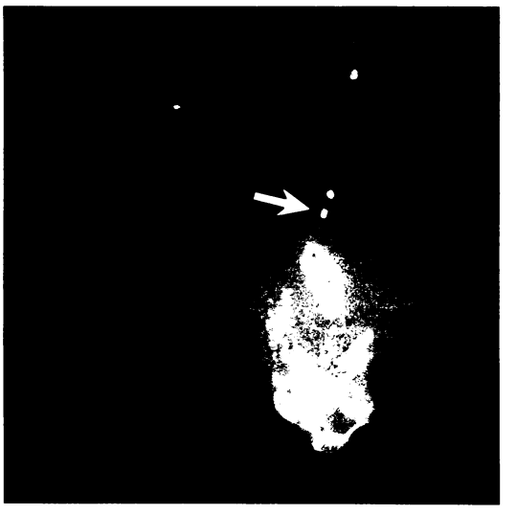
Radio galaxy survey focuses on hotspots



Adam Black, Mullard Radio Astronomy Observ./VLA

False-color image of the galaxy 3C 433 shows faint jet extending north (up) for about 250,000 light-years and then veering left; a radio lobe heads south but appears to lack a corresponding jet. The radio core (arrow) has two components. A galactic merger might explain 3C 433's mismatched features.

Astronomers exploring radio galaxies are like tourists visiting New York City: They seek out the hotspots. And just as the high-energy venues of New York are transient and scattered throughout the city, the hotspots associated with radio galaxies form a crazy quilt that changes over time, new research indicates.

Radio-wave hotspots mark regions where high-speed jets of galactic particles and radiation slam into gaseous material, dumping their energy and prompting intense radio emissions. Examining 30 highly luminous radio galaxies, researchers have now mapped the location, shape and intensity of hotspots in unprecedented detail. These observations, says Stefi A. Baum of the Space Telescope Science Institute in Baltimore, may shed light on the structure of hotspots and the nature of the powerful energy sources, deep inside galaxies, that create the jets.

Baum and her co-workers describe the new work in the May 15 MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY.

Researchers believe that radio galaxies typically spew out two jets in opposite directions, each carrying about 1,000 billion times more kinetic energy and radiation than the sun's total output. Each jet apparently terminates in a series of spectacular hotspots.

In the past, astronomers haven't always found the jets they know must exist in order to feed hotspots. But for five of the eight galaxies in their initial analysis, Baum and her colleagues used the Very Large Array radiotelescope near Socorro, N.M., to identify jets too faint to discern with lower-resolution instruments. The jets correspond to known hotspots at the outskirts of these galaxies, placing the relationship between jets and hotspots on a surer footing. While not surprising, these findings suggest that many radio galaxies sport jets that are ordinarily masked by the bright background emissions from the galaxies.

Other new findings – such as dramatic differences in hotspot features, even those produced by jets from the same galaxy – are more difficult to fathom, Baum notes. "The hope was that as you looked more closely, patterns would emerge that would allow you to model things more simply. But the bottom line is that things are more complicated," she says.

Baum's group found that pairs of oppositely directed jets that dump their energy into hotspots near the confines of their parent galaxy, rather than many light-years beyond, have the greatest asymmetry in hotspot size, intensity and location. She speculates that the gas and dust in the interstellar medium – the region between stars inside a galaxy – clump together more than material in the space between galaxies, which appears to be distributed relatively smoothly. Pairs of jets that terminate at opposite edges of their galaxy may thus slam into materials of strikingly different densities, accounting for the differences in the hotspots they form. Variations in the knots of radio emissions that result when energetic particles splatter back into the galaxy after hitting a hotspot also support this scenario, Baum says.

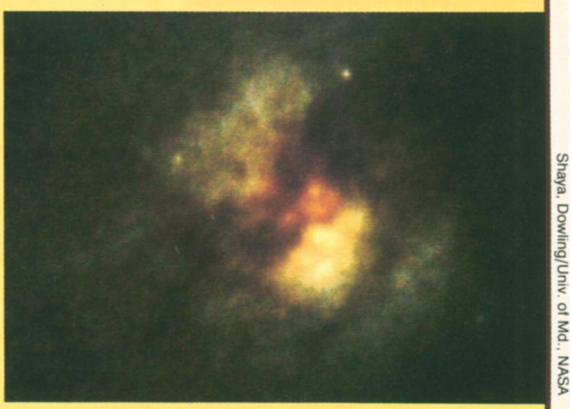
In some of the galaxies, the researchers observed ghost images of faint hotspots adjacent to more intense, presumably newer emissions. This, says Baum, indicates that hotspot locations change over time and that the high-speed jets that feed them wriggle in space much as a garden hose flops around when someone turns on the water full blast.

In one bizarre radio galaxy, 3C 433, jets and hotspots display such dramatic twists and turns that only a cataclysmic event, such as one galaxy gobbling another, could have produced the changes, she adds. Such a merger could have induced the radio galaxy's "central engine" – possibly a black hole – to begin spewing jets in new directions.

Radio astronomer Lawrence Rudnick of the University of Minnesota in Minneapolis says the new work, while not a breakthrough, "constitutes a considerable step forward" in tying together radio observations made over the past 15 years.

– R. Cowen

Hubble camera finds huge star clusters



Shaya, Dowling/Univ. of Md., NASA

They could be the Arnold Schwarzeneggers of star clusters. When the Hubble Space Telescope peered into the center of an oddly shaped galaxy called Arp 220, it imaged six densely packed clusters of stars – the largest star-packed regions ever observed by a telescope.

Ten times larger and thousands of times more luminous than the elderly, densely star-packed regions that surround our Milky Way, bigger and brighter than the young, giant clusters that Hubble found in the elliptical galaxy NGC 1275 (SN: 4/6/91, p.218; 1/25/92, p.52), the youthful star clusters in Arp 220 likely emerged after a violent collision, report Edward Shaya and Dan Dowling of the University of Maryland in College Park. The researchers suspect that two spiral galaxies collided to form Arp 220; star clusters could arise from the dust and gas unleashed in such a merger.

In 1983, NASA's Infrared Astronomy Satellite revealed that Arp 220 is one of the brightest of about a dozen galaxies that emit most of their light in the infrared. Since then, scientists have debated the source of the brightness. Shaya, who presented the new findings this week at a press briefing in Washington, D.C., says it now appears that the newly discovered star clusters account for about half the galaxy's luminosity, with the rest coming from a compact source that Hubble has seen at the center of the galaxy. He estimates that the clusters are about 20 million years old, radiate a billion times the total energy output of the sun and contain many massive, short-lived stars that may soon explode as supernovas. The giant clusters may last only a few hundred million more years before tidal forces at the galaxy's center rip them apart.