COSMIC BACKGROUND BY MARCIA BARTUSIAK

Radio Stars

A long time ago in a galaxy far, far away

I smiled when I heard the news. In the summer of 2011 an international team of astronomers had just announced the discovery of the most distant quasar, the luminous core of a young and active galaxy situated a whopping 12.9 billion light-years away. That means the light from this quasar started on its journey only 770 million years after the big bang. The universe was just a baby at the time.

I was amused because this headline has regularly been appearing in the news for exactly half a century. There's no news like old news. The most-distant-quasar record has gotten replaced as often as a newborn's diapers. It all started when Caltech astronomer Maarten Schmidt recognized the first quasar on February 5, 1963. And in doing so, he revealed an entirely new side to the universe's personality, one that both surprised and amazed astronomers. That's because they had grown up thinking of the universe as fairly serene.

Hints that the early cosmos was edgier than once imagined had already been arriving by the late 1950s. At that time the noted British radio astronomer Martin Ryle reported that he counted more far-off cosmic radio sources than expected; the intense radio signals suggested that distant (and therefore, from our viewpoint, young) galaxies were more active than the older galaxies in our present-day universe. Spurred on by such discoveries in radio astronomy and not wanting to miss the boat, the United States built its own state-of-the-art radio observatories. One of them, a complex situated in California's Owens Valley and run by Caltech, was able in 1960 to narrow down the location of a particularly strong source, labeled 3C 48 for being the forty-eighth object in the Third Cambridge Catalogue of radio sources.

Astronomer Allan Sandage then swiftly used the grand 200-inch Hale telescope atop southern California's Palomar Mountain to see what visible celestial object might be situated at that spot. Expecting to see a galaxy, he instead found a blue pinpoint of light, a real surprise. At first, everyone just assumed it was a star in our own galaxy, making it the first known "radio star." But there was a catch: "I took a spectrum the next night," said Sandage, "and it was the weirdest spectrum I'd ever seen."

Over the next two years, a handful of similar objects were discovered. On first look they appeared to be simply faint blue stars within the Milky Way, just like 3C 48. But again, the light waves emanating from these so-called radio stars displayed spectral features unlike those of any star ever observed. It was like riding down a familiar turnpike and finding all the road signs written in gibberish. Optical astronomers couldn't even find evidence that hydrogen was present the main component of all stars. Yet, everyone kept assuming they were stars because, well, they *looked* like stars through an optical telescope. Not until February 1963 was the identity of these peculiar radio beacons finally unmasked.

On the fifth day of that month the thirty-three-year-old Schmidt, who had arrived a few years earlier at Caltech from the Netherlands, was sitting at his desk attempting to write an article for the British journal *Nature* on the radio star known as 3C 273. He had just obtained an optical spectrum of this strange object, using the Hale telescope. With the spectrum spread before him, Schmidt came to recognize a familiar pattern of spectral lines that had eluded him for weeks. The pattern resembled the light waves typically emitted by simple hydrogen—but they were in the wrong place. That's why hydrogen had appeared to be missing! The hydrogen lines were

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there, but shifted *waaaay* over, toward the red end of the spectrum. That meant this starlike object was moving away from us at a tremendous speed. Just as the pitch of an ambulance siren gets lower as it races away, a light wave is stretched when its source recedes from us, and, because a light wave at the red end of the spectrum is longer, we say it gets "redder." This "redshift" lets astronomers gauge not only how fast a celestial object is moving but also its distance, because—as Edwin Hubble found in 1929—there's a systematic link between a galaxy's speed and its distance in our expanding universe. The faster the velocity, the more distant the galaxy.

In this way, Schmidt swiftly grasped what that redshift meant. 3C 273 was not an unusual star situated within the Milky Way, but rather a bizarre object located about 2 billion light-years away (one of the farthest cosmic distances ever recorded at that time). 3C 273 was rushing away from us through space at some 30,000 miles per second, carried outward with the swift expansion of the universe. Schmidt knew that only an incredibly bright source could be visible from such a distance; he figured 3C 273 was radiating the power of trillions of stars and suspected it was the brilliant and very disturbed nucleus of a distant galaxy. This galaxy appeared starlike only because it was so far away.

With that revelation, all fell into place. The spectra of other mystifying radio stars were quickly deciphered. These blue, extragalactic specks were soon christened quasi-stellar radio sources (QSRS). Before long, they were simply called *quasars*. For his role in vastly extending the boundaries of the visible universe, Schmidt made the cover of *Time* magazine.

3C 273 is now considered relatively close to us, as quasars go. Its distance is small potatoes compared with those of later finds. The latest record holder is more than six times as far away. And the fact that earthbound observers are able to photograph such quasars across the vastness of the universe means that these objects are the most powerful denizens of the heavens.

What could possibly be the source of a quasar's monstrous energy? That's the first thing everyone asked when 3C 273's secret was revealed. "The insult was not that they radiate so much energy," said Schmidt, "but that this energy was coming from a region probably no more than a light-week across." Astronomers came to know this by seeing the quasars dim and brighten over a matter of weeks or days. In the case of 3C 273, they checked old photographic plates of the 13th-magnitude object, going back some seventy years. In one picture it was faint, a month later it was brighter. Such relatively swift and sizable fluctuations meant that the quasar's power source was small, perhaps less than the diameter of our solar system. (Any small luminosity change in a vastly larger object would get lost in the noise.) Yet from such a cosmically tiny region spewed the energy of billions of Suns. Tapping into such a cosmic dynamo for just one second would power the world for a billion billion years.

Since Schmidt's discovery, quasars have been closely examined by an array of telescopes—radio, infrared, optical, and X-ray. And all point to one answer to a quasar's identity: it's a supermassive black hole residing in the center of a young, gas-filled galaxy. The vast energies are likely released as matter spirals in toward the black hole, and also by the spinning hole itself acting as a powerful dynamo, causing huge beams of energy to shoot out of the black hole's north and south poles.

The center of our home galaxy, the Milky Way, was probably a quasar in the distant past. The black hole lurking there, estimated to contain the mass of around 4 million Suns, is now fairly quiet, having grabbed all the nearby "food" it can get. Its engine is on idle, but this behemoth might wake up one day, perhaps as we slowly collide with our close neighbor, the Andromeda galaxy, about 4 billion years from now.

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