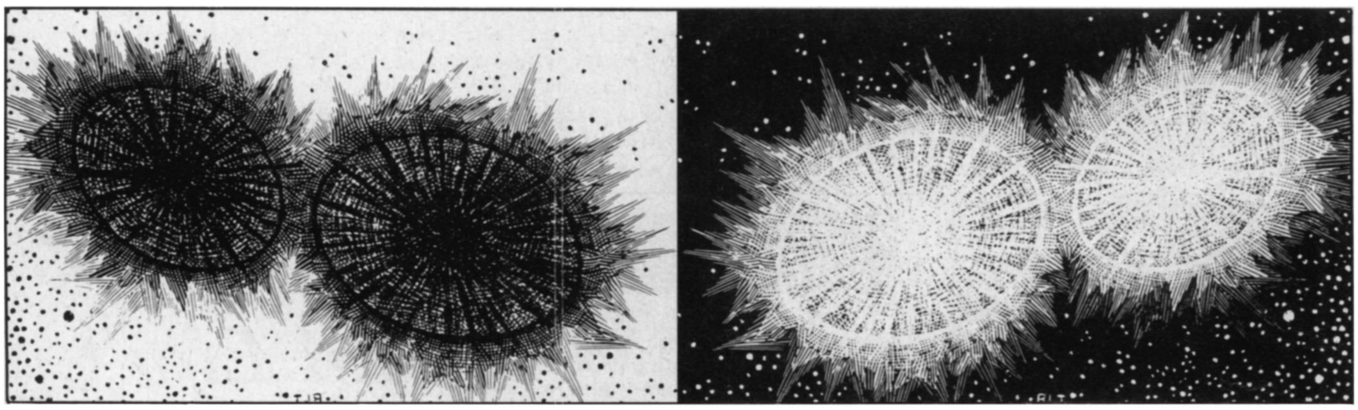
Does the universe need antimatter?

Many cosmologists worry about not finding antimatter in the universe. Now one says antimatter isn't necessary.

by Dietrick E. Thomsen

Symmetry between matter and antimatter is one of the basic principles of particle physics. To every particle there corresponds an antiparticle; to every proton an antiproton; to every neutron an antineutron. It is possible to build up antiatoms, and a certain poem went so far as to conjure up antiworlds in which Professor Edward Teller met his opposite, Professor Edward Antiteller. When Professor Teller and Professor Antiteller shook hands, "all the rest was gamma rays." Such a process is a helpful postulate where highly efficient conversion of mass to energy is wanted.

Gary Steigman of Yale University suggests that this and other astrophysical invocations of matter-antimatter annihilation just may not be so. He proposes that the antimatter may not be there and may never have been. In rebuttal to those that argue that the symmetry must exist he mentions a number of theoretically permitted symmetries that nature does not take advantage of. "We know many symmetries in physics, but the real world tends not to exploit them," he says.



But antiworlds are not entirely a joke. Cosmologists have been concerned to fit the matter-antimatter symmetry into the universe, and they have postulated precisely antiworlds and maybe antigalaxies and groups of antigalaxies. An elegant theory has grown up in which the big bang that starts the universe produces equal amounts of matter and antimatter. The matter and antimatter are somehow blown apart to form separate regions. There are as many antiworlds as there are worlds.

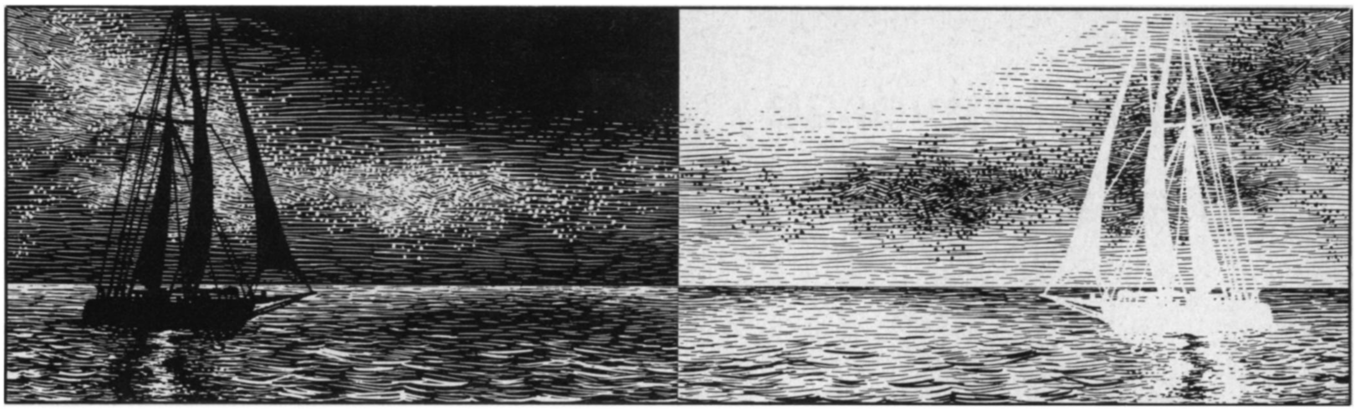
Astrophysicists have used antimatter to explain strange celestial phenomena. Quasars are an example. Quasars are small bodies yet they radiate more energy than galaxies. To do so they have to have a very efficient means of converting fuel into energy. One suggestion has been the annihilation of matter and antimatter. When matter and antimatter collide, they turn all of their mass and energy into radiation.

Maxwell's equations, which govern classical electrodynamics, predict the behavior of radio transmitters. The mathematical solutions indicate that under the proper conditions radio waves will emanate in all directions from a transmitting antenna. Curiously enough the solutions also indicate an equal flux of incoming waves falling on the transmitter, not waves from any other transmitter but waves somehow associated with the activity of the one transmitter. This is a very unphysical phenomenon. The incoming waves simply don't happen, and in using the mathematics, physicists get around the problem by imposing boundary conditions that cancel out the prediction of incoming waves.

Closer to the home of matter and antimatter are the macroscopic world's disregard of two important particle-physics symmetries. The particle world is symmetric under reversal of time. For example an electron and a positron may annihilate to form a gamma ray. A gamma ray may also create an electron and a positron. Given a diagram of either event a physicist could not tell which was happening or in what direction time was flowing. In the macro-world we always know which way time is flowing. We always grow older, never younger. Seeds grow into trees; trees do not shrink into seeds. Similarly, the particle world is symmetric with regard to left- and right-handedness; the macro-world is not.

Steigman further supports his contention with a review of the observational evidence, which so far shows no indication of antimatter anywhere in the universe. "The solar system is not symmetric," he says. Neither our space probes nor the meteorites that hit the earth have caused any annihilation reactions.

Since we are not able to travel even to the nearest star, we cannot tell directly whether there are antistars in



our galaxy. But we do get cosmic rays. The cosmic rays "travel through a good part of the galaxy," notes Steigman, and there is "so far no evidence for antiparticles in the cosmic rays. What we receive is a good sample." Evidence indicates there has been little change in cosmic rays in 4.5 billion years, during which time we have circuited the galaxy several times. There is therefore, he concludes, not much antimatter in the galaxy.

Perhaps then a whole gang of galaxies is matter and another gang antimatter. But one should be able to tell antigalaxies by the Faraday rotation, the rotation of the polarization of their light, which should depend on whether electrons or positrons dominate the region through which the light comes. If matter and antimatter are separated, there must be boundary regions, and in these regions annihilations should occur. The annihilations should produce gamma rays that would go a long distance from their source. Neither of these effects are observed. Some astronomers invoke the so-called Leidenfrost phenomenon: A few annihilations at the border maintain a pressure that keeps large amounts of matter and antimatter apart. But Steigman says, "If the mixture were half and half, you'd still expect more annihilation of matter; the mixing of materials is just too efficient for matter and antimatter to stay totally separated . . . and all matter would long since have disappeared."

Unlike some cosmologists, who are dismayed at the failure to find evidence of antimatter, Steigman shrugs and says: 'Either there was not as much antimatter surviving the early stages of the universe as some theorists predict, or our model of the early stars may be wrong. In any event, scientists should not postulate the existence of antimatter to solve a problem in astrophysics, and then use the solved problem to prove that antimatter exists. Antimatter may be one of those phenomena which is possible on an atomic scale, like the 'left-handedness' of atoms, but which just happens not to be observed in most of the large-scale universe." □