



Galaxy Number 160 in Halton Arp's Atlas of Peculiar Galaxies has three radio sources close to it.

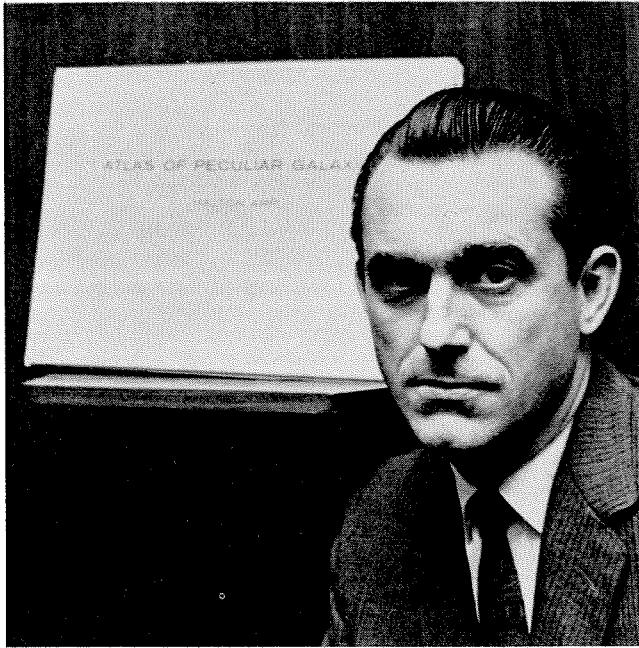
Peculiar Galaxies — New Light on Quasars

by Graham Berry

Quasars may not be the most distant objects in the universe ("Extending the Frontiers of Space" —*E&S*, May 1965) but instead may be small, compact galaxies at intermediate distances. Halton C. Arp, staff member of the Mount Wilson and Palomar Observatories, said he has found evidence that some quasars (quasi-stellar radio sources) have been exploded out of peculiarly shaped galaxies that are only 30 million to 300 million light years distant. Among these quasars are 3C-273, which was the first one identified, and possibly 3C-9, sup-

posedly one of the most distant known objects.

The evidence is contained in a study Dr. Arp has made of what he calls "peculiar galaxies." These objects do not resemble "normal" spiral and elliptical galaxies, but appear to be distorted and deformed as though they had undergone titanic explosions. A total of 338 of these abnormal objects is contained in a recently published *Atlas of Peculiar Galaxies* which he has compiled over the past four years. The objects were photographed through the 200-inch Hale telescope at Palomar Observatory.



Halton Arp, staff member of the Mount Wilson and Palomar Observatories, and his Atlas of Peculiar Galaxies.

Dr. Arp lists eight quasars that he says probably are near seven of the peculiar galaxies, and three more that may be near three other similar galaxies. He has found a consistent pattern in which peculiar galaxies are bracketed by radio objects. Some of these radio objects are quasars, and some are radio galaxies. Both quasars and radio galaxies radiate energy as light and as radio waves. He lists 19 such probable systems and 10 possible ones.

In general there is a tendency for filaments and axes of the peculiar galaxies to point toward the radio sources. Some peculiar galaxies have four neighboring radio sources, tending to be paired oppositely. And one of them in the southern sky is surrounded by five sources.

Dr. Arp believes that the peculiar galaxies originally were large galaxies that became unstable for some undetermined reason and ejected luminous material and plasma into space. With nothing to stop it, the material may have continued traveling out in two opposite directions and become radio galaxies and quasars.

The quasar 3C-273 is located on one side of a peculiar galaxy—No. 134 in his atlas—and the radio galaxy Virgo A (a very strong radio source) is located about the same distance away on the other side of the peculiar galaxy. Jets of material appear to be emerging both from 3C-273 and Virgo A. Moreover, Virgo A's jet points toward yet another radio galaxy. There are several other systems with the same pattern—a central peculiar galaxy flanked by radio sources on each side of it, and the radio sources emitting jets.

Quasars have been thought to be much farther away than virtually all other known objects because of their very large red shifts. The red shifts for what were thought to be the three most distant quasars indicate they are receding at more than 149,000 miles a second. However, they are comparatively bright and emit strong radio signals. If they were as far away as their red shifts indicate, they would be the most energetic objects yet found and many times brighter than galaxies.

Astronomers have considered the possibility that quasars are not at cosmological distances. One possibility is that the red shifts of quasars are not indicative of velocities and distances. Perhaps the quasar's red shift is determined by its gravitational field. If a quasar is a very compact, heavy body, it may have a strong enough gravitational field to lengthen the wavelengths of the light radiating from it, producing a red shift. A second possibility considered by Dr. Arp is that the red shift also may reflect a "high collapse velocity." If material in a quasar is collapsing at high speed, this velocity could show up as a red shift. Of course, there is the possibility, too, that the red shift may reflect some other, unknown phenomenon.

It may be that when matter is exploded out of a galaxy it spreads out, as radio observations indicate it does, leaving the parent galaxy peculiarly shaped. Later, under its own gravitational attraction, the spread-out matter may begin to condense. The last stages of this condensation could be a quasar. If, indeed, quasars are nearby, they are less bright than the average galaxy.

Dr. Arp estimates that the explosive events that created the systems occurred 10 million to a billion years ago. He calculates that the quasars and radio galaxies are traveling 200,000 to 200 million miles an hour and have reached distances of 3 million to 30 million light years from their parent peculiar galaxies.

Dr. Arp says that the results open many possibilities. If the red shifts for quasars are not indicative of distances, then the red-shift yardstick for galaxies should be regarded with slightly more caution. If enough material to form a galaxy can be ejected from a large galaxy, then certain kinds of galaxies, especially spirals, may be much younger than other kinds of galaxies.

Further, it may now be possible to show that the very small, compact, dwarf galaxies discovered a few months ago were ejected from nearby parent galaxies. The mechanism by which material is ejected from galaxies is very puzzling, but if understood, it could provide new insight into the formation of galaxies.