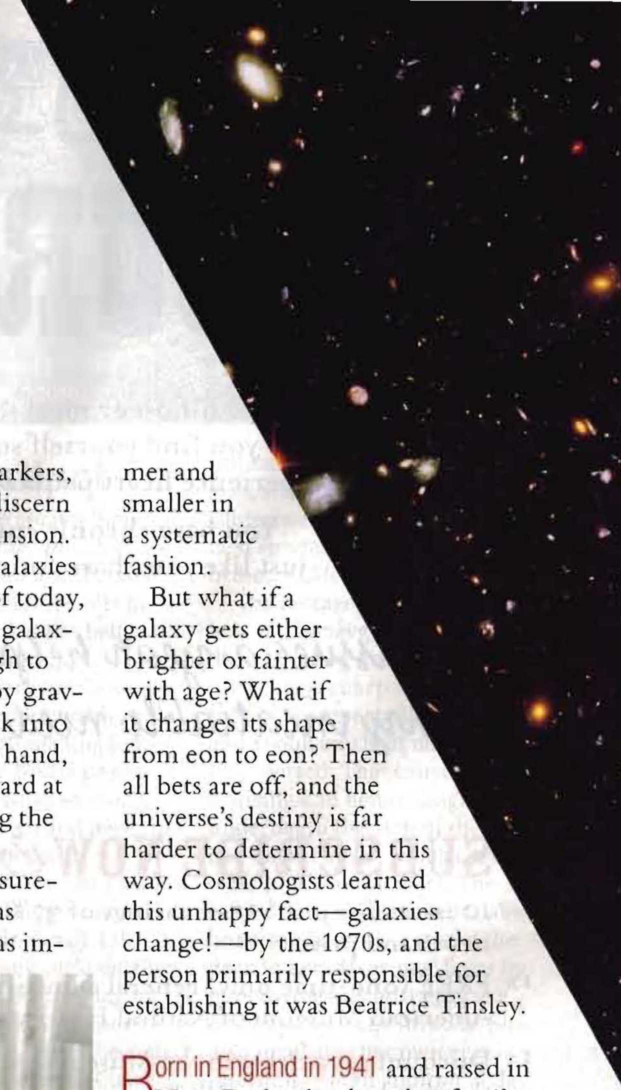
COSMIC BACKGROUND BY MARCIA BARTUSIAK

Chasing Galaxies

The legacy of "Brian Tinsley's clever wife"



By the 1930s Edwin Hubble was well into his search for far-off galaxies. Using the great 100-inch telescope atop California's Mount Wilson, he could see out to distances of a few hundreds of millions of light-years. But beyond that, the smudges on his photographic plates were dim, fuzzy, and next to impossible to identify. "There," wrote Hubble in 1936, in his classic book *The Realm of the Nebulae,* "we measure shadows, and we search among ghostly errors of measurement for landmarks that are scarcely substantial." Ever since, astronomers have struggled to trace the evolution of galaxies back through space-time—not just hundreds of millions of light-years outward, but billions.

Hubble himself saw no changes over the relatively shallow span he surveyed. Galaxies "are enormous systems, and it is reasonable to suppose that their evolution is correspondingly slow," he concluded. And this became the prevailing view for the next three decades. Astronomers just assumed that all the galaxies—every spiraling pinwheel and bulbous elliptical—formed fairly quickly after the big bang and then coursed serenely through the cosmos, changing very little over the eons. They had no reason to doubt this. Given how far back astronomers could see at the time (which wasn't very far), distant galaxies looked pretty much like the galaxies right by us.

Early cosmologists depended on this axiom. Their prime motivation for tracking galaxies at all was their insatiable desire to learn the universe's fate. They were not so much interested in the galaxies themselves. Galaxies were simply little markers, convenient spots in space to discern the rate of the universe's expansion. By comparing the speeds of galaxies in earlier epochs with those of today, they hoped to judge whether galaxies were slowing down enough to someday stop in their tracks by gravitation and eventually fall back into a "big crunch." On the other hand, maybe they were flying outward at an unstoppable speed, keeping the cosmos forever open.

Using galaxies for this measurement was a fine idea, as long as galaxies could be thought of as immutable objects that drifted on in tranquil isolation. By maintaining a uniform size and brightness over time, the galaxy could be used as a cosmological yardstick. An astronomer estimated a galaxy's distance by measuring its luminosity and angular width on the sky. As observers peered deeper and deeper into space, viewing the universe as it was in the past, they assumed that ever more distant galaxies would appear dimmer and smaller in a systematic fashion.

Beatrice Tinsley in 1977

But what if a galaxy gets either brighter or fainter with age? What if it changes its shape from eon to eon? Then all bets are off, and the universe's destiny is far harder to determine in this way. Cosmologists learned this unhappy fact—galaxies change!—by the 1970s, and the person primarily responsible for establishing it was Beatrice Tinsley.

Born in England in 1941 and raised in New Zealand, where her family moved after World War II, Tinsley did a master's thesis in solid state physics. Soon after, in 1963, she moved to the United States when her husband, physicist Brian Tinsley, garnered a research job in Dallas. By then she had plans to pursue a doctorate, but now she wanted to specialize in her longstanding passion—cosmology, a choice that hadn't been available to her in New Zealand.

Though some judged Tinsley as a mere Dallas housewife with no experience in astronomy, her top-notch academic record convinced the head of the astronomy department at the University of Texas, Austin, to take a chance on admitting her, even with the added burden of her commuting the 200 miles from Dallas to Austin.

Initially Tinsley planned to take part in the longstanding cosmological pursuit of deciding whether the universe was open or closed. But as

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she examined all the observables in this line of work—the diameters of clusters of galaxies, galaxy magnitudes, galaxy sizes—one question kept diverting her: how were the galaxies changing over time? How were they evolving? That information was crucial to finding an answer to the universe's fate.

At that point she chose the problem that became her dissertation: actually simulating the evolution of a galaxy. Setting up a numerical model, she would track its changes in color and brightness over billions of years as the stars within it are born, fiercely radiate, and then inevitably die. It was an ambitious task, as numerical simulations were grueling in this primordial era of computing.

No one before had ever tackled such a problem in great detail. It has been described as "one of the boldest graduate thesis projects ever undertaken." Tinsley had to set up an initial population of stars and then decide how quickly they would die and how soon new stars would be generated to take their place. And no one yet knew for sure whether a galaxy's brightness depended more on the collective light emanating from its numerous long-lived, low-mass stars or from its scarcer—but far brighter—short-lived, massive ones. Tinsley constructed her model based on the best theoretical and observational evidence available at the time.

After her dissertation was completed in 1967, she continued to refine her models over the years, each simulation concluding that galaxies can undergo substantial evolution through time, far more than astronomers had previously thought. A young galaxy starts out bright and blue, when its resources of gas to form stars are at their peak, and then gently reddens with age and dims considerably as the stars age and die over the eons.

Some more senior authorities at first took issue with these conclusions, but eventually her findings encouraged observers to start pushing outward with their telescopes to discern her predicted galactic evolution firsthand. As a consequence, Tinsley's papers began to be cited in dozens of scientific publications. Yale University took notice in 1975 by offering her a professorship, a post she had been unable to secure years earlier (to her great frustration) in Texas or elsewhere. The woman once regarded in Dallas as "Brian Tinsley's clever wife, rather than as a scientist in her own right," according to science historian Joann Eisberg, had proved that people had vastly underestimated her talent.

It didn't take long for astronomers to get direct confirmation of Tinsley's theoretical findings. In 1977 astronomers Augustus Oemler Jr. and Harvey Butcher used the 84-inch telescope on Kitt Peak in southern Arizona to analyze the light emanating from two galaxy clusters now known to be situated some 5 billion light-years away (hence 5 billion years back in time). What they saw matched Tinsley's prediction: the galaxies in both clusters were radiating more blue light than the more reddish clusters near us today. No longer mere markers, distant galaxies were now viewed as fascinating and evolving cosmic creatures worthy of study all on their own.

All those efforts ushered in a new era in extragalactic research. Gradually Hubble's "shadows" began to disappear as new and improved instrumentation allowed the early universe to come into better focus. Faraway galaxies that had been smudges in Hubble's day are being viewed today with impressive clarity. And what astronomers are seeing is that galaxies over time can exhibit diverse personalities. Some do move serenely through the cosmos, evolving internally as Tinsley calculated, but astronomers now know that many can also change more recklessly. Galaxies may collide, merge, sideswipe one another, or gobble up unwitting passersby. The resultant galaxy-wide temblors often trigger the birth of millions of stars. It is a wondrously invigorating picture of extragalactic affairs, in which galaxies evolve, either dimming or brightening as they age, owing to *outside* influences.

Sadly, Beatrice Tinsley witnessed very little of the new era she inspired. In 1978 a lesion on her leg was diagnosed as melanoma, a malignant skin cancer. While continuing to teach and carry out research, she underwent extensive radiation and chemotherapy, but ultimately the treatments were unsuccessful. She died in March 1981 at the age of forty. Writing in *Physics Today* a few months later, Sandra Faber of the University of California, Santa Cruz, observed that Tinsley had "changed the course of cosmological studies."

Two weeks before her death, while hospitalized in the Yale infirmary, Tinsley submitted her last scientific paper to *The Astrophysical Journal.* No longer able to use her right hand, she had written it with her left. The article advanced her work on galaxy evolution and was published the following November without revision by the editors.

A professor of science writing at MIT, MARCIA BARTUSIAK has been writing on physics and astronomy for more than three decades. Her latest books are The Day We Found the Universe *and* Archives of the Universe: 100 Discoveries That Transformed Our Understanding of the Cosmos.