science news
OF THE WEEK

The universe may be far thinner than thought

The density of matter in the universe is an extremely important cosmological datum. If the universe is dense enough, the mutual gravitational attraction of its parts will eventually slow down and reverse the expansion, and the universe will begin to collapse. Many cosmologists would like to have this kind of closed universe with a limited maximum size because the other alternative, limitless, infinite expansion, is difficult to contemplate.

Unfortunately, results just obtained by John B. Rogerson and Donald G. York of Princeton University tend to indicate a density too low for closure and contraction. The density is calculated from the abundance of the deuterium found in interstellar space.

The Princeton astrophysicists obtained their value for the deuterium abundance, which Rogerson says is the first measurement of deuterium abundance outside the solar system, with the Princeton telescope on the Copernicus satellite. They observed the absorption of the ultraviolet light of the star beta Centauri by deuterium between it and the earth, and were thereby able to calculate the abundance of deuterium in that space. It comes to one deuterium atom in every 100,000 atoms.

According to current theory the only place in nature where deuterium could have been made is in the big bang at the beginning of the universe. Thus any deuterium we see now is a relic of the big bang, and its abundance can indicate what fraction of the primordial hydrogen was fused into deuterium near the time of the origin. Knowing this fraction, one can calculate how much original hydrogen there was, and that enables computation of the present density of the universe. Rogerson and York figure it out to one hydrogen atom in every 10 cubic meters. (In the universe as a whole elements other than hydrogen and deuterium are too rare to affect the density very much.)

This figure, says Rogerson, is a factor of 25 or 30 too small to cause closure and contraction of the universe. Thus there doesn't seem to be the large amount of unseen matter that some cosmologists had hoped there was.

It should be noted that the present results are based on observation of only the one star, beta Centauri. The work continues with efforts to observe other stars in different directions. It remains to be seen whether future data will support the present calculations. Nevertheless, Rogerson says, the result from the one star alone seemed important enough to justify immediate publication. A report is being submitted to the ASTROPHYSICAL JOURNAL. □

Just how far can the universe collapse?

According to the big-bang theory of cosmology the universe started in a small, perhaps infinitesimally small, hot fireball that exploded and began to expand. Cosmologists try to deduce what conditions may have been like in that fireball. Even though the evidence reported above seems to tell against the idea, they also worry what might happen if the universal expansion stops and the universe begins to collapse under the influence of its own gravitation. Could the universe collapse to a point and vanish like the Cheshire cat? Or perhaps the events of collapse might resemble stages gone through in the reverse direction during expansion.

In the Aug. 6 NATURE PHYSICAL SCIENCE, C. J. Isham of Imperial College, London, Abdus Salam of Imperial College and the International Center for Theoretical Physics in Trieste and J. Strathdee of the International Center for Theoretical Physics bring to bear on the question a reworking of gravitational theory that they have been engaged in for some time. Their work is a reformulation of Einstein's theory that takes into account the difference between two main classes of subatomic particles, the hadrons and the leptons. Their reformulation proposes that gravity affects the two classes differently (SN: 4/10/71, p. 249).

When gravity thus takes account of the differences between the two kinds of particles, Isham, Salam and Strathdee find that there is indeed a limit to the possible collapse of the universe: a radius of 100 million kilometers —somewhat less than the radius of the earth's orbit. They also find a limit to the density: 100 quadrillion (10^{17}) grams per cubic centimeter.

The limits are for a universe composed of 10^{80} neutrons with their spins all aligned in the same direction. (Neutrons are specified because after collapse has reached the point of crushing atoms, the electrons will be driven into the nuclei, where they will turn the protons into neutrons; in effect, nothing remains but neutrons.)

There are some difficulties with this picture, however. There must be some mechanism for aligning the spins; none is specified in the calculation. There may be trouble from the so-called exclusion principle, according to which two neutrons with the same energy may not be in the same place at the same time. Finally the size of the collapsed universe remains so large that other effects of the mechanics of the microcosm have not been taken into account. □

Quasars' great distance: A voice from radio

Astrophysicists have long been arguing over whether the quasars are as far away as the redshifts in their light make them appear to be. Or, putting the question in slightly different terms, are the redshifts due entirely to the quasars' velocities of recession or does part of the redshifts come from some other cause?

Two astronomers of the National Radio Astronomy Observatory, Robert L. Brown and Morton S. Roberts, now have evidence from the radio spectrum of quasar 3C 286 in favor of the all-redshift-due-to-velocity point of view. Their findings, issued last week by NRAO, support the hypothesis that quasars are at or near the edge of the observable universe.

An unexplained flurry of neutrinos from space

When asked recently "How does the sun work?" Richard Tousey of the Naval Research Laboratory quipped, "The sun works fine." But the real truth of the matter is that while the sun is apparently working, solar scientists really don't know *how* it works—exactly. There are many theories, some of which will have to be revised as a result of the voluminous data now being returned from the six Skylab solar telescopes (see p. 120).

One fundamental question about the sun concerns neutrinos. Neutrinos are believed to be by-products of nuclear fusion in the sun's interior. Raymond Davis Jr. of the Brookhaven National Laboratory has been trying to catch neutrinos since 1967 in an underground tank in South Dakota. He and John C. Evans presented the results so far of the five-year search this week at an international conference on cosmic rays in Denver.

The process for catching this illusive matter is complex. Neutrinos have no rest mass, and they travel at the speed of light. They can pass through the entire earth with no interaction. The Brookhaven group is the only team trying the experiment, which makes the results even more difficult to interpret. So Davis understandably is very cautious about what he claims.

The hitch is that for the last five years, Davis has not been catching as many solar neutrinos as had been predicted. This has led to a flurry of new theories about the sun to explain the "missing" neutrinos (SN: 3/10/73, p. 155).

But now there is another mystifying result. During an experiment last year, Davis caught three times more neutrinos than he has ever snared before or since. The experiment in question began July 7, 1972, and lasted until Nov. 5, 1972.

During the three-month period the group collected 57 ± 23 atoms of argon 37, presumably produced by that many neutrinos in the chlorine tank. During the previous three-month run, the count had been 10 ± 9 atoms. During the succeeding three-month run the count was 16 ± 15 atoms.

During that period in 1972 two events occurred in the neighborhood of earth: a large solar flare on Aug. 4 (SN: 8/19/72, p. 119) and a large radio outburst in Cygnus X-3 from Sept. 2 to 11 (SN: 9/9/72, p. 165). The Air Force's Vela satellites were also detecting high gamma-ray pulses from outside the galaxy.

Davis has found no direct correlation between the gamma-ray pulses and his high neutrino count.

Some solar scientists think the count might have something to do with the solar flare. Perhaps the neutrinos indicate that something drastic happened inside the sun's interior, and the only event observed by man was a ripple (the flare) on the surface. But Davis believes the sun is an unlikely source for his neutrinos. "I belong to the old school of solar thought," he says, "which believes the sun just doesn't change all of a sudden. Something happening on a month by month time-scale is improbable." He also considers the Cygnus X-3 outburst an unlikely source.

What about a supernova (stellar explosion)? "This is not unreasonable," Davis says. Astronomers think a supernova occurs when a star gets so hot that photons escape as neutrinos prior to the star's collapse.

If the missing neutrinos were an enigma, the high count may develop into an even bigger one. Davis' tank may prove to be a scientific gold mine—an indicator of extragalactic events. The problem is to find the event that matches the results.

"There may never be an explanation," says Davis.

In the spectrum of 3C 286 taken with the 300-foot NRAO radio telescope at Green Bank, W. Va., they found an absorption line at a wavelength of 37.5 centimeters. They believe this represents absorption of waves emitted by the quasar by neutral hydrogen in some galaxy lying between us and the quasar.

Neutral hydrogen at rest absorbs at a wavelength of 21.1 centimeters. Thus the new position at 37.5 centimeters represents a sizeable redshift, one indicative in fact of a velocity of more than 100,000 miles per second, nearly seven-tenths the velocity of light. It is the largest redshift yet discovered in a radio spectral line.

Since gas pervading some galaxy between us and the quasar should not be subject to any strange processes going on in the quasar, such as might produce a nonvelocity redshift, the galaxy's redshift must be due entirely to velocity and thus should represent its distance. The galaxy's redshift turns out to be 80 percent of that measured for the quasar.

Since the quasar is at least as far away as the galaxy, the conclusion is that at least 80 percent of the quasar's redshift represents distance, and that quasars are indeed among the most distant objects in the universe. □

Molecule building in the prebiotic soup

How did molecules destined to become the building blocks of life form on the primitive earth? Scientists have attempted to get these answers by conducting chemical experiments under simulated prebiological conditions. So far, nucleotides, which make up cells' genetic material, have been synthesized under such conditions. So have many of the 20 amino acids that make up peptide chains, and in turn proteins. But how did nucleotides evolve into chains of nucleotides and amino acids into peptide chains? A unified scheme for such activation is presented in the Aug. 17 NATURE by Rolfe Lohrmann and L. E. Orgel of the Salk Institute of Biological Studies.

The chemists' scheme is based on a series of reactions that they carried out under simulated early earth conditions. Unlike any suggested before, these reactions parallel contemporary biological mechanisms.

First they determined that polyphosphates, such as ATP, were probably the primary energy reserve for primitive chemical reactions. (ATP is the major source of energy in modern living organisms.) Polyphosphates' importance on the primitive scene had been suspected before. But it had not been documented chemically.

They next placed imidazole, an amine, in the presence of ATP and magnesium. ATP provided the source of polyphosphate energy. The resulting products were phosphoramidates. Phosphoramidates are nucleotides that under acidic conditions have a tendency to condense on a complementary nucleotide template. Lohrmann and Orgel found that one of the phosphoramidates, which contained adenylic acid, condensed on a complementary template containing uridylic acid. The result was short nucleotides.

Then they found that amino acids, which are also amines, formed phosphoramidates. Although the phosphoramidates were energy-rich compounds, they could not react directly to form peptides. But if the phosphoramidates were put in the presence of imidazole, they formed short peptide chains.

Polyphosphates, magnesium, imidazole and amino acids, then, were some of the ingredients that they used to make chains of nucleotides and chains of amino acids. "But it is probable," Lohrmann and Orgel say, "that other organic molecules can replace them." □