Cosmology: The First Large Radio Red Shift

Radio telescopes have detected quasars, pulsars, molecules, and exploding galaxies, but until recently old-fashioned optical telescopes were needed to determine how far away were most of the newfound objects. Astronomers who use the great optical telescopes have been fond of pointing out that only their old but versatile instruments could measure red shifts—the indicators of distance in an expanding universe.

The markers by which the reddening is measured are the bright emission lines of hydrogen and other atoms, lines that are usually found superimposed on the continuous spectrum of light from distant astronomical objects. Occasionally, narrow sections of the bright spectrum are darkened when gaseous material intervenes between the source of light and the observer. The darkened lines, or absorption lines, may be shifted just as emission lines are shifted, due to the Doppler effect for receding galaxies. Absorption red shifts have been found for many objects, particularly quasars, but the studies of quasar emission and absorption lines have always been made with optical telescopes.

Last month Morton Roberts and Robert Brown, astronomers at the National Radio Astronomy Observatory, Green Bank, West Virginia, reported that they found an absorption line in the radio spectrum of a quasar. Choosing the most abundant element in the universe as the most likely absorber, Brown and Roberts looked for hydrogen absorption that was shifted toward the red (low-frequency) end of the radio spectrum, and reported that they found it for the quasar 3C 286. The prominent 21-cm radio line of hydrogen, which occurs at 1420 Mhz in our galaxy, would be found at 768 Mhz if it were red shifted as much as the visible emission lines from the quasar. The absorption feature that Brown and Roberts discovered in the radio spectrum of 3C 286 is red shifted almost as much as the visible light: it occurs at 839 Mhz. If the absorbing material is indeed hydrogen, then the radio red shift is 0.69, while the quasar's emission red shift is 0.85.

To make a certain identification of a red shift at optical frequencies, more than one line is desirable. The intrinsic spectra are quite rich with lines, and many different red shifts could explain the position of any single line. The situation is quite different for radio spectra because very few radio lines are observed from astronomical bodies, except toward the center of our galaxy where lines from about 40 complex molecules are found. But 3C 286 is observed at an angle more than 80 degrees away from the plane of our galaxy. According to Roberts, there is a very slight chance that the absorption line is produced by some exotic and unknown molecule, but hydrogen is expected to be the strongest feature.

Accepting the idea that the new line comes fom hydrogen at a large red shift, what is the source of the hydrogen? Roger Lynds, at the Kitt Peak National Observatory, Tucson, Arizona, has suggested that the material that causes optical absorption lines has either been ejected from the quasar or is part of some unrelated object that falls in the line of sight from the earth to the quasar. Lynds thinks that there is some evidence of interaction between absorption line systems at different red shifts that would indicate that the material is ejected. But Roberts and Brown think that the feature they have detected is caused by a galaxy that just happens to be in front of the quasar, because the absorption line they found is extraordinarily narrow.

The width of the radio line indicates that the absorbing material is moving at a uniform velocity, within 8 km/sec. But if the absorbing gas was ejected from the quasar, it must be moving away at approximately one-tenth the velocity of light. Roberts and Brown argue that the ejected gas must have been moving outward for about 1 million years, and that it is highly improbable that the gas could have moved so fast for so long and still have a velocity spread as small as they observe.

On the other hand, the details of their measurements seem to agree fairly well with the assumption that the absorbing gas is part of an intervening galaxy. First, the amount of gas, estimated from the extent of absorption, is comparable to that Roberts had earlier observed for the Andromeda galaxy. Second, the spread of gas velocities is approximately consistent with the spread in Andromeda, 20 to 30 km/sec. But if the object associated with 3C 286 is a normal galaxy, it is farther away than any galaxy that has a confirmed observation with an optical telescope. Most visible galaxies run out at a red shift of about 0.4 because they become too faint for the largest optical telescopes to detect. (H. Spinrad at the University of California, Berkeley, has reported two objects with red shifts of about 0.7 as galaxies, but his measurements have not been confirmed.) Thus, the intervening object, if it is a galaxy, would be more distant than any galaxy whose red shift has been measured.

Finally, Brown and Roberts turn to their data with an eye toward determining whether red shifts are really cosmological (indicative of great distance) for quasars. They say, "As we have no reason to suspect that such an object with a [hydrogen] velocity dispersion of [less than] 10 km/sec is at anything other than its cosmological distance, we infer that at least . . . 81 percent of the red shift of the quasar 3C 286 is cosmological."

Radio telescopes still cannot measure emission red shifts, and the point about the necessity of optical telescopes for measurement of distances is still valid for all practical purposes. But with the combination of several radio dishes to form interferometers, the accuracy of radio positions can match optical telescope accuracy, and when the Very Large Array telescope begins operation near Socorro, New Mexico, in about 5 years, the resolution of radio pictures will routinely be as good as the resolution of optical pictures. The optical telescope is one of the most versatile scientific instruments ever invented, but with the latest encroachments from radio technology, the private domain of the optical astronomer is shrinking fast.—WILLIAM D. METZ