Cosmic lenses magnify distant galaxies

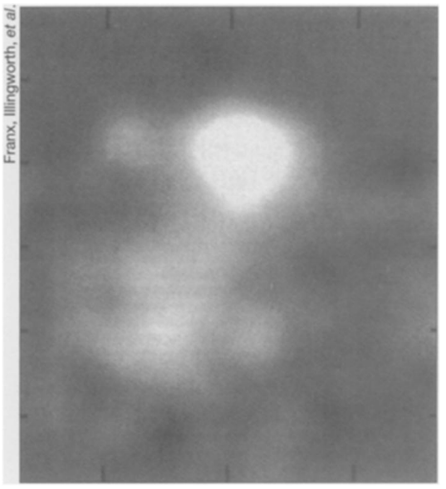
In the past 3 years, astronomers have discovered a universe of distant galaxies—some 600 starlit bodies that lie at least 8 billion light-years from Earth. They hail from a time when the cosmos was less than one-third its current age. As important as that population of galaxies has become for understanding the early cosmos, studying these objects has a drawback. Precisely because they lie so far away, distant galaxies appear too small and too faint for astronomers to observe in detail.

Thanks to the cosmic equivalent of a zoom lens, however, 15 newly discovered distant galaxies loom bigger and brighter than the rest. Magnified some 20 times, images of these galaxies have revealed a surprising secret. Each possesses a mammoth, high-speed wind that blasts material into space. These winds send out a hot gas rich in the materials that astronomers call metals—carbon, oxygen, silicon, and heavier elements.

The billowing winds are so vast that they could account for the entire quantity of metals in the young cosmos, says Tom J. Broadhurst of the University of California, Berkeley. He reported the findings this week in Paris at the Texas Symposium on Relativistic Astrophysics.

To probe the structure of distant galaxies, Broadhurst and his colleagues relied on a phenomenon that Albert Einstein pointed out in the 1930s. According to his theory of general relativity, gravity bends light and a massive object distorts and magnifies light from an object behind it.

The astronomers recently focused on three massive, relatively nearby clusters of galaxies known to act as gravitational lenses. They observed reddish arcs, indicating that the clusters bent light from distant galaxies. To examine the area, Broadhurst's team used a spectrograph on the world's largest visible-light telescopes, the twin Keck telescopes atop Hawaii's Mauna Kea. The spectra of the magnified images showed that the galaxies rank among the most distant known,



Franx, Illingworth, et al.

Image of a distant galaxy magnified and distorted by a gravitational lens.

residing at least 10 billion light-years from Earth.

The cosmic enlargement enabled the team to study light from the galaxies in unprecedented detail. The researchers found that the galaxies are about one-tenth the size of the Milky Way and form stars in a few, widely distributed clumps.

Broadhurst and Brenda Frye of Berkeley reported on the first of the galaxies they observed in the June 1 ASTROPHYSICAL JOURNAL LETTERS. After studying the spectra of light from several more galaxies, they have concluded that each has a superwind containing an abundance of metals. The winds stream out at speeds of 300 to 400 kilometers per second. Broadhurst suggests that type II supernovas, explosions of massive stars, produced both the metals and the powerful winds that drove them out into space.

The hot winds of ionized material from the galaxies "crashed into each other, and they polluted the whole of the intergalactic medium" of the early universe, Broadhurst says. He notes that this distribution could explain a long-standing puzzle: Why is the gas bathing today's clusters of galaxies so rich in metals? Broadhurst proposes that clusters incorporated metal-enriched gas that had been made by galaxies in the early cosmos.

According to a rival theory, galaxies produced the metals after they had already congregated in clusters. However, the supernova explosions required would have been so forceful that the metal-enriched gas generated would have been ejected from the clusters, Broadhurst says.

Garth D. Illingworth of the University of California, Santa Cruz and his colleagues published an earlier report on a distant galaxy magnified by a gravitational lens. Although the chance alignment between a distant galaxy and a lens is rare, he predicts that galaxies viewed that way will be "valuable pathfinders to star formation and the internal structures of [the first] galaxies." *—R. Cowen*

Ancient ancestor reveals skeletal stamina

A new fossil find in South Africa represents the most complete skeleton to date attributed to the australopithecines, an extinct line of two-legged, small-brained creatures who were early members of the human evolutionary family.

Anthropologists last week announced their discovery of the largely intact skull and lower body, which they found in an underground cave. A brief description of the skeleton appears in the Dec. 10 NATURE. The October SOUTH AFRICAN JOURNAL OF SCIENCE contains a more detailed account by Ronald J. Clarke of the University of the Witwatersrand in Johannesburg.

Clarke supervised two colleagues who found the australopithecine specimen after descending about 45 feet into the Silberberg Grotto of the Sterkfontein caves. Prior excavations elsewhere at Sterkfontein yielded fragmentary remains of *Australopithecus africanus*, a human ancestor of uncertain evolutionary status dating approximately to between 3.2 million and 2.4 million years ago.

"This is a remarkable find," says Witwatersrand's Phillip V. Tobias, who directs all Sterkfontein excavations. "We don't know its species or sex yet, but it looks like an adult australopithecine."

Clarke found foot bones from the skeleton while working at Silberberg Grotto in 1994. He discovered more parts of the same foot stored in boxes from prior excavations there (SN: 7/29/95, p. 71).

Clarke then organized another exploration of the site. Investigators identified many of the individual fossil's limb, hip, and back bones, as well as a nearly complete skull, protruding from limestone in the cave. The skull's jaws bear full sets of teeth.

It will take at least a year to remove the entire skeleton from its rocky resting place, Clarke says. He plans to examine the limb joints to test the theory—so far, based only on the foot bones—that this creature combined upright walking with considerable tree climbing.

Analyses of magnetic properties of limestone, taken from below and above the fossil, place it between 3.2 million and 3.6 million years old.

Until now, the most complete australopithecine skeleton was that of Lucy, a 3.2-million-year-old find assigned to *Australopithecus afarensis*.

"This new skeleton contains important information about the size and shape of the australopithecine body that's been hard to come by," remarks anthropologist Bernard Wood of George Washington University in Washington, D.C.

Wood suspects that the specimen belongs to *A. africanus*, which in his view lessens its potential for generating evolutionary insights. Lower-body remains from at least one other australopithecine species at Sterkfontein from the same time, he asserts, would allow for the identification of species-specific limb features. *—B. Bower*

Clarke

Skull from new South African fossil find.