ASTRONOMY

Did Galaxies Bloom in Clumps?

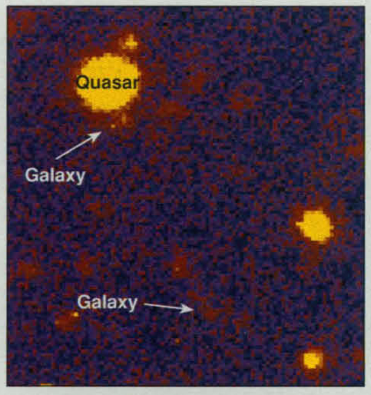
WASHINGTON, D.C.—The beginnings of the great clusters and walls of galaxies seen in today's universe may date back practically to the big bang. By searching the neighborhood of distant quasars—galaxylike objects so bright they can be seen shining from a time when the universe was less than a billion years old, or 10% of its current age—astronomers have found that nearly every one has a fuzzy companion galaxy or two. These small gatherings in the infant universe, says team leader George Djorgovski of the California Institute of Technology in Pasadena, are "the possible cores of future rich clusters of galaxies."

They are also a challenge to the notion that the clumpiness of today's universe emerged fairly recently. If the universe contains as much mass as some theorists believe, the formation of dense clusters would have been retarded by the gravity of the surrounding universe. But the belief in a dense universe has already taken a blow from the discovery of great walls of galaxies when the universe was just 2 billion years old (*Science*, 4 April 1997, p. 36). Now, Djorgovski thinks he can discern large-scale structures even earlier in cosmic history.

Like all astronomers wanting to probe the farthest reaches of the universe, the team had to rely on quasars, because they are so much brighter than ordinary galaxies. At great distances (also referred to as high redshifts because light originating there is drastically reddened by the expansion of the universe), observers have cataloged dozens of quasars. But because only a small fraction of galaxies flare up as quasars, these objects by themselves can't reveal clustering in the early universe. That would be like trying to learn where cities are concentrated by mapping only the ones that have a Q in their name. So Djorgovski's team used the light-gathering power of the 10-meter Keck telescope at Mauna Kea, Hawaii, to search the surroundings of the most distant quasars, at redshifts of between 4 and 5, for neighboring faint galaxies at the same distance.

"This is very much work in progress," says Djorgovski, who presented the preliminary results early this month at a meeting of the American Astronomical Society here. "Only some 10 quasar fields have been studied so far, but in nearly every case, we found at least one companion galaxy at the same redshift as the quasar. This is the first clear detection of primordial large-scale structure at redshifts larger than 4." Djorgovski points out that the quasar companions found by his team are not yet full-fledged galaxies. "There hasn't been enough time [since the big bang] for these things to be anything else than primordial protogalaxies," he says.

Charles Steidel of CalTech, who identified galaxy groupings at redshifts of about 3, when the universe had reached the 2-billion-year mark, isn't sure that Djorgovski's team really has discovered the precursors of the structures he sees. "They're using a different approach, observing only very small fields," he says. And Neta Bahcall of Princeton University is troubled by Djorgovski's finding that the distant quasars seem to have more companion galaxies than quasars at lower redshifts. "This is not what you expect, since further clustering [over time] would only increase their numbers," she says. But Bahcall, who advocates a low-density universe, agrees that Djorgovski has found strong evidence for very early clustering.



S. G. DJORGOVSKI *ET AL.*/CALTECH/KECK OBSERVATORY

Togetherness. Fuzzy protogalaxies cluster near a brilliant quasar.

The observations suggest that only scattered regions of the early universe were dense enough for galaxies to form, so the first galaxies naturally appeared in clumps. "These are very special places in the universe," says Djorgovski. "Chances are that we miss most of them when we observe random spots on the sky." If so, astronomers looking for action in the early universe need to follow the bright lights of quasars.

–Govert Schilling

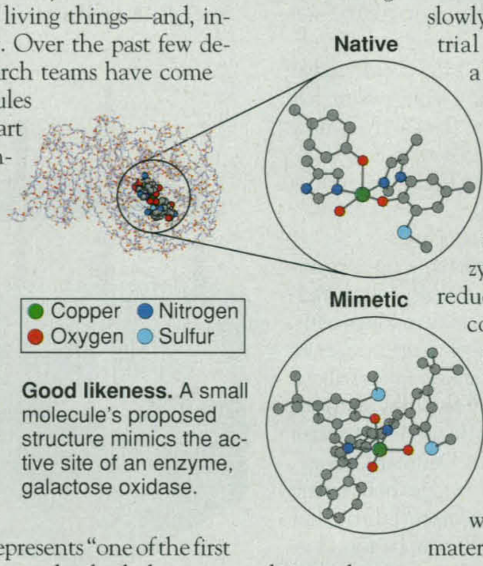
Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

CHEMISTRY

Mimicking an Enzyme in Look and Deed

Making model airplanes and ships look like the real thing requires a delicate touch. But getting those models to actually fly or sail requires another level of sophistication entirely. So it is with efforts to create durable small molecules that look and act like enzymes, the biological catalysts that carry out a multitude of chemical reactions in living things—and, increasingly, in industry. Over the past few decades, numerous research teams have come up with small molecules that resemble the heart of one enzyme or another. But even when these models catalyze the same chemical reactions as the enzymes, they rarely do so in the same way. And those models that faithfully duplicate an enzyme's function rarely resemble their mentor.

Now, a new model catalyst, reported on page 537 of this issue, represents "one of the first good examples to bring together both the structural and reactivity aspects," says Tom Sorrell, an organic chemist and enzyme modelmaker at the University of North Carolina, Chapel Hill. This model, the work of a five-member team at Stanford University led by inorganic chemist Dan Stack and structural expert Keith Hodgson, mimics the active site of an enzyme known as galactose oxidase. Like the enzyme, it works at ordinary temperatures and pressures to transform one set of organic compounds—alcohols—into other compounds called aldehydes, which serve as intermediates for making still other essential compounds. It "is quite an impressive piece of work," says Harvard University inorganic chemist Richard Holm.



Y. WANG AND D. STACK

Good likeness. A small molecule's proposed structure mimics the active site of an enzyme, galactose oxidase.

The new galactose oxidase mimic works too slowly to be useful in industrial processes, where the alcohol-to-aldehyde conversion is a first step in making everything from drugs to perfumes. But Holm and others say it may point the way to other enzyme mimics that could reduce the complexity and cost of many industrial reactions—as well as lower their output of unwanted, polluting byproducts. Properly designed model catalysts could work on a wider range of starting materials and in harsher conditions than enzymes can. And models that have the same basic structure as the corresponding enzymes are most likely to be efficient enzyme mimics, says Stack. "Nature has already solved the problem of how to run certain reactions. All we need to do is copy her."

Key to the function of both galactose oxidase and the new model is a single copper atom at the core of each compound. Copper, like other metals, is good at snatching elec-