copper ions could free themselves from the metal surface and diffuse to the reaction centers. If the ozone-mediated reactions that produce copper sulfide were already tapping copper ions as fast as they became free, that might explain, Graedel says, why the double whammy posed by light and ozone is no worse than exposure to ozone alone.

The AT&T researchers believe that if ozone and sunlight can enhance corrosion, other reactive oxidants probably can too. By characterizing exactly how they do this, the chemists hope eventually to be able to tailor more protective coatings for easily corroded metal surfaces. But Graedel admits, "it's too early in the game to do that now."

—J. Raloff