A handful of high-speed quasars

Quasars have repeatedly provided surprises for astrophysicists. Through the telescope, quasars look like stars, but from their first discovery 25 years ago it was clear that they are not stars: They radiate energy at rates equivalent to whole galaxies. Detailed inspection, using the technique known as radio interferometry, shows that quasars tend to consist of a number of blobs, lobes and jets of matter apparently shot out of some central source. In a few cases, some of the blobs seem to be moving faster than light. These "superluminals" have occasioned a lot of discussion, but until recently they appeared to be rare.

Now, a single series of observations doubles their number from seven to 14 and may soon triple it. Six others studied in the survey are likely to prove "superluminal" after another year's observation of their movements.

This sudden population increase means that "superluminals" can no longer be regarded as rarities. They become a class of astrophysical objects that needs a consistent and believable theoretical explanation.

"Superluminal" is in quotes because reputable astrophysicists overwhelmingly do not believe that anything is really moving faster than light. The appearance of superluminal motion is held to be an optical illusion, but the illusion imposes serious difficulties on attempts at an explanation.

Astronomers determine the motions by combining and comparing signals received from a particular quasar at widely separated receiving stations. From the correlations and differences among the signals, they can deduce details of the quasar's structure too fine for a single telescope to make out. In this case, radiotelescopes distributed from California to central Europe were used. Led by Anthony Readhead, director of Caltech's Owens Valley Radio Observatory at Big Pine, Calif., the group includes astronomers from the Max Planck Institute for Radio Astronomy in Bonn, West Germany, and from the Naval Research Laboratory in Washington, D.C. They are submitting reports to ASTROPHYSICAL JOURNAL, NATURE and ASTRONOMY AND ASTROPHYSICS.

Combining such widely spaced receptions, the astronomers draw charts of the detailed structure of the quasar. When they return and observe it again after a certain lapse of time, they find that some of the blobs have moved. In this way, apparent velocities up to seven or eight times that of light have been calculated.

According to the theory of special relativity, no material object can go faster than light, but the same theory yields a way of explaining these motions as almost but not quite at the speed of light. Suppose these "superluminal" blobs are coming toward us, or nearly so. In that case, special relativity provides for a difference in the perception of time: The time in which terrestrial observers see the motion taking place is less than the time perceived by a hypothetical observer riding on the blob, and so the motion appears faster to the terrestrial observer than it does in the blob's frame of reference.

In that way, nothing is going faster than light *in its own frame of reference*, and so the cosmic speed limit is not violated. Nevertheless, this means that some of the observed blobs are going at rates of up to 99 percent of the speed of light in their own reference frames.

If this explanation holds, all the "superluminals" we see must be coming more or less straight at us; by definition it doesn't work for motions at right angles to our line of sight. If we see a large number of "superluminals" pointed at us, then, by the usual randomness of nature, there must be even more that we don't seem to see pointing in various directions — unless the earth is a specially privileged location, an idea that astronomers don't like.

As Kenneth Johnston of the Naval Research Lab points out, there is an explanation why we should preferentially see the ones pointed toward us: "The theory of relativity indicates that any radiation from an object that is moving at nearly the speed of light is strongly beamed in the direction of motion," he says. "Thus objects moving toward us will appear unusually bright, and therefore easy to see, while objects moving at large angles to the line of sight will be relatively faint and difficult to see."

Even so, if the number of "superluminals" continues to climb, this relativistic-illusion explanation may become strained: It will be more and more difficult to believe that so many of the most energetic and violent objects in the universe point themselves right at us. Astronomers may be fooling themselves to think that all these blobs are moving in the line of sight. *—D. E. Thomsen*

Radio interferometry steps off the earth

Radio interferometry has shown astronomers fine structural details of many kinds of celestial objects, particularly active galaxies and quasars (see story above). Interferometry works by combining signals from a given source recorded by widely spaced receivers; the more widely spaced the receivers, the finer the detail observed. Until recently the technique was limited to linking together radiotelescopes located on the earth. Now, for the first time, astronomers have linked earth-based radiotelescopes with a receiver on an orbiting satellite, a member of the Tracking and Data Relay Satellite system, and succesfully observed three quasars with a resolution of detail greater than that of any solely terrestrial combination of telescopes.

The experiment, reported in the Oct. 10 SCIENCE, shows that a receiver moving in orbit can be succesfully combined with others fixed on earth for this kind of work. It represents a first step on what radioastronomers hope will be a march into space and even to the moon. Particularly, according to the astronomers who did it, it demonstrates the feasibility of the proposed QUASAT project now under study by NASA and the European Space Agency. This would put up a satellite dedicated to radioastronomy to work as an interferometer with radiotelescopes on earth.

Interferometry combines signals received simultaneously at different telescopes and uses the correlations and differences among them in phase, intensity, amplitude or a combination of those attributes. The resolution of detail it obtains can be as fine as that of a single telescope that would extend over the distance between the linked telescopes, or the baseline of the interferometer.

The first interferometers used receivers spaced a few hundreds of meters or a few kilometers apart. They had wired connections and combined the signals in a central processor in real time. Very long baseline interferometry, which can be intercontinental, has to forgo the physical link between telescopes. It records the signals and combines them later. Getting it right requires ultraprecise timing, exact knowledge of the locations of the telescopes and some sophisticated computer programs. The present experiment shows that the constantly changing location of an orbiting satellite and its relation to locations on earth can be known well enough for interferometric purposes.

Gerald S. Levy of the Jet Propulsion Laboratory in Pasadena, Calif., led a group of astronomers from the United States, Australia and Japan in the work. Observing the quasars 1730-130, 1741-038 and 1510-089, they achieved a resolution equal to that of a telescope 1.4 times the size of the earth's diameter. QUASAT would give a 25,000-kilometer baseline, or about twice the size of the earth; the moon would give almost 30 times the size of the earth.

—D.E. Thomsen