The Red Shift Yardstick

Are quasars as far away as their great red shifts imply? Is the red shift a valid yardstick for measuring their distance? James E. Gunn has produced evidence that seems to answer yes to both of these questions. On the other hand, Halton Arp has found two unusual galaxies that do not conform to the red shift yardstick. Both astronomers are staff members of Hale Observatories.

The red shift is a carefully calibrated gauge for measuring the distances of galaxies. It is obtained by sorting the light from galaxies into its respective wavelengths and recording them as lines on a photographic plate. The farther away the object, the farther these lines are shifted toward the red—or longer wavelength—end of the spectrum.

All quasars have comparatively large red shifts, and some are much larger than those of any other object in the universe. The question of how an object that appears to be so bright can be so far away has led some scientists to conclude that quasars must be comparatively nearby. If this is true, it would indicate that their great red shifts may not be valid distance indicators.

One way of solving the problem would be to find a quasar associated with a group of galaxies and then to compare the quasar's red shift with that of the galaxies. If they were similar, it would seem to show that the brighter quasar was really very distant and that the red shifts of quasars are good yardsticks for both quasars and galaxies. This is just what James Gunn has done.

Using the 200-inch Hale telescope at Palomar Observatory, Gunn photographed and obtained the spectrum of a bright quasar in an unnamed cluster of galaxies. He compared the red shift of the quasar and of its associated galaxies and found that they are apparently the same, placing both about three billion light years distant from earth. This finding is direct evidence that quasars are as distant as they seem to be; and it supports the validity of the controversial red shift yardstick for measuring the great distances of the universe.

In the March 15 issue of *The Astrophysical Journal*, Gunn reports his success in making this comparison with one actual quasar and with one quasar-like object—a large galaxy with a quasar-like nucleus.

The quasar Gunn used has the name PKS 2251 plus 11. The PKS means that it was discovered at the Parkes Radio Observatory in Australia and is listed in the Parkes catalog. The numbers give its position in the sky in terms of right ascension and declination.

Astronomer James Gunn has discovered evidence that the red shift is a valid distance indicator for quasars, but...

PKS 2251 plus 11 has all the characteristics of a quasar: It is bright—about ten times more luminous than the brightest galaxies in its cluster; it has a small star-like image; it is blue; and it has a large red shift. It also radiates energy in the radio frequencies as many quasars do.

Near PKS 2251 plus 11 Gunn found an unusual, fuzzy, cloud-like object that may have been ejected from the quasar. Named Ton 256—because it is the 256th object listed in the catalog of Mexico's Tonantzintla National Observatory—this object is now known to be an elliptical galaxy with a brilliant quasar-like object as its nucleus. Comparison of the distances of Ton 256 and of the cluster of galaxies in which it is found again showed the validity of the red shift as a measurement of distance.

Halton Arp's investigation of two very bright—but also very unusual—galaxies seems, however, to controvert the theory. One of the galaxies is considerably larger than the other, and they are apparently connected by a plainly visible arching bridge—presumably of stars—and a second fainter bridge with a much more pronounced arch. According to their red shifts, these galaxies should be a third of a billion light years apart. However, Arp's direct photographs indicate that they are only 30,000 light years from each other.

The red shift of the larger of these galaxies indicates it is some 325 million light years distant from earth. The much greater red shift of the smaller of the two implies a distance of 650 million light years—twice as far away as its companion.

Using a three-hour exposure Arp photographed these companion galaxies with the 200-inch Hale telescope. His findings, reported in the February issue of *Astrophysical Letters*, indicate that neither object is a spiral like our Milky Way Galaxy. The larger one, NGC 7063 (NGC stands for New General Catalog), is a Seyfert galaxy, the kind of galaxy that has a very bright nucleus. The smaller galaxy apparently was ejected from the larger one some 10 million years ago, leaving a trail of luminous material behind it. The larger galaxy is disturbed—with a small, compact nucleus that shows evidence of hot, excited gas. The smaller is brighter per unit area than its companion and is perhaps a compact body of stars.

These are very unusual galaxies, and Arp interprets their red shift as a combination of two effects—of recession and some other effect as yet unknown.

...colleague Halton Arp's discovery of these two unusual galaxies just might controvert the theory.