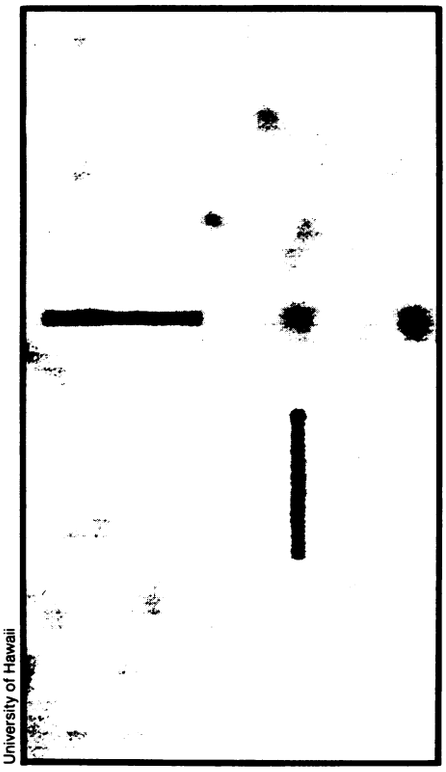
lated from the speed, but the computation uses the Hubble constant, which is so difficult to determine that astronomers cannot agree on its value. The value taken by Lilly makes the universe 15 billion years old, and on this basis 0902+34 is 12 billion light-years away. Other values of the Hubble constant yield ages for the universe between 10 billion and 20 billion years. Adopting any of them would change the distance to 0902+34 proportionately.

By whatever distance estimate, 0902+34 is far enough back in time to make trouble for a class of currently high-interest cosmological theories, the cold dark-matter theories, says Len Cowie, assistant director of the Institute for Astronomy at the University of Hawaii. Astronomers have a number of reasons for believing that a large amount of unseen, undetected matter pervades the universe. In most models this dark matter is composed of subatomic particles, neutrinos or maybe something more exotic. These models are divided into two classes according to whether the dark matter is hot or cold. The cold dark-matter theories appear to be the most popular at the moment, but the discovery of 0902+34 could make trouble for them, since they do not allow for galaxies as well formed as this one existing at such an early epoch.

Speaking from Mauna Kea, where he was observing, Lilly told SCIENCE NEWS that the discovery arose as part of a project to survey certain radio sources to see whether optical counterparts could be found for them. Since 1986 he has been concentrating on the dozen most promising ones chosen from his original sample. Object 0902+34 is the only one of the dozen or so that looks like a galaxy. A report will appear in ASTROPHYSICAL JOURNAL.

Although radio sources like 0902+34 are usually associated with very luminous galaxies, none appeared for this one when it was first studied in 1982. In his work on the object, Lilly used two telescopes, both on Mauna Kea, and a variety of recently developed, very sensitive recording equipment. In 1985, using the United Kingdom Infrared Telescope, Lilly detected a faint infrared source at the position of the radio source. Then, with the Canada-France-Hawaii Telescope, he got a visible-light image. Returning to the United Kingdom Infrared Telescope, he used a newly available infrared array camera to make an infrared image of the object. Finally, back at the Canada-France-Hawaii Telescope, he used a newly developed faint-object spectrograph, which obtained a spectrum that showed a strong emission feature.

This feature can be identified with a resonance of atomic hydrogen, whose emission, at rest in the laboratory, appears at an ultraviolet wavelength. In 0902+34 it is shifted completely across the visible range into the infrared, and from this Lilly calculated the redshift of 3.4.



University of Hawaii

Black bars point to 0902+34, the farthest galaxy yet.

The spectrum of 0902+34 indicates that the light comes from stars, and therefore the object is a galaxy. Among several indicators that support the conclusion, says Lilly, is the uniform brightness of the spectrum in the optical range — "too flat to be a quasar," the only other class of objects astronomers are used to seeing at such redshifts.

From the spectral evidence Lilly concludes that 0902+34 contains two distinct populations of stars. One is young blue stars, indicating that the galaxy is converting annually about 100 times the sun's mass of interstellar matter into new stars. The second population, accounting for more than 90 percent of the galaxy's mass, is mature reddish stars at least 1 billion to 2 billion years old. These are responsible for the stronger emission at infrared wavelengths than at visible ones.

The antiquity of the galaxy and of the stars within it make it very important for theories of cosmology and for models of the formation and development of galaxies and of stars. "The importance of 0902+34 for cosmological theories cannot be overemphasized," says Cowie. Donald N.B. Hall, director of the Institute for Astronomy, remarks that it will be important to determine whether 0902+34 is an anomalous object or one of a class. Are there other galaxies with similar redshift and similar appearance waiting to be found? The continuing development of more sensitive recording equipment and, in a few years, the launching of the Space Telescope and the completion of the 10-meter Keck Telescope, also on Mauna Kea, may make it possible to find out.

— D.E. Thomsen

Corn yields to genetic tinkering

California researchers have achieved a long-awaited first by growing corn plants genetically engineered to carry a foreign gene.

Inserting foreign genes into plants is not new; scientists have been engineering broad-leaved, dicot plants such as tobacco and tomatoes for more than a decade. But until now the monocot grain crops, such as corn and rice, have been notoriously hard to engineer. These difficulties have left the world's important cereal crops almost untouched by advances in genetic engineering.

In the recent work with corn, scientists at the Sandoz Plant Protection Corp. in Palo Alto, Calif., inserted a gene for antibiotic resistance into specially prepared corn-plant cells called protoplasts, and grew the protoplasts into whole corn plants. Each cell in the new plants carries the foreign gene.

Years of painstaking research led to this success. First, other scientists got foreign genes to pass into corn protoplasts but couldn't get the protoplasts to grow into full plants. Early this year researchers reported that they had grown genetically unaltered corn protoplasts into full corn plants. The growth of full plants from genetically altered protoplast, reported in the April 8 issue of SCIENCE, was the logical combination of these results.

The corn plants' resistance to the antibiotic is not useful in itself, but the antibiotic-resistance gene can be paired with a more useful gene. Then the presence of antibiotic resistance will show which plants have also taken up the useful gene. Genes for resistance to herbicides and to corn-eating pests are likely candidates for future insertion into corn plants. Now that corn has been engineered by this method, other cereal crops may soon follow, according to Carol Rhodes, one of the report's authors.

There remains one major problem with the engineered corn plants: They produce no corn. The researchers, however, think this may be just a result of the techniques used and say they expect this problem to be solved in the future. "I don't know how long it will be," says Rhodes, "but it's definitely going to happen."

— C. Vaughan