## Starlight spotlights galaxy's slow start

A study of starlight from two of the Milky Way's oldest structures strongly supports the notion that our galaxy took three times longer to evolve than estimated by a widely accepted theoretical model.

During the past decade or so, several researchers have speculated that the young Milky Way may have taken as long as 3 billion years to collapse from a spherical cloud of gas into its present disk shape. This contrasts with a standard theory proposed in 1962, which calculates the collapse time at 1 billion years.

The researchers based their revised timetable on differences in the color and brightness of stars, including some residing in globular clusters—ancient, densely packed stellar regions that surround both the central bulge and periphery of the Milky Way (SN: 4/6/91, p.218). In particular, several teams of astronomers in 1989 and 1990 asserted that differences in the properties of stars from two globular clusters, NGC 288 and NGC 362, could best be explained if the clusters were separated in age by 3 billion years. Since globular clusters rank among the first objects formed in the Milky Way, the proposed age span would require the galaxy to take at least that long to evolve from a gaseous sphere to a disk.

Critics countered that this evolutionary scenario left open a major loophole. The observed differences in stellar color and brightness, they argued, might instead result from a variation in chemical composition among stars in the two clusters. If the two clusters had the same age but different compositions, then the standard theory of formation would still hold for the Milky Way.

An international research team has now gathered data that appear to close the loophole. Roger A. Bell of the University of Maryland in College Park and his colleagues used a high-resolution spectrograph to analyze the visible light emanating from the surfaces of a total of 15 red giant stars in the two clusters. In the May 16 NATURE, they report that NGC 288 and NGC 362 have nearly identical chemical compositions, supporting claims that the clusters indeed differ in age by 3 billion years.

Bell notes that astronomers previously estimated that both clusters had a relatively low ratio of iron to hydrogen. But his team's spectroscopic study, conducted at the Anglo-Australian Telescope in Siding Springs, Australia, used a different strategy to determine and compare chemical composition. For the first time, the researchers measured the abundances of three key elements — carbon, nitrogen and oxygen — relative to the abundance of hydrogen.

As a stellar core burns hydrogen, nuclear reactions convert one element to another, changing their relative abundances in the star's interior, Bell explains. Eventually, the modified composition may alter the elements' relative abundances on the surface of the star, masking the star's original chemical make-up, he says. This makes it difficult to determine whether one star really began with a composition similar to another.

But a star's *total* abundance of all three elements remains constant and thus provides a more reliable guide for comparison, Bell says. When he and his collaborators added up the abundances of carbon, nitrogen and oxygen for each of six stars from NGC 288 and nine from NGC 362, they found nearly equal total abundances among all the stars — clinching the argument that the two globular clusters have a similar chemical make-up.

"The significance of this paper is that it shows chemical composition is not involved [in the observational differences between stars in the two clusters]," comments Leonard Searle of the Carnegie Institution of Washington in Pasadena, Calif. "That certainly increases the presumption that age is what *is* involved."

Searle, who first suggested in 1978 that our galaxy took 3 billion years to evolve into a disk, speculates that a longer-than-expected time interval for the Milky Way's evolution indicates that it may have formed from the merger of two galaxies.

Bell says his group plans to confirm and expand the new results by analyzing the chemical composition of stars in other Milky Way globular clusters.

*— R. Cowen*

### Rice: Methane risk rises

**Climate change analysts have estimated that rice paddies contribute about 14 percent of the methane — a major greenhouse gas — emitted into the atmosphere by human activities each year. But that calculation, based largely on Western data, may substantially underestimate the global warming threat posed by rice cultivation.**

**A new study suggests that Chinese fields—which produce about 185 million tons of rice annually, or 36 percent of the world's total — may generate four to 10 times more methane than U.S. or European fields.**

**Scientists from the Oregon Graduate Center in Beaverton and Academia Sinica's Institute of Atmospheric Physics in Beijing, China, collaborated on a two-year study of methane emissions from rice paddies in TuZu, a rural village in the heart of the Sczhuan province. Alternating between morning and afternoon sampling periods, the researchers measured methane emissions from six sites in four separate fields every other day throughout two 120-day growing seasons. The roughly 13,000 separate readings indicate that the TuZu paddies emit roughly 60 milligrams of methane per square meter each hour.**

**This overall methane emission rate is five times higher than that of U.S. rice fields, 3.75 to 8.5 times higher than Italian fields and 15 times higher than Spanish fields, report M.A.K. Khalil and his coauthors in the May ENVIRONMENTAL SCIENCE & TECHNOLOGY. The researchers note, however, that methane fluxes vary considerably throughout the growing season. The TuZu fields emitted about 15 percent more methane in the afternoon than during the morning, for instance, and their offgassing rate tended to increase as the growing season progressed. The rates plummeted once the plants reached maturity and outdoor temperatures fell.**

**As the collaborators continue their studies, they hope to tease out the extent to which climate, soil conditions, fertilizer type and rice variety affect a paddy's methane releases.** □

## Enigmas overturned by Chinese fossils

With the help of a new fossil discovered in China, paleontologists are starting to make sense out of some of the most problematic and bizarre animals known in Earth's history. Several of these strangers from 530 million years ago — previously viewed as failed evolutionary experiments, with no counterparts in the modern world — now appear to fit into an existing animal phylum.

The newly found caterpillar-like animal is among the latest prizes to emerge from an extraordinary set of fossil beds in the Chengjiang area of southwestern China. The dozens of species discovered so far within these rich formations are painting a picture of life in the early Cambrian period, which began just after the evolutionary "big bang" that gave birth to almost all the major groups of modern multicellular animals.

For decades, paleontologists have labored to understand the Cambrian's oddball creatures, which don't fit readily into existing animal phyla. Using the new, as-yet-unnamed Chinese fossil as a guidepost, two researchers now suggest that some of the most enigmatic of these animals belong to the phylum Onychophora, which in the modern world includes the velvet worms of the tropics. Lars Ramsköld of the Swedish Museum of Natural History in Stockholm and Hou Xian-guang of the Nanjing Institute of Geology and Paleontology in China describe their findings and conclusions in