SCIENCE NEWS OF THE WEEK

Cosmic Caldron Bubbles Up Universe

Ever since Edwin Hubble, astronomers have been telling us that we live in an expanding universe. An expanding universe is not difficult to deal with physically and mathematically, provided you are positioned some distance down the expansion. Extrapolating back to time zero exposes a number of perils. More than one way of getting around them has been proposed. Now, in the Jan. 28-Feb. 3 NATURE, J. Richard Gott III of Princeton University proposes a new theory of the universe that he says explains more of the facts than the standard big bang model and takes more advantage of the recent developments in theoretical physics than the standard big bang. The new theory eschews the primal explosion for a kind of cosmic Schweppervescence.

Extrapolating the expansion back to time zero leads in the simplest way to a notion that that point was also space zero. The standard big bang does essentially that by proposing that time zero was a singularity. A singularity is the mathematical creature that sits in the center of a black hole and eventually swallows everything that falls into the black hole. Space and time disappear at a singularity too. The singularity proposed for the start of the universe is somewhat the reverse of a black hole singularity: It is the point from which things appear rather than into which they disappear.

As several critics have pointed out, starting from a bare singularity means that the early stages of expansion go so fast that parts of the universe get out of touch with each other. A light signal sent from one part cannot catch up with other parts. That raises a difficulty exactly with regard to radiation: the primordial radiation.

The original big bang postulates that the universe began as high-energy radiation. Zero space means infinite density and so infinite temperature. Nothing but radiation could exist at the beginning. As the universe expanded and cooled, this radiation begat everything else. We see a remnant of this radiation in the so-called universal microwave background. This background is extremely isotropic. Only the minutest deviations from evenness have been found. The isotropy argues that the universe was in thermal equilibrium in its early stages. Thermal equilibrium means complete intercommunication and thorough mixing of energy. But that is what the singularity theory won't give.

Instead, Gott proposes to start with a finite beginning, a dense (3×10^{93} grams per cubic centimeter), hot (5×10^{31} kelvins) state called a de Sitter space because of its geometric qualities. Universes (ours and any number of others) form as low-density bubbles in this de Sitter space. The universes then expand in the usual way. In this theory our universe is open; it expands indefinitely with negative curvature (saddle-shaped space). Instead of a cosmic explosion this is more like a gradual bubbling up. The early stages of expansion are not so fast in this scheme that pieces of the universe get out of touch with one another. Thermal equilibrium is preserved.

We would like to be able to say also that the radiation is thermal in character. It's hard to imagine mechanisms for making nonthermal radiation at the beginning of the universe. But if the radiation is thermal, as it cools, it must yield equal amounts of matter and antimatter. We don't see much antimatter, so a number of ingenious schemes were devised to find places to hide it. Today the rules of physics have changed a little from what they used to be: Antimatter can turn into matter according to the new grand unified theories (GUTS). If we bring GUTS explicitly into cosmology, says Gott, we can have a universe progressively dominated by matter as it ages. Thus we can confidently say that the primeval radiation was thermal: Time unbalanced matter and antimatter. And then Gott can say what he really wants: that the radiation was Hawking radiation.

Hawking radiation comes from an event horizon. An event horizon is the surface around a black hole through which we cannot see because light cannot escape from a black hole. Stephen Hawking showed that an event horizon ought to emit thermal radiation. There are event horizons in Gott's de Sitter space. They separate nascent universes and prevent intercosmic communication. So the universe(s) begin(s) as bubbles of Hawking radiation in a hot de Sitter soup.

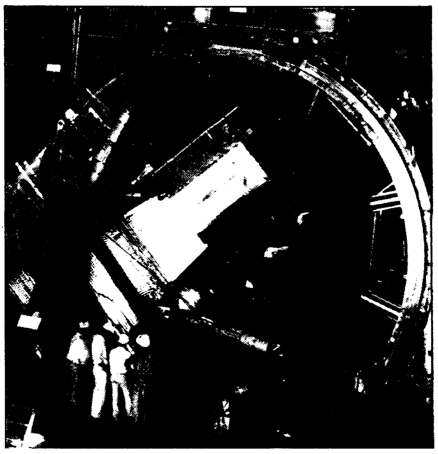
—D. E. Thomsen

Great magnetic strength of Yin and Yang

A thermonuclear plasma, the ionized gas used in experiments aiming for controlled nuclear fusion, is not very dense. Keeping this tenuous thing together, however, requires some very strong forces cleverly deployed. Devising means of confining the plasma has been a major part of the almost 40 years of research effort.

What is billed as the world's largest superconducting magnet recently passed its first tests at the Lawrence Livermore National Laboratory in Livermore, Calif. Its purpose is to confine plasma in the Mirror Fusion Test Facility, an experiment that is expected to be a major step in showing that fusion can be a practical energy source.

Superconducting coils generate strong magnetic fields for virtually no expense in electric power. Superconductivity is the property of some metals to pass an electric current without resistance. For these metals, it happens only at temperatures near absolute zero, so the fabrication of superconducting magnets involves both somewhat exotic metallurgy (the superconducting metals are not the common ones) and advanced refrigeration technology. When a new, big superconducting magnet works according to design, it is a matter of great satisfaction.


Lawrence Livermore Nat. Lab.

This magnet works. The coils, which are made of niobium-titanium filaments encased in a copper matrix, carried 5,775 amperes of current to produce a field of 77,000 gauss (the standard measure of a magnetic field's strength). Energy consumption in the coils themselves was only 100 watts; the electrical leads took another 1,200 watts.

It is called a Yin-Yang magnet because of its shape, two C-shaped coils interlocked with each other. Its purpose is to confine a dense plasma to serve as a plug in one end of the 60-foot-long MFTF vessel. A similar plug will be built for the other end. The two plug plasmas will help confine a third plasma in the solenoid space between them. The third plasma will be the actual fusion fuel.

The coils together with their support rods weigh 789,000 pounds. The assembly stands 25 feet high and hangs inside the 36-foot diameter of the MFTF vessel. Some visiting physicists have found this arrangement a bit unusual; they would have expected the plasma vessel inside the magnet rather than vice versa. With the field on, the structure experienced stresses up to 80,000 pounds per square inch and withstood them. A force of 22 million pounds acts to spring the lobes of the coils apart. It was successfully countered by encasing the coils in special 304 LN stainless steel, which in places, is five inches thick.

—D. E. Thomsen