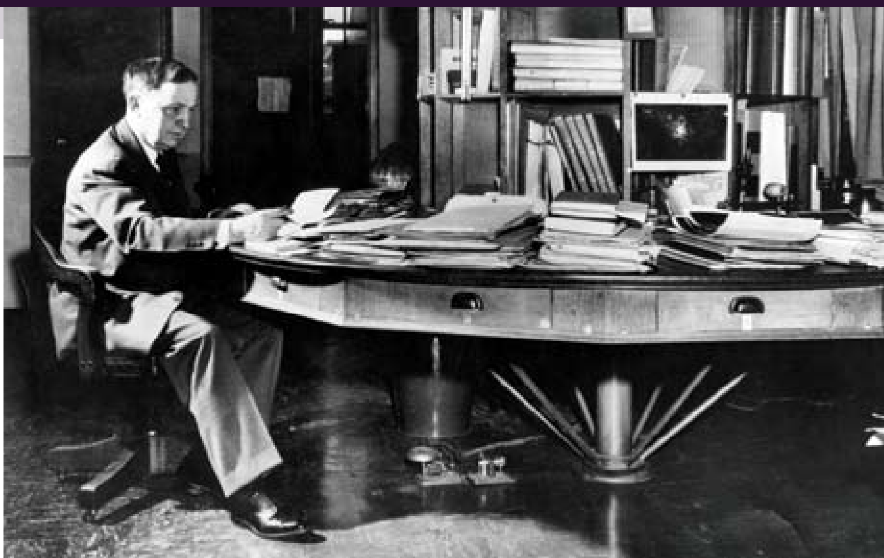
CELEBRATING ASTRONOMY

Man Is Not Such a Big Chicken

By Marcia Bartusiak

Harlow Shapley carried on the Copernican tradition by showing that the Sun is not at the center of the Milky Way.



Harlow Shapley sits at his rotating desk at the Harvard College Observatory, where he served as director between 1921 and 1952.

A globular cluster appears through a telescope as an assembly of brilliant specks of light hovering around a dense and blazing core. With stars packed in like subway commuters at rush hour, a cluster is an exotic locale compared with our celestial neighborhood. The star closest to the Sun, Alpha Centauri, is about four light-years away. But if the Sun were in the center of a globular cluster, it would have thousands of stars closer than that, bejeweling Earth's sky both day and night. Near misses between stars would be commonplace.

Today, globular clusters are known to be arranged in a globe-like halo surrounding the disk of the Milky Way, somewhat like bees buzzing around a hive. But in the mid-1910s, when astronomer Harlow Shapley began his seminal work on the clusters at the Mount Wilson Solar Observatory near Pasadena, California, no one knew that—or even how big a globular cluster was. Some astronomers, including Shapley early on, even pondered whether the clusters might be distinct external galaxies, separate from the Milky Way and similar to it in size. Shapley's goal was to learn the clusters' true sizes, distances, and compositions to see if they were indeed external galaxies. His findings, however, ultimately did something else: they revealed the true immensity of the Milky Way and our solar system's humble place within it.

Shapley did the best research of his long, illustrious career at Mount Wilson (which has since dropped the word "Solar" from its name). During his seven years there, from 1914 until 1921, he wrote or contributed to some 150 notes and papers. It would have been hard to predict that career outcome. Born in 1885, Shapley had grown up on a Missouri hay farm. With little formal schooling, he'd taken his first job, at age fifteen, as a reporter covering crime and corruption in the Midwest. By 1907 he'd saved money, caught up educationally, and matriculated at the University of Missouri, where he wound up studying astronomy almost accidentally. Shapley went on to Princeton for his PhD before heading out west to Mount Wilson.

Shapley's initial observations of the globular clusters were fairly basic. Using the observatory's 60-inch telescope, he simply surveyed the colors and magnitudes of the stars in the most prominent clusters. As his photograph collection mushroomed, however, Shapley began to identify Cepheids—variable stars much brighter than the Sun. He knew they would serve as his measuring tape out to the globular clusters. Building on foundational work by Henrietta Leavitt at Harvard and the Danish astronomer Ejnar Hertzsprung [*see "Finding a Cosmic Yardstick," September 2009*], he was able to calculate the distances to the Cepheids in the clusters from their observed rates of dimming and brightening and their overall brightness as it appeared from Earth.

In some of the clusters, however, he could find no Cepheids. What they did harbor were variables that changed rapidly, in a matter of hours rather than days or months as Cepheids do. Eager to move forward, Shapley simply decided to treat his fast variables as if they behaved like Cepheids—a risky assumption. He based his distance calculations on

'AD ASTRA PER ASPERA, THROUGH RUGGED WAYS TO THE STARS,' BY HARLOW SHAPLEY, NEW YORK: CHARLES SCRIBNER'S SONS, 1969, COURTESY AIP EMILIO SEGRE VISUAL ARCHIVES, SHAPLEY COLLECTION all the variables, slow and fast alike. "This proposition scarcely needs proof," he boldly asserted, though it was a very controversial decision. But it enabled Shapley to estimate the distances to all the nearest globular clusters—a formidable task, as the stars were very faint.

For clusters farther out—too remote to spot any variables—he resorted to using the brightest stars as distance markers. And when the stars themselves could no longer be adequately resolved, he judged distance by the apparent size of the globular cluster in the sky. "The whole line of reasoning . . . was brilliant," later concluded astronomer Allan Sandage, now emeritus staff at the Carnegie Observatories in Pasadena. But it was painstaking, routine labor that took four years to complete.

Between 1916 and 1919 Shapley published his growing body of data on the globular clusters in a few overlapping series of papers. Each article added another piece to the puzzle, and it began to dawn on him that the Milky Way was far larger than anyone had previously conceived. The first hints arrived when he estimated that some well-known star clusters within the Milky Way were at least 50,000 light-years distant—well beyond the galaxy's presumed maximum girth of 30,000 light-years. Then he began finding that the distances to the globular clusters ranged anywhere from 20,000 to 220,000 light-years. He started to see that the clusters were serving a little like surveyor posts, marking the boundaries of our galactic borders.

Beginning in November 1917, having plotted the positions of all sixty-nine known globular clusters, Shapley fired off seven related articles to report what he described as a "striking" result. Most of the clusters resided in one particular direction, over by the constellation Sagittarius. They were evenly arranged at great distance from a particular spot within the Milky Way—a spot rich in stars and nebulae and far from our solar system. The clusters were not arranged around the Sun at all, which had long been assumed to reside at the galaxy's center. Instead, good old Sol was situated, by Shapley's initial estimate, around 65,000 light-years off to the side.

Shapley knew his conclusion was going to be revolutionary, so he stacked his ammunition with orderly care in four of those papers. The full-scale assault took place with a bombshell paper submitted to the *Astrophysical Journal* in April 1918. Not only were the globular clusters uniformly scattered around the center of the galaxy, with the Sun marginalized, but the Milky Way was far larger than anyone had presumed. Shapley now gauged it was an astounding 300,000 light-years across, ten times greater than once estimated.

Just as Copernicus in the sixteenth century had removed Earth from the center of the solar system, Shapley, by age thirty-two, relocated the solar system from the heart of the Milky Way. "The solar system is off center and consequently man is too, which is a rather nice idea because it means that man is not such a big chicken," Shapley wrote in a 1969 memoir.

His results had still larger implications. The Milky Way was now so big, Shapley figured, that it had to be the dominant feature of the universe. At the time, the existence of distinct galaxies—or "island universes" in the parlance of the day—had not been proven, but spiral nebulae were considered the best contenders. That had seemed reasonable when the Milky Way was thought to span only 10,000 or 30,000 light-years, but everything changed when Shapley enlarged our galaxy. Once a believer in island universes, Shapley now considered it more rational to assume that the spiral nebulae were closer: either nestled cozily inside our galactic borders or situated just outside, as smaller outlying colonies. The idea of island universes, then on the verge of acceptance, was put back on shaky ground. Astronomers split into opposing camps: one believed the universe held multiple distinct galaxies, whereas the other, led by Shapley, remained convinced of the Milky Way's uniqueness.

Shapley had carried out a tour de force, and his findings hit the astronomical community like a lightning bolt. But since he had based his results on such novel methods as the Cepheid beacons and had rashly ignored many uncertainties, acceptance was hardly unanimous. In hindsight, he did get certain things wrong. The most serious, of course, was the idea that the Milky Way is the universe's sole galaxy—Edwin Hubble laid that theory to rest in 1925 [*see "The Day We Found the Universe," June 2009*], and the spiral nebulae are now recognized as distinct galaxies.

Shapley was also wrong about the fast and slow variable stars that he lumped together in his computations. They turned out to be very different animals, prompting readjustment of his cluster distances. Later, astronomers reduced the Milky Way's girth to 100,000 light-years. Yet Shapley's discovery held up over time on the essentials: first of all, that the Milky Way was a far larger metropolis of stars than previously suspected, and, second, that the Sun was situated in its suburbs.

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