PROFILE VERA RUBIN

The Bright Face Behind the Dark Sides of Galaxies

Vera Rubin has raised four scientists, measured the rotations of galaxies, and advanced the cause of women in astronomy—usually in that order

Vera Rubin's first press clipping was a doozy. "Young Mother Figures Center of Creation by Star Motions," gasped *The Washington Post* on 30 December 1950. "A young mother, in her early 20s, startled the American Astronomical Society today with a daring report—so daring, in fact, that most astronomers think her theories are not yet possible."

More than 4 decades later, her friends concocted another headline: "Old Grandmother Gets National Medal of Science." It marked a real honor bestowed upon her by President Bill Clinton in 1993: a tribute to her victory over rebukes and dismissals in forging one of the most distinctive careers in 20th century astronomy.

To celebrate that career, a constellation of noted astronomers gathered here last month for a symposium* at the Carnegie Institution of Washington. Rubin, now 73, listened to presentations on the nature of galaxies, nearly all of them influenced by her pioneering studies on how galaxies revolve within massive shrouds of "dark matter." Every astronomy text describes her evidence: a methodical analysis of how stars move in the outskirts of galaxies, research that she continues today.

Just as important to Rubin's success, many noted, are the deep curiosity, unbiased eyes, and unabashed joy that she brings to her work. "She retains a child's wonder at it all," said astronomer Donald Lynden-Bell of Cambridge University, United Kingdom. "The originality of her research programs is matched only by her ability to recognize the importance of the unexpected whenever it turns up."

Other comments praised Rubin for improving the lot of women in the male-dominated field of astronomy, or for raising four Ph.D. scientists with her husband of 53 years, chemical physicist Bob Rubin. The combination of stellar career and brilliant family is "amazing," says astronomer Sandra Faber of the University of California (UC), Santa Cruz. "I'm totally blown away by that."

Rubin wears her fame lightly, welcoming even first-time visitors with genuine warmth and lack of pretense. In a field where collisions between senior astronomers are common, she radiates kindness. "She is utterly down to earth," Faber says. Sitting in her tidy office at the Carnegie Institution's bucolic campus in northwest Washington, D.C., Rubin shrugs when asked about the harsh receptions some of her ideas have received. "I just thought to myself, 'These astronomers are very cross people,' " she says of her 1950 presentation. "I was reasonably pleased that I had chosen to do something no one had ever done."

Island universes. Rubin's love of galaxies has driven her career, from Vassar College in 1947 (*inset*) to the present day.

What Rubin did, for her master's thesis at Cornell University, was to analyze the motions of 109 galaxies. She subtracted the known expansion of the universe and plotted the leftover motions on a globe. The pattern was consistent with spin around a common axis. Rubin's talk, boldly titled "Rotation of the Universe," featured statistical methods that wouldn't hold today. But she was on to something, namely, that the unexpected motions of stars and galaxies were hiding cosmic secrets.

Her curiosity about such motions dates from her childhood in Washington, D.C., when she watched the sky turn at night outside the north-facing window at her bedside. It sounds apocryphal, she admits, "but it's absolutely true. I became an astronomer because of looking at the sky." Her father, an electrical engineer, helped her make a crude telescope, but Vera did the rest. "I faked my way through high school. Every report I had to write was related to astronomy."

The young Vera Cooper received scarce encouragement along the way. Her physics teacher, upon learning that she had received a college scholarship, had these words: "As long as you stay away from science, you should do OK." An admissions officer at Swarthmore College in Pennsylvania suggested that she become an astronomical artist, advice that her family turned into a running joke whenever anyone encountered a hurdle: "Have you ever thought about going into painting?" Instead, she chose Vassar College in Poughkeepsie, New York, because Maria Mitchell—the first nationally known woman astronomer—had worked there.

Vera Cooper and Bob Rubin, soon to be a graduate student in chemistry at Cornell, met on a summer break and married after her graduation from Vassar in 1948. Her new status led her to turn down an offer from Harvard University for the then relatively unknown astronomy program at Cornell. Thus began a series of tough decisions familiar to two-career couples. "We made a number of compromises over the years, depending on where the options were most promising for each of us," Bob says.

Bob's first job was at the Applied Physics Laboratory of Johns Hopkins University, then located in Silver Spring, Maryland, where he worked with physicist Ralph Alpher. He introduced the Rubins to his colleague, astrophysicist George Gamow of George Washington University. Gamow became Rubin's adviser even though she was attending Georgetown University, which had the area's only Ph.D. program in astronomy. Her 1954 thesis on the large-scale dis-

CREDIT: (LEFT TO RIGHT) RICK KOZAK; COURTESY OF V. RUBIN

* "Galaxies: Mind Over Matter," 10–11 January.

tribution of galaxies broke new ground on a topic that remains hot today. In the meantime, Rubin fell in love with the wood-paneled library of Carnegie's Department of Terrestrial Magnetism (DTM) where she and Gamow used to meet. She joined the Georgetown faculty but did little observing, instead focusing on her family. "It took me a long time to believe I was a real astronomer," she says.

The turning point came in 1963. Bob Rubin took a 1-year fellowship in La Jolla, California, so that Vera could collaborate with noted astrophysicists Margaret and Geoffrey Burbidge of UC San Diego. The Burbidges invited her to observe at the McDonald Observatory in Texas. Using an 82-inch telescope, Rubin measured the rotation of a galaxy for the first time.

Beyond experiencing the thrill of collecting such data, Rubin felt a new sense of professional accomplishment. "The Burbidges' interest in what I had to say made it seem possible that, yes, I could be an astronomer," she recalls.

Returning to Washington, Rubin walked into DTM and asked for a job. Director Merle Tuve agreed to hire her at two-thirds of her Georgetown salary—allowing Rubin to get home in time to welcome her children from school. "Vera owes everything to DTM," says UC's Faber, noting that researchers there don't teach and rarely apply for grants. "It was just the kind of place where she could flourish and catch up. If she had gone to a university, she would have been inundated with other things to do. Carnegie was a garden in which she could grow."

One bountiful collaboration involved physicist Kent Ford, inventor of the image-tube spectrograph, a device for electronically amplifying starlight. The technical advance brought dim parts of the universe into view for the first time. The partnership lasted until Ford retired in 1990. The duo's observing trips, by themselves or with a succession of postdoctoral researchers at DTM, took them to Kitt Peak and Lowell Observatory in Arizona and to Cerro Tololo in Chile. In 1965, Rubin became the first woman legally permitted to use the 17-year-old Palomar Observatory in Southern California. She loved to plan telescope pointings, prepare photographic plates, set up heavy equipment, and guide the telescope through the cold nights—often accompanied by *The Pirates of Penzance* or more tranquil music.

She also enjoyed scrutinizing the data, which she still does today. Indeed, the Monday morning after her recent symposium found her back in her office, measuring spectra. "That's the nitty-gritty work, and she does most of it herself," says astronomer Stacy McGaugh of the University of Maryland, College Park. "She's all about the science. She just loves getting into it."

Rubin's joy washed over her family, both at home and on summer sabbaticals, often in the southwestern United States. "We lived in a household where being a scientist looked like so much fun," says daughter Judith Young, an astronomer at the University of Massachusetts, Amherst. "How could we possibly want to do anything else?" Evidently, her siblings felt the same way: older brother David, a geologist with the U.S. Geological Survey in Santa Cruz, and younger brothers Karl, a mathematician at Stanford University, and Allan, a geologist at Princeton University.

At DTM, Rubin and Ford's early work focused on quasars, distant and energetic points of light discovered in 1960. The team also detected an apparent large-scale motion of many galaxies toward one part of the sky, a phenomenon soon called the "Rubin-Ford effect." Both the quasars and the galaxy motions, however, proved too competitive and controversial for Rubin's tastes. She returned to the topic she broached with the Burbidges in 1963.

Geologic explorers. The Rubins in Rocky Mountain National Park, summer 1961: Karl, David, Allan, Vera, and Judith (left to right).

"Lots of people were working on the centers of galaxies, but I got curious about the outsides," she says. "I wanted to know how galaxies ended, which is not a question anyone ever talked about." The spectrograph allowed Rubin and Ford to examine rotation in those wispy outer reaches as never before. That search formed the heart of Rubin's career. The team compiled an exhaustive set of spectra of spiral galaxies. Each spectrum revealed the speeds of hydrogen gas and stars around the galaxy's center via the Doppler effect. Astronomers expected to see the most distant stars move slowly, just as the outer planets in our solar system orbit the sun at a snail's pace, compared to the inner planets. However, nearly all of Rubin and Ford's spectra were flat: Stars moved at a constant speed, out to the edges of the galaxies. The strange but unavoidable consequence was that unseen matter—and a lot of it—enshrouded the entire visible disks of the galaxies and added enough mass to accelerate the outermost stars.

Rubin's careful work earned her election to the National Academy of Sciences (NAS) in 1981. She was the second woman astronomer chosen—after Margaret Burbidge in 1978. Still, Rubin readily acknowledges that she did not "discover" dark matter, as some popular accounts over the years have implied. Other evidence, including data from radio astronomy, was more convincing to some observers. Rubin neither knows nor cares what role history will assign her in the unraveling of this basic cosmic mystery.

Away from the telescope, Rubin's advocacy for women has earned her great respect. She and Burbidge have been outspoken in calling for more women in the NAS, on review panels and program committees, and as serious candidates in academic searches. She has seen a lowering of the most egregious barriers—excluding women from graduate programs and observatories and actively discouraging them from entering the field. However, pervasive problems remain. Salaries for women are lower, faculty positions are hard to come by, and honor societies are still male bastions.

"My daughter has had normal academic problems for a woman; it's terrible to call them 'normal,' " Rubin says. "I have fought with the NAS, and I am outraged at the small number of women elected each year. It's the saddest part of my life. Thirty years ago, I thought everything was possible."

When Rubin talks with girls and young women considering careers in astronomy, she urges them to persist in the face of adversity. That was the key for her generation, says a friend, Nancy Grace Roman, who had a distinguished career at NASA headquarters: "We were stubborn. We never seriously wanted to do anything else."

The 1950 *Washington Post* article hints at that resolve. "The astronomers were not complimentary," the reporter concluded. "They politely and persistently questioned [Rubin's] figures, because there are not enough sure observations to substantiate them. She replied that it was worthwhile to try." A half-century later, her fellow astronomers let her know how glad they are that she never stopped trying.

–ROBERT IRION

CREDIT: BOB RUBIN