tallize. (The proteins link together in polymers instead.) In the current work, Namba, Samatey, and their colleagues got around that problem by clipping off the ends of the protein, thus removing the regions that form links with other flagellin molecules.

But yet another hurdle appeared: Only the R type of the protein crystallized, making it impossible to directly compare the structures of the two forms. Namba suggests that the longer L structure exists only in the filament, produced by the interaction between the protofilaments. "I don't think we will ever crystallize the L type of the protein," he says. That meant the researchers had to find another way to observe the change of the L form of flagellin to the R form.

So after determining the x-ray structure of the R-type protein, they used a computer simulation to stretch it, in 0.1-angstrom steps, into the longer L type. Up to a point, the stretching was accommodated by elastic strain throughout the structure. But then, a key hairpin fold in the protein snapped into a new position, pushing two regions of the protein farther apart and producing the L form.

While the simulation strongly suggests that Namba and his colleagues have spotted the flagellar switching mechanism, he cautions that his group has more to do to confirm that and to understand the interactions among the protofilaments. Even so, Hirokazu Hotani, a biophysicist at Nagoya University in Japan, describes the achievement as "very difficult to accomplish." He adds that the finding is important not only because it gives a clearer picture of how bacteria control their movements, but also because flagellin is the only protein known to undergo such a large degree of conformational change. And there could be a practical payoff in using the mechanism as a switch in nanomachines, although just how it might be incorporated into practical devices remains to be seen.

–DENNIS NORMILE

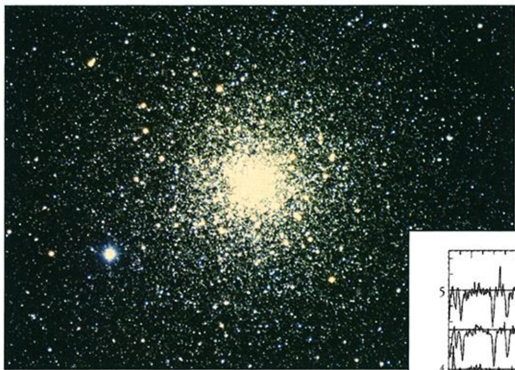
ASTRONOMY

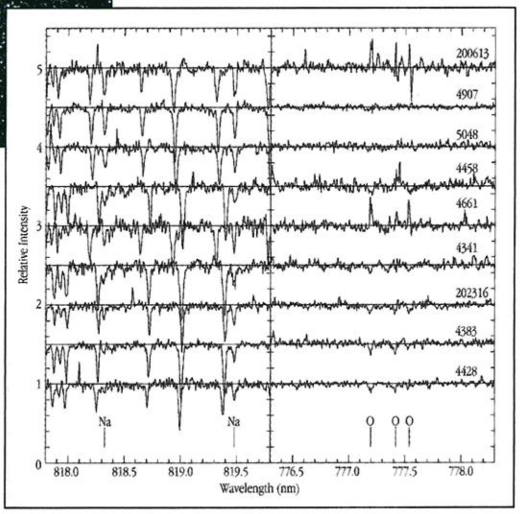
Stars Rise From Ashes In Globular Cluster

If you think cleanliness is next to godliness, avoid globular clusters. These huge, spherical concentrations of millions of old stars are among the filthiest places in the universe, according to a new study by Italian astronomers. Like houses in an industrial area, the stars in a globular cluster are polluted by the exhausts from nearby chemical plants.

In a paper to appear in *Astronomy and Astrophysics*, Raffaele Gratton of the Astronomical Observatory of Padua and his colleagues describe their discovery of polluted stars in a globular cluster known as NGC 6752, some 13,000 light-years from Earth in the southern constellation Pavo the Peacock. The cluster is about 100 light-years across and contains millions of stars, which are hundreds of times closer together than the stars in the solar neighborhood. From the Southern Hemisphere, it can easily be seen with a pair of binoculars.

Gratton and colleagues used a sensitive spectrograph on the European Southern Observatory's (ESO's) 8.2-meter Kueyen telescope in Chile (part of the Very Large Telescope) to study the chemical makeup of 18 dwarf stars—stars about the size of the sun—in NGC 6752. Because the stars in a globular cluster are believed to have formed simultaneously from the same cosmic ingredients, you would expect them to have a similar spectral fingerprint. Instead, the team found huge star-to-star variations in the composition of the stars' outer layers.





Born again. Spectrographs of dwarf stars in globular cluster NGC 6752 showed that some contain recycled ingredients.

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For giant stars, that wouldn't be too surprising. Their high internal temperatures churn up their insides vigorously enough to carry the "ashes" of a star's nuclear burning processes from its core to its surface. But that can't be happening in dwarf stars, says team member Luca Pasquini of ESO in Garching, Germany, because they're not hot enough. So what causes the anomalous abundances?

One clue comes from the observations that the stars in the cluster show "anticorrelations" between certain elements. Dwarf stars that are high in oxygen tend to be low in sodium, and vice versa. A similar relation holds for magnesium and aluminum. Sodium and aluminum form relatively late in a large star's life cycle, when oxygen and magnesium tend to be depleted.

The astronomers concluded that the dwarf stars had picked up their heavy elements from hot, massive, short-lived stars that perished billions of years ago, when the cluster was young. Mixing carried the processed material from the massive stars' cores to their outer layers. Later, the dying stars ejected those layers as planetary nebulae—vast, slowly expanding shells of gas that polluted the space between the stars in the cluster and contaminated nearby dwarf stars. Pasquini thinks the "dirty" stars may have become 10% to 30% more massive because of the stellar pollution.

The new observations challenge a scenario proposed 20 years ago by Gary Da Costa of the Australian National University in Canberra and Peter Cottrell of the University of Canterbury in Christchurch, New Zealand. Da Costa and Cottrell thought the giant stars had polluted the cluster gas even before the dwarf stars formed out of it. Pasquini says it's hard to see how dwarf stars in a globular cluster could have formed much later than giant stars, as that model requires. But he acknowledges that the evidence so far is inconclusive. "We really need a better statistical sample to distinguish between the two models," he says. Da Costa agrees: "This is an important discovery. What needs to happen now is further work to understand how this process works [in detail]."

Stellar pollution has never been observed before, except in binary star systems. In the galaxy at large, astronomers say, stars are too far apart to intercept the ashes from old stars before they slowly disperse into space. But in massive globular clusters, stars are much closer together, and their combined gravity is strong enough to keep most of the "space pollution" in the neighborhood. Gratton's team also studied eight dwarf stars in a less massive cluster, NGC 6397, but found no pollution there, probably because the exhausts of dying stars have escaped the cluster altogether.

Pasquini says it's unclear how contaminants might be affecting the life cycles of the tainted stars: "We are just starting to investigate this. We'll have to run the [stellar evolution] models to see in detail what's going on."

–GOVERT SCHILLING

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