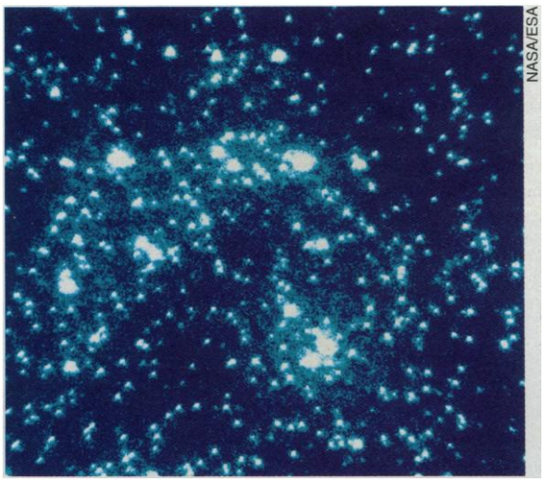
The Private Lives of Globular Clusters

For these clumps of stars and their stellar inhabitants, a little rough-and-tumble may be the secret of youth

TO AN OBSERVER WITHIN ONE OF THE DENSE knots of stars known as globular clusters, the sky would be bursting with stars—hundreds of times more than emblazon even the clearest desert night. Even from the outside, globular clusters are among the most beautiful objects in the sky. About 150 of them hang like sparkling disco balls in our own galaxy, their dense centers packing about a million stars into a sphere no farther across than the distance between the sun and its nearest neighbor.

But there's violence amid the seemingly serene beauty. As astronomers begin to look deeper into these clusters, they are seeing that stars can't live peacefully in such crowded conditions. Two recent observations of the southern-sky cluster known as 47 Tucanae have revealed the bizarre progeny of violence. One group of astronomers, led by Francesco Paresce of the Space Telescope Science Institute in Baltimore, found that the core of the cluster is populated by a startling number of ancient stars that appear to have regained their youth in collisions with other stars. Meanwhile a group of radio astronomers led by Richard Manchester of the Australia Telescope National Facility in Epping, New South Wales, and Andrew Lyne of the University of Manchester found that the cluster is also studded with millisecond pulsars—radio-emitting neutron stars that have apparently stolen additional material from close neighbors.



Hiding their age. *Ten billion years old, blue stragglers blaze like young stars.*

All this mayhem, strange to say, may explain how globular clusters—by far the oldest assemblages of stars in the universe—have survived for so long. Unhindered, the sheer mass of the cluster's core would pull stars inward, probably forming a massive black hole, says Harvard astronomer Willy Benz, who does computer models of the evolution of globular clusters. But 47 Tucanae and other globular clusters show no signs of having formed a central black hole. What keeps the clusters from collapsing? The recent observations suggest that the answer may come from these close (sometimes catastrophic) encounters in the heart of globular clusters.

"These new observations changed my view of the population of globular clusters," says John Bahcall of the Institute for Advanced Study. Until recently, Bahcall and other astronomers could do no more than speculate about the stellar makeup of clusters, where the close packing of stars has prevented ground-based telescopes from revealing more than a bright blur. But when Paresce's group finally did gain a view into 47 Tucanae using the Hubble Space Telescope (HST), they found an enigma: a clutch of 21 blue stragglers—massive blue stars that have lagged behind the usual process of stellar aging.

Among stars, blue signals a young star still well fueled with hydrogen. The trouble is, says Michael Shara of the HST team, most stars in globular clusters give every evidence of being more than 10 billion years old, and there is no gas or dust from which any newer stars could form. Only the smallest ancient stars should still be burning hydrogen; larger stars should have burned out, becoming white dwarfs or neutron stars.

But the observations also yielded several clues to the secret of these blue stragglers. One is the fact that they are concentrated near the center of the cluster; the other is their great mass—about two to three times that of our sun. From those hints, Shara and his colleagues speculate that the stragglers began as binary pairs. The pairs would weigh enough to get pulled into the cluster's crowded center, where the gravitational effects of nearby stars would tend to disturb the orbits of the companion stars. A few would suffer all-out crashes, melding into a single, more massive star.

The merged star, Shara says, would regain its youth. "If two older stars run into each other they will really thrash each other up. Lots of fresh hydrogen from the outside regions can mix back into the center," renewing the star's fuel supply and letting it burn a bright blue long after its appointed days.

While blue stragglers spring from violent encounters between ordinary stars in a binary system, more spectacular things can happen when one of the stars is a solid ball of ultradense nuclear matter known as a neutron star. By capturing a companion and siphoning off its material, a pulsar—a spinning neutron star emitting a pulse of radio waves at each revolution—that is slowing down in its old age can get "spun up" from a few revolutions a second to hundreds. Ordinarily, these millisecond pulsars are rare creatures. But Manchester and his colleagues, using the Parkes radio telescope in Australia, have just identified 10 new specimens in 47 Tucanae (one had been detected earlier).

The pulsar and blue straggler observations—published last month in separate issues of *Nature*—show that clusters such as 47 Tucanae are rife with close encounters and collisions. But the binary systems that spawn such turmoil must be still more common. If so, Bahcall says, binaries may have a profound effect on cluster structure and history.

Indeed, astronomers had long speculated that binaries might sustain clusters against the force of their own gravity. Shara and his collaborators think they may do so by acting as slingshots, flinging other stars from the center of the cluster. Georges Meylan, a member of the group that studied the blue stragglers, reports seeing the slingshots in action: He recently trained the European Southern Observatory's 3.6-meter telescope in Chile at 47 Tucanae and, by looking at Doppler shifts in stellar spectra, found two fast-moving "cannonballs"—stars he believes were flung outward when they strayed too close to a rapidly orbiting binary.

Repeated millions of times, says Shara, that process may act as a huge spring, sustaining clusters against collapse. Other astronomers believe the binary-star spring may explain why the core of M15, a cluster even denser than 47 Tucanae, appears not to be collapsing into a massive black hole.

Of course, astronomers acknowledge, the mechanisms that sustain M15 and rejuvenate stars and pulsars in 47 Tucanae aren't necessarily at work in other globular clusters. Luckily, there's no shortage of places to test these ideas—our galaxy has at least 150 more of the clusters. ■ FAYE FLAM