Ring Around the Galaxy

Polar-ring galaxies may help add pieces to the dark-matter puzzle

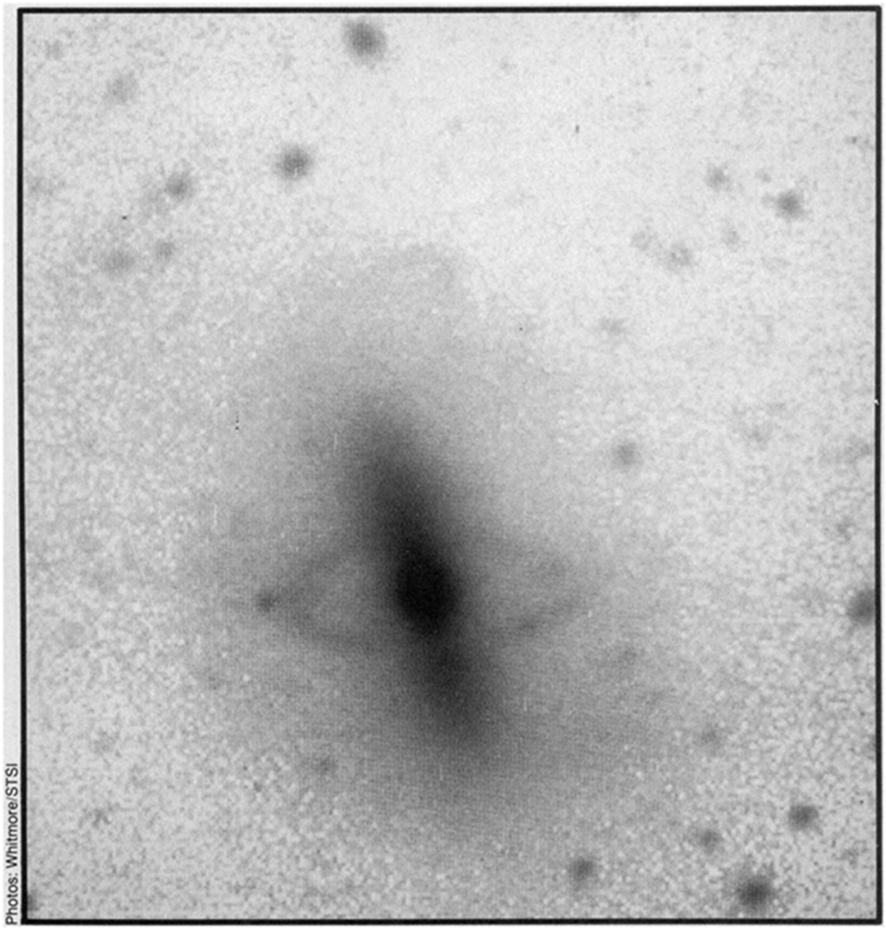
By KAREN HARTLEY

Following billions of years of development, the universe has given birth to and reared a good cross-section of galactic residents. Without the aid of a planning commission, it has managed to fill itself with ellipticals, pepper itself with spirals and even find room to scatter around a few peculiars.

Among the more intriguing peculiars—galaxies that don't fit into standard classifications — are polar-ring galaxies. Named for the ring of stars, gas and dust that encircles their central core at an angle nearly perpendicular to the core's rotational plane, these galaxies are sprinkled throughout the universe, usually clustered with two or three other galaxy types.

A few have been known since about 1940, when scientists took spectra to try to measure their rotation. But it has been only in the past few years that polar-ring galaxies have been studied for such factors as their odd geometry, their distribution of dark matter and their apparent formation from a merger or mass transfer of two galaxies.

One of the first polar-ring galaxies to be studied closely has been NGC 2685, called a spindle galaxy for its distinct spindle-shaped core. That galaxy earned the reputation in *The Hubble Atlas of Galaxies* as being "perhaps the most unusual galaxy in the *Shapley-Ames catalogue.*" Paul L. Schechter of the Mount Wilson and Las Campanas Observatories in Pasadena, Calif., and James E. Gunn of Princeton (N.J.) University studied this galaxy back in 1978. "But what is interesting," Schechter says, "is that there has recently been a succession of other galaxies that show signs of [polar rings]."



Photos: Whitmore/STSI

Negative image of polar-ring galaxy ESO 415-G26. The disk of the galaxy is tilted nearly edge-on and appears as a dark vertical band with a prominent nucleus. A narrow ring of stars, dust and gas circles the galaxy nearly at a right angle to the disk, and a diffuse halo of what may be stellar debris extends far beyond the main body of the galaxy.

So far, astronomers have identified seven definite examples of polar-ring galaxies, Schechter says, and another 15 good candidates. A polar-ring galaxy actually is a member of the S0 class of galaxies — a cross between a spiral and an elliptical, with mostly old stars and very little gas—surrounded by a circle of stars, gas and dust. This ring, usually positioned at about a 90° angle to the central galaxy, has led some observers to believe that the galaxies spring from mergers between two galactic wanderers.

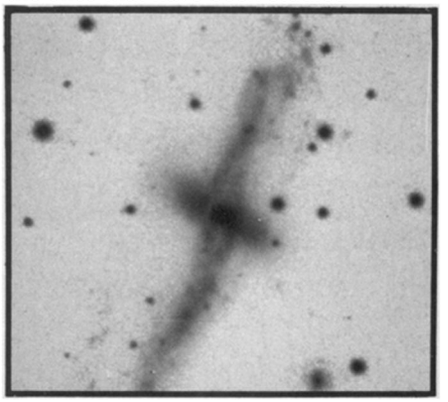
To make a polar-ring galaxy, says Bradley C. Whitmore of the Space Telescope Science Institute in Baltimore, the incoming galaxy must approach its companion slowly enough to be captured, must come in at about a 90° angle and must hit center-on. "I think that's the reason polar rings are relatively rare," he says. If the invading galaxy doesn't come in at a 90° angle, the ring may gradually fall into the central galaxy, he explains.

Whitmore and Douglas B. McElroy, of the Space Telescope Science Institute in Baltimore, are now cataloguing the polar-ring galaxies and classifying them based on the shape and definition of the ring and its size as compared to that of the central galaxy.

So far, they say, they have established three broad categories: the Saturn type, which looks like the planet Saturn and has a small ring about the same size as the central component; the sombrero type, with floppy rings that extend far beyond

the galaxy; and the spindle type, which has a large central component and small outer ring.

These galaxies also seem to vary in age. Younger, chaotic ring structures, says Schechter, are 1 or 2 galactic years old (a galactic year being one rotation of the galaxy), ranging anywhere from 100 million to 200 million years. The older ones are some 40 or 50 galactic years old, he says, and seem to make up about half the ones that have been studied.



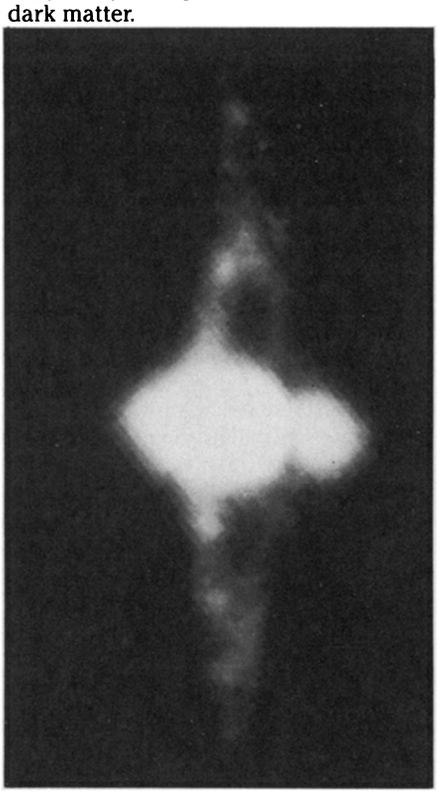
Polar-ring galaxy NGC 4650A has a central spindle of old stars and a nearly edge-on ring of gas, dust and young stars that extends above and below the disk. Astronomers think this galaxy was produced by a merger with or mass transfer from another galaxy.

Recently, Whitmore, McElroy and François Schweizer of the Carnegie Institution of Washington (D.C.) studied polar-ring galaxies to determine the distribution of "dark matter" in and around them. Using the 4-meter telescope at Cerro Tololo Inter-American Observatory in Chile, the three looked at two galaxies: NGC 4650A in the outskirts of the Centaurus cluster and ESO 415-G26 in the constellation Fornax. Both are in the Southern Hemisphere.

Normally, astronomers measure the distribution of matter in spiral galaxies by observing the rotational velocities in the disks. If all the mass were located in the core, the stars at the outskirts of the disk would rotate more slowly than those at the center. But repeated experiments show that in most galaxies, the rotation rate continues fairly constant to a point beyond where the visible matter ends. This leads astronomers to believe that there is an abundance of the so-called dark matter or "missing mass" that makes up nearly 90 percent of the universe (SN: 11/16/85, p.316). But because the dark matter is usually measured only in the disks of galaxies, astronomers don't know whether it is confined to a disk-shaped distribution or is situated above and below the galaxy as well.

Polar-ring galaxies provide a way to measure that. Because they have a ring of gas and dust surrounding the central galaxy, astronomers can look above and below the galaxy to see how dark matter is distributed. "The beauty of the polar ring is that its orbit is out of the plane of the galaxy," Schechter says. "It's a lucky break that you have an object with circular objects in two planes."

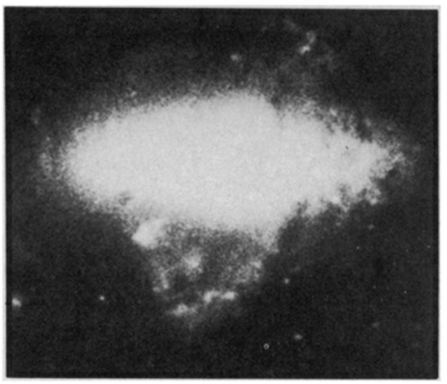
By measuring the rotation of the ring, Whitmore and his colleagues believe they have found that dark matter is not confined to the plane of the galaxy, but instead is spherically distributed around the galaxy as well. The experiment, described in the March 15 ASTROPHYSICAL JOURNAL, compared rotational velocities in the polar rings and the S0 disks, and showed that they were about the same at equal distances from the center, thus suggesting the spherical distribution of dark matter.



Regular appearance and lack of tidal debris lead researchers to believe that polar-ring galaxy A0136-0801 is one of the oldest galaxies they have looked at.

Whether that distribution is unique to polar-ring galaxies or can be generalized to other types of galaxies, such as spirals and ellipticals, is open to question. "It's difficult to generalize from the two to three cases we have," McElroy says. Currently, though, polar-ring galaxies are about the only place where such a measurement can be made.

"It's like searching for the key to the door under the lamp," Schechter says. "You ask, 'Why do you look there?' and the answer is 'Well, that's where the light is.' " Another light may be available, he says, when the Advanced X-Ray Astrophysics Facility (still awaiting federal funding) is put into service to observe the X-ray halos thought to encircle many elliptical galaxies.



NGC 2685, one of the first polar-ring galaxies studied, was first noted for its spindle-shaped interior.

Finding the dark matter spherically shaped around polar-ring galaxies helps provide some constraints on theories of how galaxies in general form, Whitmore says. And, says Schechter, it could support the idea that many galaxies are the product of mergers. McElroy agrees: "This does bolster the theory that mergers do play an important role in some galaxies, but how much of a role and how important a role" is still undetermined.

In another study, Schechter and Jerome Kristian, also of the Mount Wilson and Las Campanas Observatories, and J.H. van Gorkom of the National Radio Astronomy Observatory in Socorro, N.M., found other evidence to support the idea that polar-ring galaxies are the result of mergers. "If you have a merger, what you expect is a roughly spherical stellar debris and gaseous debris, which should settle into a ring or a disk," he says. In some polar-ring galaxies, though, all that can be seen is a well-structured ring without any sign of chaos. In the case of one of the galaxies Schechter studied, he says, "it's still chaotic." Neither the gas nor the stars have settled into their ultimate configuration, so the evidence of a possible merger is still visible.

Although polar-ring galaxies are intriguing, they haven't attracted much attention from the astronomy community. "There are so few of them and it's such a hard game working with them because they're so faint," Schechter says. Yet they have the potential for revealing much about dark-matter distribution and galactic mergers, he says. "I take them as being signposts indicative of what's going on. These are particular cases of mergers where [the merging galaxies] have been hung up in an odd shape where we can see what's happened. It's an auto wreck that hasn't been cleared from the road."□

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