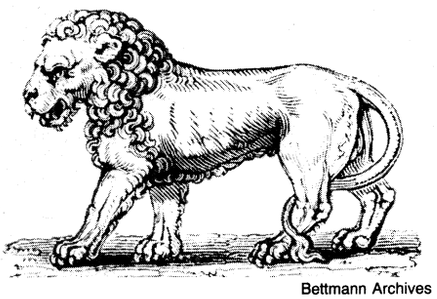
A Cosmic String in Leo?

A new gravitation lens system may be evidence for an ultramassive cosmic string winding from one side of the universe to the other



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ASTRONOMERS have discovered that a pair of previously known quasars are actually two different images of the *same* quasar, thereby revealing an extraordinary gravitational lens and an equally extraordinary concentration of mass in the universe.

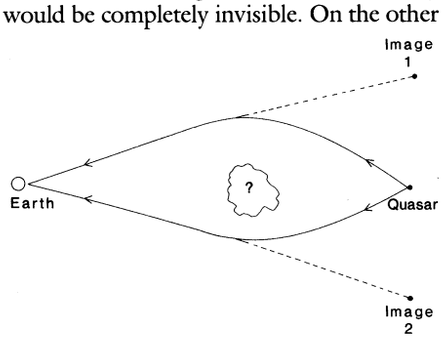
"It's entirely astonishing," says Edwin L. Turner of Princeton University, leader of the team that made the discovery. The two images are separated by 157 seconds of arc, more than 20 times larger than any gravitational lens previously reported. Moreover, the mass required to deflect the quasar's light to such an extent is on the order of 10^{15} times the mass of the sun, or roughly the mass of a supercluster of galaxies—and yet, in the region between the images where the lensing object would normally lie, no such supercluster has been seen. Cosmologists are therefore excited: this kind of anomalous lensing effect is exactly what is expected from a much hypothesized, but never detected, phenomenon known as cosmic string.

The two quasar images, known as 1146+111 B and C, lie in the constellation Leo not far from its border with Virgo. This patch of sky first drew attention in 1979, when Halton Arp of the Mount Wilson and Las Campanas Observatories and several colleagues noticed a striking concentration of quasars—nine—lying within a few arc minutes of each other. Indeed, they noticed that the quasars B and C in the group had identical redshifts of 1.01. However, they dismissed the possibility that these were a pair of gravitational lens images because the separation seemed implausibly large.

In late 1985, however, Princeton's Bohdan Paczyński again called attention to these quasars, along with four other pairs elsewhere in the sky, as possible examples of gravitational lensing by cosmic strings.

Cosmic strings—which are very different from the "superstrings" recently proposed as a fundamental theory of elementary particles—are threads of energy predicted in certain grand unified field theories of particle physics. They would be infinitesimally thin, about 10^{-30} centimeter; enormously massive, about 10^{22} grams per centimeter; and exceedingly taut, with about 10^{42} dynes of tension. Thus, only infinite strings and closed loops of string are possible. A string with two ends would quickly snap to a point and disappear.

If such theories actually do describe nature, then the strings would have been produced abundantly in the Big Bang. Indeed, many cosmologists now think that the closed loops of string may have formed gravitational "seeds" for collecting ordinary matter into galaxies in the early universe. The infinite strings would be much less common. And being so thin, of course, they would be completely invisible. On the other hand, being so massive they would produce detectable gravitational effects. In fact, calculations show that a straight section of string crossing between us and a distant quasar would produce a gravitational lens effect with large separations between images, perhaps as much as 6 minutes of arc.



Where is the lens?

A massive object lying between Earth and a distant quasar will deflect the quasar's light in much the same way that a lens will. As a result, astronomers see the quasar split into two or more images. In this case, however, the wide separation of the images implies a very massive lensing object. Where is it?

Thus the interest in 1146+111 B and C, which are separated by 2.6 minutes of arc. Acting on Paczyński's suggestion, Turner and his team observed the quasar pair on the nights of 6 and 7 March, using the 4-meter Mayall telescope at Kitt Peak National Observatory. They verified that the redshifts are indeed identical and, even more important, that the spectra are virtually the same. Since quasar spectra tend to be as individual as fingerprints, this makes it almost certain that the two quasars are actually two images of the same object. "It's not logically irrefutable," says Turner, "but evidence is as good as, or better than, what we have for other lenses."

The obvious question now is the nature of the lensing object. Astronomers all over the world have rushed to investigate. As Turner himself says, "I've hardly done anything else since March." The most conventional explanation, for example, is that the quasar is in fact being lensed by a very distant supercluster. Since any such cluster would obviously have to be closer than the quasar, it should easily be detectable with optical telescopes using longer exposure times.

If no cluster is detected, then more exotic possibilities have to be considered—a 10^{15} solar mass black hole, for example. Such an object would cause a "dropout" in the 2.7-K cosmic background radiation, which should be detectable with the Very Large Array of radio telescopes in New Mexico. However, a 10^{15} solar mass black hole would also be roughly a million times more massive than the black holes postulated for the interiors of quasars themselves. It is hard to imagine where such a monster could have come from.

And finally, of course, there is cosmic string. Since a string by its very nature would stretch across the sky in a more-or-less straight line, astronomers should be able to trace its path by finding other widely separated quasar images. None of the other quasars in the 1146+111 field itself are paired, since they all have different redshifts. But some of them may have much fainter companion images; a search for those is already under way. "The way those images line up will have a significant impact on what we think the lensing object is," says Turner. A string would also be detectable as a subtle discontinuity in the 2.7 K cosmic background, with the temperature of the radiation slightly elevated on one side of the string and slightly lowered on the other. ■

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ADDITIONAL READING

Edwin L. Turner *et al.*, "An apparent gravitational lens with an image separation of 2.6 arc minutes," *Nature (London)* **321**, 142 (1986).

Bohdan Paczyński, "Will cosmic strings be discovered using the Space Telescope?" *Nature (London)* **319**, 567 (1986).