Latest Quarry in the Quasar Quest

Just about every time astronomers hunting for the most distant quasars—those brilliant beacons at the fringe of the visible universe—carry their search to even greater distances, they come up with a new record-holder. In March 1990, a team of veteran quasar stalkers working at the 200-inch telescope at Mount Palomar inaugurated a new strategy for searching at unprecedented distances. Now, a year and a half later, the researchers—Donald Schneider of the Institute for Advanced Study in Princeton, Maarten Schmidt of Caltech, and James Gunn of Princeton University—have analyzed their first round of data. The result: a quasar at a red shift of 4.897, unseating the earlier record holder, a red shift-4.733 quasar discovered by the same group in 1989.

The record red shift means that the quasar is so far off (perhaps 12 billion light-years), and hence is speeding away from Earth so fast, that the wavelengths of its light are stretched—reddened—by a factor of almost 6. The quasar gives astronomers their earliest point of reference so far in the infant universe. And it adds to mounting evidence that gargantuan structures—quasars are thought to be massive black holes buried in early galaxies—took shape much earlier than most theories can comfortably explain.

The new record-holder was already shining when the universe was less than 7% of its current age—perhaps less than a billion years old. The cold-dark-matter scenario, in recent years the favored theory of structure formation in the early universe, is hard pressed to explain how something so massive could have formed so quickly from the smooth distribution of matter left by the Big Bang. "You have to stretch to make [cold dark matter] work" for such distant quasars, remarks theorist Jeremiah Ostriker of Princeton, "although of course none of this casts any doubt on the Big Bang itself."

What's more, features of the light from this and the handful of other comparably remote quasars hint at even earlier and more widespread structure than is seen directly. The fact that the quasars are visible at all, says Ostriker, is a sign that most of the neutral hydrogen along the line of sight has been swept away by radiation from other, unseen quasars or by the gravitational pull of early galaxies. And the light from this quasar, like its rivals, shows that it must have had ancestors. Its spectrum bristles with lines revealing the heavy elements carbon, nitrogen, oxygen, and silicon, which must have been forged in earlier generations of stars. "That just pushes the problem [of how these structures formed] even further back in time," says Ostriker.

Finding the new record-holder required a way to comb large swaths of sky in search of quasars' faint but distinctive fingerprints. The project relies on a special-purpose camera, designed by Gunn, called the 4-Shooter. The camera divides the field of view of the 200-inch telescope into four quadrants, which are recorded simultaneously by separate arrays of electronic detectors as Earth's rotation carries the sky past the aperture.

Key to the high-red shift search is a set of filters mounted in the light path: They highlight regions of the spectrum where a telltale quasar feature—an emission line from the glowing cloud of hydrogen surrounding the source—should fall at red shifts of 4 to 5.5. Back at the Institute for Advanced Study, Schneider has been running data from the 4-Shooter through a computer program that picks out objects that are unusually bright at one of the telltale wavelengths. From the 40,000 objects recorded in the first survey, the program picked out 100 quasar candidates. A closer look at these candidates revealed several genuine quasars—including the new record-holder, described in this month's issue of *The Astronomical Journal*.

"The exciting thing," says Schneider, "is that we've looked at only a seventh of our data." Newer results from the 4-Shooter are awaiting analysis, and Schneider thinks this new record won't stand for long. "I think it's inconceivable that this is the most distant quasar." ■ TIM APPENZELLER

Astronomers Get a Whiff of Methanol

When a new star flares to life within a cloud of gas and dust, the cloud often heralds the star birth by producing powerful signals called masers. Excited by radiation from the newborn star, molecules in the cloud emit beams of coherent energy, much like an earthbound laser—only at microwave rather than optical wavelengths. The spectrum of the first celestial maser, discovered in 1965, showed that the energy was being generated by radiating hydroxyl molecules; since then, water, silicon monoxide, and other kinds of masers have been added to the list. These microwave beacons have become astronomers' most reliable tracers of stellar nurseries, which are invisible to optical telescopes.

Now, this celestial tool should become even more useful with the discovery this summer of an unusually strong, low-frequency maser coming from methanol molecules. Weaker methanol masers have been detected before in other regions of the spectrum, but this maser emits such a bright signal that its spectral fingerprint may become the emission "line of choice" for searching for star-forming regions, says Jim Moran, associate director for radio and geoastronomy at the Harvard-Smithsonian Center for Astrophysics.

The discovery, which will be reported in the 20 October *Astrophysical Journal (Letters)*, was made in June by Harvard radio astronomer Karl Menten, who was using the 140-foot radio telescope at Green Bank, West Virginia, to observe microwave emissions from the vicinity of newborn stars. In this particular search, Menten was tuned to a low frequency—6.6 gigahertz. Menten was stunned when he found a signal so strong and so bright that it is now considered the second strongest maser ever detected. "It was a real surprise," says Menten.

Menten is not the only astronomer stunned by the discovery. The 6.6 gigahertz frequency lies in a region of the spectrum familiar to radio astronomers, yet none had picked up the methanol maser's signal. "Here's this tremendously strong signal sitting there for decades," says Moran. "Anybody who tuned in could have found it." Menten speculates that it had been missed because most radio astronomers concentrated on the high-frequency end of the microwave spectrum.

Menten's discovery is creating a stir in part because astronomers had not thought of methanol as an abundant ingredient of star-forming regions. But adding to the excitement, says Moran, is the fact that this maser signal has now turned up in virtually all of the 100 known star-forming regions that Menten has checked so far—indicating that it is an excellent signpost for finding new ones.

The new maser may also be useful for probing the dynamics of known stellar nurseries. Menten explains that methanol masers provide a steady signal that can be observed over time to trace the motion of star-forming clouds. "Such observations promise to reveal further information on the interaction of newborn stars with the warm, dense gas left over from their birth process," says Menten. The strength of the new methanol maser may be the key to future studies. As Menten explains, "With its high intensity, the methanol maser line can be observed in molecular clouds throughout our galaxy, and perhaps even in others." ■ ANN GIBBONS