Hale Observatory

NGC 4631: Energy flows from the centers of galaxies such as this one indicate that matter may be created.

COSMOLOGY

Supporting evidence for the theory of the steady state

Observations in the infrared region are showing that energy might be flowing into the universe through the centers of galaxies

by Dietrick E. Thomsen

Cosmology attempts to deduce the history of the universe from astronomical observation. Its great difficulty is that the events concerned take millions or billions of years to work themselves out, and it is therefore hard to observe the history in progress and be exactly sure what one is seeing.

Modern cosmologists are left with two general classes of theory: the so-called big bang or cosmic fireball and the steady-state or continuous creation theories.

In the middle 1960's radio astronomical observations provided evidence that was taken as very dramatic support for the big-bang theory, and the buildup of data became so convincing to many cosmologists that they were ready to bury the rival steady-state theory. Recent observations in infrared light, which have been possible only in the last few years, give proponents of the steady-state ammunition to strike back.

The difference between the two theories rests on the density of the universe. If the universe has been expanding for any length of time, everyone agrees there must have been a time when it was very small, and the question is: Did it then have the same amount of matter as it has now?

If it did, then the pressure temperature and density were beyond anything imaginable today. This is the cosmic fireball and its physical conditions suggest that it must have exploded and thus given the impetus for the expansion now seen.

The other side says that this did not happen. The matter in the universe was always as dense as it is now, and therefore there was never a hot, high-density state. This requires that matter be added as the universe expands. It can be continually created out of nothing or pumped in from some realm beyond the universe, possibly through galaxy centers.

It is the centers of the galaxies that the latest evidence concerns. Since 1965 Dr. Frank J. Low of Rice University and the University of Arizona and various collaborators have examined the sky for sources of infrared light. They began to find strong sources of broadband infrared, which Dr. Low calls irtrons.

Irtrons radiate fantastic amounts of energy, in some cases many times more than the total power emitted by all the stars in the largest galaxies. The accumulation of evidence has convinced Dr. Low that irtrons are characteristic of the centers of all the external galaxies, though not always at the same power level. His most recent observation, done with Dr. H. H. Aumann,

shows such a source in the center of our own galaxy too.

The irtron radiation is so strong that the source of it is probably the mutual annihilation of matter and antimatter, which is the most efficient way of generating powerful radiation. Dr. Low cites as examples four Seyfert galaxies (NGC 1068, NGC 1275, NGC 7469 and 3C 120), the centers of which appear to emit about 2 times 10^{46} ergs per second in the infrared, or 500 times the total output of our galaxy.

From statistical and structural evidence, Dr. Low figures that these galaxies are probably older than a billion years. If they have been radiating at the observed rate for all that time, the total radiation represents the destruction of 30 million times the mass of the sun. This, he says, "is as great or greater than the rest mass of that part of the galaxy."

Since even the annihilation process is no more than 10 percent efficient in producing infrared radiation, these numbers lead him to "the inescapable conclusion" that matter amounting to something between a billion and 10 billion times the mass of the sun has gone through the center of one of these galaxies. This he considers support for continuous creation. "Something fairly drastic like that may be required," he says.

It is possible, of course, that the matter passing through the galactic centers may be going in instead of coming out, and the universe is suffering a net loss instead of a gain. There is a theory that sees the centers of galaxies and other unusual objects such as quasars as so-called black holes into which matter is falling under the impulse of gravitational forces and where it is destroyed by some gravitational process whose details are not clear.

But if the black hole hypothesis were true, says Dr. Low, observers should see matter falling into the galactic center at a great rate. In fact, he says, "the body of observational data shows that matter is flying out at a great rate." Galaxies appear to expand as they age.

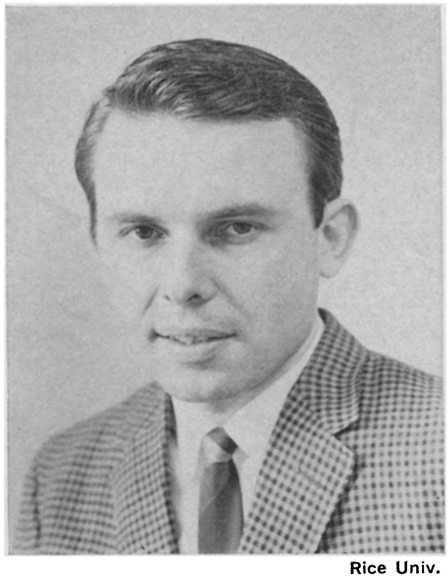
The source of matter for galactic expansion, as Dr. Low suggests, could be some kind of continuous creation or pumping-in process at the centers. Some of the matter is annihilated at or near the source; some survives to build up the galaxy.

Acceptance of this idea immediately raises the problem of antimatter. According to currently accepted laws of particle physics, when matter is created, so is an equal amount of antimatter.

There is no observational evidence for any large amounts of antimatter in the visible universe. On the other hand, there is no observational evidence against its presence. An antistar would look precisely like a star, so there is no way to tell.

Rice Univ.

Low: Matter comes from the centers.



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Aumann: Irtrons from the galaxies.

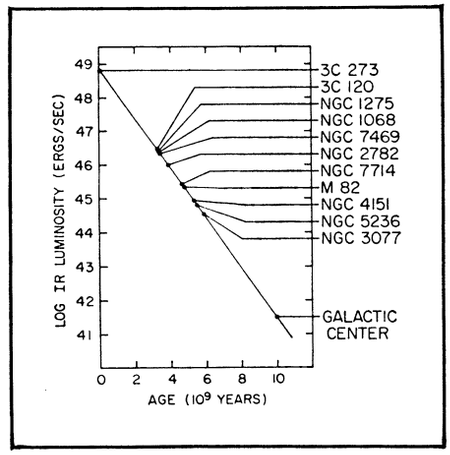
Some cosmologists, notably Drs. Hannes Alfvén of the Swedish Royal Institute of Technology and Aina Elvius of the Stockholm Observatory, suggest that a separation process goes on in the galactic centers that segregates matter and antimatter into different parts of the galaxy (SN: 12/13, p. 562).

On the other hand, Dr. Low's model does away with a difficulty over the spiral arms that many galaxies have. If matter is collapsing toward the centers of the galaxies, either because the galaxies are condensing out of a mass of evenly spread gas left over from a big bang—a popular theory—or because matter is going down black holes at the centers, it should be impossible for galaxies to maintain the spiral arms. They should fall into the centers.

If the matter is coming out of the centers, there is nothing against maintaining spiral arms. In his model, says Dr. Low, "the spiral arm problem goes away."

Meanwhile the evidence on which the proponents of the big-bang theory based their jubilation a few years ago remains, though its interpretation is more and more questioned. Radio astronomers had found a background of radio waves whose spectrum corresponded to a perfect thermal radiator or blackbody at a temperature of three degrees above absolute zero (SN: 7/5, p. 9). Existence of such a blackbody background is a prediction of the big-bang theory, and the discovery seemed to be evidence for it.

There are other possible interpretations of this radio spectrum, although the blackbody is the simplest. Extension of the observations into the infrared was eagerly awaited since it was



Astrophysical Journal

Galactic luminosity related to age.

in this range that the background's blackbody character should show up unmistakably.

The infrared observations so far have not been happy for the blackbody enthusiasts. The first of them showed background infrared fluxes, which, if they were thermal, were hotter than three degrees. These could be explained away as the background plus something else.

The latest infrared observations are direct and extend the search to wavelengths of less than half a millimeter. Drs. Dirk Muehlner and Rainer Weiss of Massachusetts Institute of Technology, who did the observation with a balloon-borne detector, conclude that in this range the radiation may not be thermal.

The battle between the rival cosmologies is far from over, but with the advent of infrared observations it is becoming clear that the steady-state theory, over which some cosmologists were reading funeral orations a few years ago, is very much alive again. □