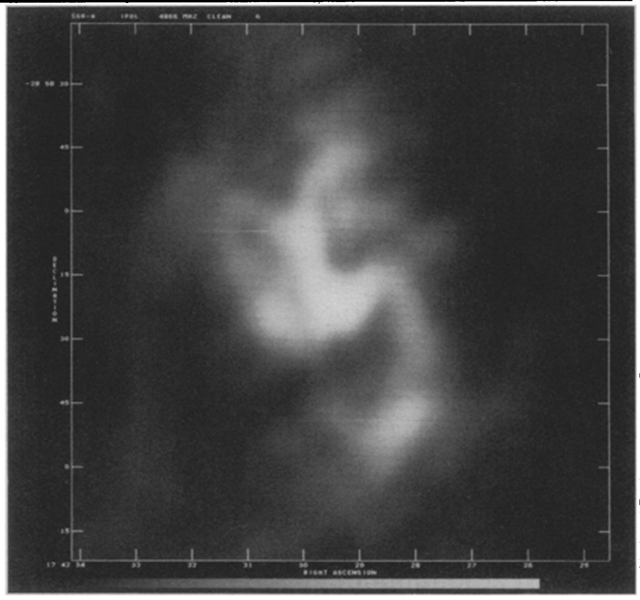
No more Milquetoast Milky Way: Is there a quasar in our future?



Radio picture of the center of our galaxy illustrates that the thickest regions of radio-emitting ionized gas are found in a region of S-shaped symmetry at the center.

National Radio Astronomy Observatory

In recent decades astronomers have gotten used to seeing many examples of spectacular astrophysical fireworks in places far removed from us — quasars, Seyfert galaxies, "active" galaxies of various kinds. Theorists have more and more tended to attribute the extremely high energy outputs of such objects to the action of supermassive black holes in their centers. By contrast our own galaxy has been regarded as fairly quiet, not to say a little dowdy.

That view is now changing. As a seminar at this week's meeting in Washington, D.C., of the American Physical Society showed, recent observations of the center of the galaxy using several ranges of the electromagnetic spectrum seem to show that our Milky Way is not quite the milquetoast it may have been made out to be in the past. Opinion seems to be converging on the notion that there is some kind of "exotic" object there, possibly a mediomassive black hole. According to at least one theoretical formulation, if there is a black hole of at least a certain size there, it could grow until, in some distant future, our Milky Way becomes a quasar.

The center of the galaxy is not visible to us in ordinary light. Large clouds of dust surrounding it absorb its light. However, the dust is heated by this absorption, and the dust in turn radiates infrared. Measuring this infrared, which does reach earth, can develop information about the luminosity of the center. According to Ian Gatley of the United Kingdom Infrared Telescope in Hawaii, the luminosity in the center is about 10 million to 30 million times the total luminosity of the sun. This is the luminosity within one parsec of distance around the center (which is located in the constellation Sagittarius). Some of this comes from ordinary stars that are known to be there, but most, Gatley says, may originate in a compact "exotic" source concentrated at the center, the same source of energy that is ionizing gas there. According to ordinary astrophysical theory, the most likely source of so much energy in so little space is the conversion of gravitational energy of matter falling into a black hole.

The ionized gas, presumably spiraling in a magnetic field, gives off a type of radio known as synchrotron radiation, which can be received by radiotelescopes on earth. The Very Large Array radiotelescope in New Mexico made a study of the galactic center, which was reported by Robert L. Brown of the National Radio Astronomy Observatory. The thickest regions of this radio-emitting gas are found in a region of S-shaped symmetry around the center (see illustration). Such a pattern could arise if a rotating body were shooting out material in narrow jets in opposite directions.

In fact, the picture that arises from reasoning about these observations is similar to a model developed for quasars and Seyfert galaxies (particularly by Roger Blandford of California Institute of Technology and Richard Lovelace of Cornell University): In the center is a rotating black hole. The gravitational attraction of the black hole draws matter from the neighborhood. The rotation makes this matter form a so-called accretion disk in the equatorial plane of the black hole. Some material from the inner edge of the disk is continually falling into the black hole, but other material there gets caught in twisting electric and magnetic fields that shoot it in oppositely directed jets more or less along the rotation axis of the black hole. This model has recently been applied also to the starlike object SS433 located within our galaxy. Brown says he thinks SS433 and the galactic center are the same kind of object. However, there is a sizable body of astronomical opinion that holds that the center of SS433 is a neutron star, not a black hole.

An accretion disk such as this model contains is a good place to produce gamma rays, and the center emits both a continuous spectrum of gamma rays and a bright, sharply defined line at the specific energy of 511,000 electron-volts. Gamma ray observations of the center are the work of at least 19 scientists from six institutions, who were represented at the meeting by Marvin Leventhal of Bell Labs. Friction in the disk could produce the continuum gamma rays. The 511,000-electron-volt line is exactly the energy of gamma rays produced in the annihilation of electrons and positrons. Since positrons do not exist naturally in our galaxy, the object at the center has to be energetic enough to produce a large flux of them. (Incidentally, SS433 does not produce the annihilation radiation.) Both the continuum and the line gamma ray brightness of the galactic center vary greatly over a period of about six months. This means that the object producing them can be no larger than six light months across, quite small in galactic terms. (For an object to change overall, all of its parts have to be in communication with each other, and that means it can be no larger than the distance light can go in the time it takes to complete the change.)

The possibilities are summed up by the theorist Richard Lingenfelter of the University of California at San Diego. If the radiation emitted by this exotic object at the center of the galaxy is isotropic, the high efficiency of energy conversion in the electron-positron annihilation process implies that the emitting region is about one-tenth the diameter of the earth and contains a black hole about 100 times the mass of the sun. If the radiation is not isotropic the region can be bigger (to the size of the orbit of Jupiter) and the mass can go to a million solar masses. Such black holes might be the result of the aggregation of a great many stars. The ordinary black hole that comes from the collapse of a single star is a few solar masses at most; the ones proposed for quasars are in the hundreds of millions of solar masses.

The figure of 100 solar masses is quite interesting, Lingenfelter points out. It is the threshold in a theory of massive black hole development worked out by the Russian astrophysicist Leonid Ozernoi. If a black hole starts out at much more than 100 solar masses, according to Ozernoi, it will continue to eat its surroundings until it develops to quasar size. If it starts out much less than 100 solar masses it will eat its immediate surroundings until it reaches a point where further nourishment is beyond the reach of its gravitational forces. Then it will stop developing. So if there is a black hole in the galactic center, and if it is more than 100 solar masses, the Milky Way could someday become a quasar. —*D.E. Thomsen*