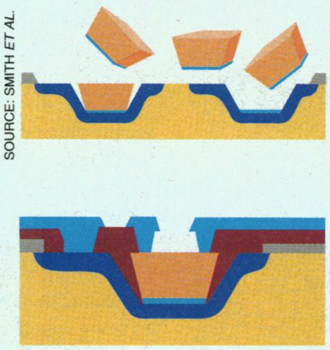
lasers drop into the holes. "When the lasers go in properly, they stay," says Smith. If they land on their sides or upside down, they don't sit flush and can be swept out again by the moving fluid. Once the lasers are in place, the wafers are heated, melting metal layers on the floor of the divots and the base of the lasers to bond the lasers in place. Conventional semiconductor processing techniques then add metal leads to carry electrical impulses from the chip to the lasers.



SOURCE: SMITH *ET AL.*

Everything in its place. Lasers settle out of a liquid slurry onto a silicon chip; metal leads are added to complete the optoelectronic structure.

Still, says Choquette, the Berkeley group faces some hurdles, among them showing they "can get all the [lasers] in the little holes and get them to work." In past experiments with dummy blocks instead of real lasers, the researchers filled more than 99% of the holes with the help of a pump designed to move the ethanol-block slurry across the openings. That device worked well when there was a lot of slurry and many openings for the blocks to drop into. But it couldn't be used in the current experiment, because the expense of making the lasers limited the researchers to using a smaller number of them—and therefore less slurry. At the same time, the chip contained fewer holes, to give it a closer resemblance to potential optoelectronic chips. The result was a much lower success rate: 10%.

To improve their hole-filling rate, the researchers are developing a new pump and ultrasonic agitators to shake the fluid, says Smith—the same technique that improves the odds with ball bearings. If the group succeeds, integrating optics and electronics may soon become child's play.

–Robert F. Service

ASTRONOMY

Radio Galaxies: Born in Cosmic Crackups?

For decades, astronomers have been tuning in to some of the most powerful radio beacons in the universe without fully understanding their message. The broadcasts come from objects called active galactic nuclei (AGNs), which nestle at the centers of galaxies and pour out far more than their fair share of visible and ultraviolet light and x-rays.

In some instances, these strange objects—the brightest of which are known as quasars—emit intense radio waves as well. But not all; some AGNs are silent at radio wavelengths. The neat division between radio-loud and radio-quiet is a puzzle that "hits you in the face," says Caltech astronomer Roger Blandford, and it deepens the mystery of what turns on the cosmic radio stations. Now Andrew Wilson and Edward Colbert of the University of Maryland, College Park, have come up with a dramatic answer.

Last week at the American Astronomical Society meeting in Pittsburgh, the two astronomers proposed that radio-emitting AGNs, or radio galaxies, are the progeny of colossal cosmic accidents. The researchers propose that the radio broadcasts begin after two radio-quiet AGNs collide and giant black holes at their centers, each millions of times as massive as the sun, whirl around each other and coalesce into a single fast-spinning black hole. That scenario, they say, explains why radio-loud AGNs are comparatively rare and why they are found almost exclusively in elliptical galaxies, thought to be the product of collisions, and never in spirals. "What attracts me to [the theory]," says Blandford, "is that it makes rather strong contact with the observations."

Wilson and Colbert build on earlier explanations of a key feature of radio galaxies: spectacular jets of ionized gas that spurt millions of light-years from their centers and act as giant radio transmitters. The jets, say Blandford and some other theorists, are one expression of the black holes that are widely believed to power AGNs and quasars. In all AGNs, theory says, the black hole draws material from the surrounding galaxy into a disk. From there, the gas gets sucked gradually into the black hole, generating brilliant light and other radiation. If the black hole is spinning, according to Blandford and others, it can interact with magnetic fields generated by the disk to fire huge jets of plasma into space along the spin axis, transforming the AGN into the radio-loud variety.

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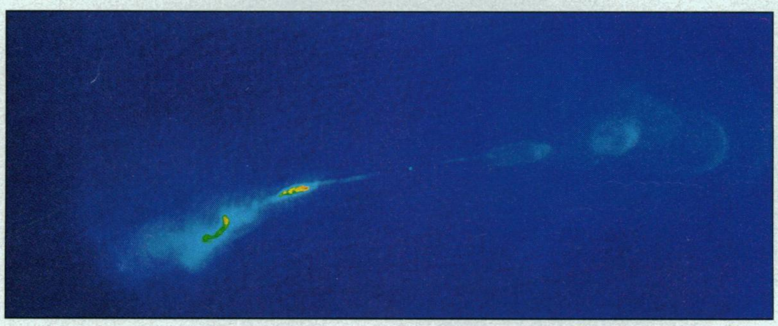

NRAO/AUI/PHOTO RESEARCHERS

A big turn-on. Radio galaxies like Hercules A, whose vast jets of plasma are visible in an image *(above)* from the Very Large Array in New Mexico, may be the offspring of colliding galaxies like the Antennae galaxies at top.

That picture left open the question of where the spin came from. Wilson and Colbert's new theory tries to fill that gap by attributing the spin to an earlier collision between two AGNs. Wilson and Colbert realized that black holes at the centers of colliding spiral galaxies could be "spun up" by the angular momentum created as the black holes circled each other before merging. The larger black hole resulting from the merger would then inherit the spin.

The picture would explain why radio-loud AGNs are "never, never, never, never, never [found] in a spiral galaxy," says Wilson, as collisions inevitably convert spirals to ellipticals. At the same time, it can explain why not all ellipticals are radio-loud: Only when the parent black holes have about equal masses will they produce a spinning "daughter," says Wilson, because "if a little black hole falls into a big black hole, it doesn't give the big one much angular momentum."

Still, Blandford says, there are plenty of alternative theories—such as the idea that concentrations of normal stars simply block the jets in some AGNs and not others. Only further observations of the stars and gases in galactic centers will settle the issue, says Blandford. Until then, astronomers will be tuning in without quite catching on.

–James Glanz