Quasar Hunt Bags Unusual Quarry

Twin images of a distant quasar yield double payoff

By RON COWEN

When Richard McMahon and Michael Irwin began searching photographic plates for faraway quasars, they had no idea they would discover the most distant cosmic mirage ever detected.

The British astronomers and their colleague, Cyril Hazard of the University of Pittsburgh, started hunting for distant quasars in 1986, using a new tool: a computerized scanning machine that enabled them to examine some 50 million images on photographs taken by the U.K. Schmidt Telescope in Epping, Australia. The study revealed several intriguing, star-like entities that glowed brightly in red light but dimly in blue – characteristics of distant quasars, notes McMahon, of the University of Cambridge in England.

Follow-up observations with telescopes in the Canary Islands of Spain further illuminated the findings. By 1990, McMahon, Hazard and Irwin, of the Royal Greenwich Observatory in Cambridge, had confirmed that 11 of the star-like objects were indeed distant quasars, which lie many billions of light-years from Earth yet appear unusually bright on photographic images. Last year, the researchers announced that they had found additional quasars, for a total of 33 of the most distant objects ever detected in the universe (SN: 6/15/91, p.375). Since looking into deep space is the same as peering back in time, these findings indicate that ultrabright quasars formed when the universe was less than 10 percent of its current age, says Irwin.

This menagerie of unusually bright, very distant quasars poses a further problem for astronomers already struggling to understand what happened soon after the birth of the universe, says cosmologist Edwin L. Turner of Princeton (N.J.) University.

Turner and most other scientists assume that the universe got its start in a violent explosion, the Big Bang. Immediately afterward, the universe would have consisted of an extremely uniform, smooth soup of material. This scenario seems at odds with the lumpy collection of galaxies and clusters of galaxies known to reside throughout nearby regions of the universe. (Indeed, researchers have had to invoke the theoretical existence of an invisible matter, called cold dark matter, that would supply the needed gravitational tug to turn a soupy universe into a lumpy one.) But if large numbers of very bright quasars, along with their parent galaxies, were fully developed a mere billion years after the Big Bang, then even the standard theory of cold dark matter might not explain the formation of large-scale structure in the universe, says Turner.

Most astronomers believe quasars arise from the activity of an unimaginably powerful energy source at the center of galaxies – perhaps a black hole devouring its surroundings. The brighter the quasar, the more powerful the energy source and, presumably, the bigger the parent galaxy. So the existence of bright quasars early in the universe would imply the existence of large, fully grown galaxies in that epoch.

As a way out of this cosmological conundrum, some scientists have suggested that the quasars found by McMahon, Irwin and Hazard aren't as bright as believed. Rather, the researchers might have been fooled by gravity.

Albert Einstein was the first to describe such a gravitational illusion, which relies on the principle that mass bends light. Like a mischievous sprite, a galaxy or other massive object situated between the quasar and Earth can act as a gravitational lens, focusing diverging light rays from the quasar, intensifying the quasar's image and even creating multiple images of the distant object. Thus, the measured brightness of a quasar image on a photographic plate might not reflect the true brightness of the object.

Intrigued by this possibility, McMahon and Irwin decided to take a closer look at their data. Last February, using two large telescopes atop Hawaii's Mauna Kea, they examined at high resolution 12 of their sample of 33 bright and faraway quasars. Searching for lensing by looking for closely spaced, double images of any of these quasars, they found evidence that light from only one of the 12 had been bent by a foreground galaxy. McMahon and Irwin reported their results in April at the first annual meeting of the Royal Astronomical Society in Durham, England.

McMahon emphasizes that the other 11 quasars may undergo a small amount of lensing that the Mauna Kea telescopes couldn't detect. But the study suggests that the majority of quasars in the sample, including the two most luminous bodies, are about as bright as originally calculated, he notes. "We weren't being fooled," McMahon says. Thus, this quasar collection still presents a challenge to cosmologists.

The lone quasar found to undergo gravitational lensing merits attention in its own right, he observes. Known as BR0952-01, it lies about 12 billion light-years from Earth and has earned the title of the most distant object known to undergo lensing – beating out a lensed quasar recently detected by the Hubble Space Telescope (SN: 2/1/92, p.79). This newly identified quasar, which emits a million billion times as much light as the sun, appears about four times as bright as it would without lensing. In particular, an unidentified foreground galaxy splits the quasar's image into two components separated in space by one arc-second – equivalent to a separation of about 10,000 light-years at the estimated location of the foreground galaxy. The primary image generated by lensing has about three times the quasar's true surface brightness, while the secondary image roughly matches the quasar in brightness.

The split images and the quasar's great distance from Earth provide astronomers with a unique tool for examining the intergalactic medium, McMahon says. Researchers have routinely used quasars as cosmic flashlights, probing the location and composition of gas and dust that lie between these brilliant bodies and Earth. For instance, a giant cloud of hydrogen gas would make its presence known by absorbing a particular wavelength of light from the quasar, depending on the cloud's distance from Earth. The presence of many clouds at different distances creates a thicket of absorption lines, called the Lyman alpha forest, within the spectrum of light emitted by the quasar. Last year, the Hubble telescope analyzed the spectra of several quasars and discovered that the neighborhood of our galaxy contains a surprising abundance of hydrogen clouds (SN: 5/25/91, p.326).

No one knows the dimensions of any of these mysterious clouds, which could represent material that somehow failed to coalesce into galaxies. But the lensing properties of BR0952-01 may allow astronomers to gauge their size.

McMahon suggests that Hubble, and perhaps some ground-based telescopes, could analyze the spectrum of light from each quasar image. Light from each image stems from a different part of the quasar and takes a slightly different path to Earth. So, if light from both images carried the same fingerprint – the same absorption line – this would indicate that the hydrogen cloud was wide enough for both beams to pass through it. Similarly, if light from only one image contained a particular absorption line, it would mean that the cloud was smaller than the separation between the images. While arduous, such measurements promise to shed new light on the structure of these intriguing clouds, McMahon says.

In the meantime, he and his co-workers plan to extend the lensing survey to include their entire list of distant quasars. They expect to find that only a few additional quasars undergo lensing.

For McMahon, the cosmological implications of the study remain paramount. "We're detecting a universe that was much more lumpy [early on] than people had hypothesized," he says. □

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quence of evolution since the Big Bang. If we do not believe that events one hour hence are unalterably occurring "somewhere," why should we believe that the events of one hour ago are still "out there," controlling the future for the folks *two* hours ago? Each time span since the beginning has its own history – its own totally different universe.

It may be disheartening to accept that there is no place "over the rainbow" we might get back to where JFK is still alive or the Titanic sails the seas, and it is perhaps a little frightening to realize that, were we to slip a microsecond in time, there would be no United States, no Earth and no Milky Way (I think), but it sure solves a lot of time travel paradoxes. I will defer to larger brains to explain how time dilation fits into this model, and whether or not it works at all in non-Big Bang universes.

Charles D. Feldman
Lindenhurst, N.Y.

The laws of physics are descriptive, not prescriptive. They do not "allow" anything. Time travel to the past is not possible because time's arrow runs forward only. Because chemical and nuclear reactions can be reversed or because equations can be solved in either direction does not mean time goes in both directions. Just because with language (math or words) we *can* express truths does not mean language *must* express truths.

A solution to an equation is sensible only if it describes what actually is. We sometimes tend to forget this fact about "laws" of nature.

P.M. deLaubenfels
Corvallis, Ore.

Arsenic on tap

A recent assessment by the California Environmental Protection Agency ("Arsenic in water: Bigger cancer threat," SN: 4/18/92, p.253) revealed that the current federal guideline of 50 parts per billion of arsenic allowed in drinking water has a 1 in 100 chance of causing cancer. The study also indicated that this environmental hazard is just as serious as being exposed to radon gas or secondary cigarette smoke. The researchers believe that the current standard should be lowered. I most definitely agree.

The current U.S. EPA standard, established in 1976, is apparently outdated because it claims that the risk of developing skin cancer from our drinking water is 2.5 in 1,000. I hope the U.S. EPA will enact new guidelines immediately. If they do not respond soon, our population will continue to be exposed to harmful substances such as arsenic. The most obvious outcome is a major rise in the cancer rate.

Sheila A. Edwards
Sacramento, Calif.

Michael N. Bates and his co-workers at the University of California, Berkeley, have completed a new risk assessment for the ingestion of arsenic-contaminated water. Primarily on the basis of studies of people living on the southwest coast of Taiwan, they conclude in the March 1 AMERICAN JOURNAL OF EPIDEMIOLOGY: "... daily consumption of 1 liter of water containing arsenic at the current U.S. maximum contaminant level [50 ppb] might be associated with an increased lifetime cancer mortality risk of up to 1 in 100." – J. Raloff

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Rightmire's contention that a measurable split occurs between *H. erectus* and *H. sapiens*. Leigh examined 20 *H. erectus* skulls from Africa, China and Indonesia that span a broad time range, as well as 10 early *H. sapiens* skulls. Significant expansion of brain size from the oldest to the most recent specimens occurs in the latter group, whereas the three regional samples of *H. erectus* show no such increases, Leigh reports in the January AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY.

However, analysis of the Chinese and Indonesian skulls reveals substantial brain-size increases that do not necessarily coincide with Rightmire's view of an anatomically stable *H. erectus* inhabiting the entire Old World, Leigh points out.

The single-species view gets further ammunition from another study of 70 hominid craniums, mainly *H. erectus* and *H. sapiens* specimens. The seven derived features considered unique to Asian *H. erectus* by Peter Andrews also appear on many African fossils attributed to *H. erectus*, as well as on a significant number of *H. habilis* and early *H. sapiens* specimens, according to Gunter Brauer of the University of Hamburg, Germany, and Emma Mbua of the National Museums of Kenya in Nairobi.

Although additional anatomical features need study, cladistic procedures mistakenly assume that unique derived traits are either present or absent in all members of a species, Brauer and Mbua contend in the February JOURNAL OF HUMAN EVOLUTION. They emphasize Tattersall's point that the same derived features may occur to a greater or lesser extent in different hominid species. Investigators need better data on variations in the skeletal anatomy of living primates and fossil hominids, they conclude.

Some anthropologists take a dim view of the entire controversy surrounding hominid species. "These fights over species classification are somewhat of a waste of time," says Alan Mann of the University of Pennsylvania in Philadelphia. "Most researchers see *Homo erectus* as a single species that evolved into *Homo sapiens*."

Others argue that fossil bones provide too little evidence for teasing out hominid species.

"Fossil species are mental constructs," contends Glenn C. Conroy of Washington University in St. Louis, who directed an expedition that recently found an approximately 13-million-year-old primate jaw in southern Africa (SN: 6/29/91, p.405). "Cladistic approaches try to separate species out of a vast array of biological variability over a vast time range, and I don't think they're capable of doing that."

Conroy prefers to group hominid fossils into "grades," or related groups tied together by general signs of anatomical unity with no evidence of sharp breaks between species. Thus, an *Australopithecus* grade (which includes the more than 3-million-year-old "Lucy" and her kin) merges into a grade composed of *H. erectus* fossils and then shades into a *H. sapiens* grade, in Conroy's view.

"I'd put our limited funding into looking for new fossil primates or studying living primates, rather than pushing cladograms or arguing about the number of *Homo* species," he asserts.

But anthropologists wrangling over *H. erectus* and other hominid species find room for optimism amid their discord.

"The really interesting question isn't whether *H. erectus* existed," remarks William H. Kimbel of the Institute of Human Origins in Berkeley, Calif., a proponent of phylogenetic analysis. "For the first time in years, we're taking a step back and asking about the theories that underlie our work and the units we use to establish evolutionary relationships. It's a healthy sign that we're debating these questions vigorously." □