By the Light of Burning Quasars

On its way to us quasar light illuminates some other astrophysical mysteries

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Second of two articles

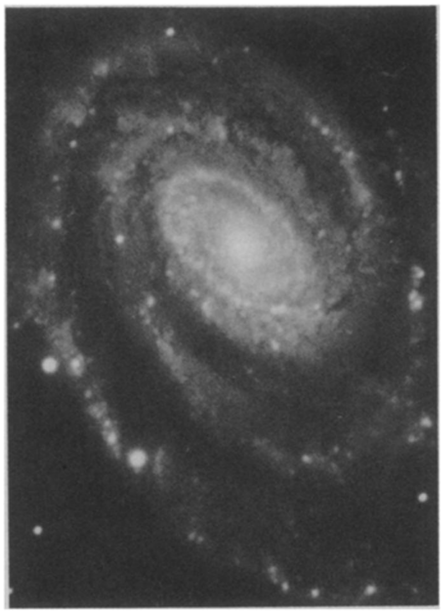
There is probably more unseen matter in the universe than there is matter that we can see. ("See" in this context refers to recording any kind of radiation.) A lot of the unseen matter may be the exotic stuff, miniature black holes or massive neutrinos, that cosmologists have proposed to justify their theories of the history of the universe and the development of clusters of galaxies. That kind of dark matter is invisible on principle. Black holes and neutrinos interact so little with other matter that they are almost unable to betray their presence in any way.

Other unseen matter consists of more ordinary stuff, clouds of gas and dust made of familiar chemical elements and compounds. This variety tends to be invisible because it is too cool to radiate much energy on its own, or its physical condition otherwise prevents it from radiating. Illuminated by a sufficiently strong beacon, it may show up. Matter of this kind has important relations to the evolution of stars and galaxies, so astronomers find its study important.

Quasars seem to be providing the illuminating beacon for such study in some cases. If quasar light passes through such a cloud, say in the dark halo surrounding a galaxy that lies between us and the quasar or in intergalactic space, the cloud will absorb energy from the light in a resonant way and so delete certain wavelengths and stretches of wavelengths from the light. As the quasar light arrives on earth, the missing wavelengths show up as dark lines in the spectrogram of the light. Circumstances of this kind were part of the discussion at the recent meeting of the Astronomical Society of the Pacific in San Diego. So far the analyses of the data seem to be deepening mysteries rather than elucidating them.

As the quasar light is analyzed in observatories, it shows line features that may come from things associated with the quasar itself or from intervening objects. The first thing to decide is which is which. In the case of the series of lines called narrow absorption lines that appear in many quasar spectra, the question was whether the matter doing the absorbing was in clouds near the quasar that had been ejected from it or whether it was in intervening unrelated bodies.

According to Ray Weymann of the University of Arizona Steward Observatory, "the 'interventionists' have won." The absorbing matter appears to be in the haloes surrounding intervening galaxies, that is in clouds of unseen matter surrounding the disk of bright stars that our eyes record. Weymann qualifies that statement by pointing out that the galaxy doing the absorbing cannot always be indentified, and concedes that some cases may be due to ejecta moving away from the quasar at high velocity.



NGC 5364, Palomar Obs.

Assuming, however, that the majority of cases are the work of intervening galactic haloes, both Weymann and Frederic H. Chaffee of the Whipple Observatory in Amado, Ariz., hypothesized about its composition. (Chaffee spoke for himself, Weymann, David W. Latham of the Harvard/Smithsonian Center for Astrophysics and Peter W. Strittmatter of the Steward Observatory.)

A very important question is whether there are metals in these clouds. Metal elements are made in stars. If the metal abundance is low or nonexistent, the clouds may be primordial matter uncontaminated by stellar activity, and of a good deal of cosmological and other interest. There don't seem to be metals. Weymann says these clouds seem to be depleted in metals to between 1/300 to 1/1,000 the typical metal abundances of stars, and he calls this "remarkable."

It gets more remarkable. Chaffee points out that a cloud lacking in metals can cool only by collisions, not by radiation. This means slow cooling. Primordial material starts out hot, and so a metal-free cloud should still be fairly hot, something like 25,000 kelvins. However, Chaffee and coworkers studied the ratios between hydrogen and deuterium in some of these objects using the Multiple Mirror Telescope on Mt. Hopkins in Arizona. ("Seventeenth-magnitude objects," says Chaffee. "Who would have thought five years ago we could do this?") This results are puzzling. They indicate that the cloud temperatures can be no more than 17,500 kelvins. So, says Chaffee, there is "no metal-free cloud that fits the observed limits. The clouds must have metals." But even if metals can be found in the same abundances as on the sun (typical for stellar activity), they might not lower the temperature enough. "Metals may not help us out," he says.

In another attempt to put some kind of limits on the extent and contents of galactic haloes, Arthur M. Wolfe of the University of Pittsburgh studied systems that show absorption lines of two elements, ionized magnesium and ionized carbon. After some consideration he concludes that most magnesium absorbing systems are not associated with galaxies. They may have been ejected and are floating around space where they are "zapped" by quasar spectra.

This scenario resembles the one suggested by Weymann for the systems that contribute broad absorption lines to a few quasar spectra. These would be clouds ejected from spiral galaxies driven by a wind from the quasar. "If you believe this," he says, the clouds could reach velocities of several thousand kilometers a second, and it would not take them long to get out into intergalactic space and even quite far from the parent galaxies. This may be why appearance of such broad emission lines is not too well correlated with the appearance of a galaxy near the quasar.

In the light of quasars, astronomers can also look for clouds in the disks of galaxies, that is, among and around the stars of those galaxies. One way to do this is to look for absorption of 21-centimeter radio waves by neutral hydrogen in the galaxy disk. Wolfe says that in 15 years, 6 such absorbing systems have been found, and three are confirmed as galaxies. There are some dynamical oddities involved, but in all three cases the chemical composition of the gas is consistent with solar abundances, he says.

According to Wolfe the best way to look for galactic disks is not with the 21-cm radiation, but by looking for attenuation of the hydrogen line known as Lyman alpha (in the ultraviolet). One expects to find 10 disks in observing 100 quasars. So far there is only one confirmed instance in studying 35 quasars, and this one is a puzzle. "There are no heavy elements, no carbon or silicon such as we see in our own interstellar medium," he says. The abundance of carbon is less than two ten-thousandths that of the sun.

Puzzlement, mysteries and even a little confusion are not atypical of a field of astrophysics, which like this one, is still fairly new. They mean plenty of opportunity for further work. On a number of mountaintops that exactly what is going on. □