than isoleucine. From an alignment of the bovine COII amino acid sequence with the sequence of codons in the human COII gene, they observed that methionines occur opposite ATG at two and opposite ATA at five positions. Provided there was no large scale evolutionary interconversion of isoleucine and methionine codons it would appear that AUA codes for methionine in human mitochondria. There is not yet enough protein sequence data to determine whether AUA also codes for methionine in yeast mitochondria.

The structural grounds for the AUA to Met and UGA to Trp codon assignments are presumed by Barrell *et al.* to be nucleotide bases present at the wobble positions in the anticodons in $tRNA^{Met}_{mt}$ and $tRNA^{Trp}_{mt}$. The presence of U or modified U at the 5′ end of the anticodon in each case might allow translation of AUA and UGA by A-U base pairing and of AUG and UGG by wobble base pairing (Crick, *J. molec. Biol.* **19**, 546; 1966). Recent sequencing work by Sanger and Coulson (cited by Barrell *et al.*) has established that the anticodon of human $tRNA^{Trp}_{mt}$ has a sequence consistent with these postulates.

These variations of the mitochondrial genetic code from that which directs translation in *E. coli* illustrate that, once a genetic code came into existence, it was not immutably fixed in all its details. Will still more exotic variations in the code be found in other organisms? For the answer, consult the dictionary in your favourite dinoflagellate, protozoan or archaebacterium. □

# Antimatter from space

*from P.C.W. Davies*

THE origin of matter is one of the great unsolved problems of science: the visible Universe contains about $10^{50}$ tons of material. Where did it come from? At one time it was supposed that all this cosmic stuff — from which the galaxies, the stars and our own bodies are made — always existed. Modern cosmologists, however, believe that the Universe is not of unlimited age, but came into existence about 15 billion years ago in the hot, dense, explosive eruption, popularly called the big bang.

If this primaeval explosion marked the creation of all the cosmic matter, physicists would like to understand the details: what precisely happened in the first microsecond of existence? Since the early 1930s it has been known that matter can be created from energy in the form of subatomic particles, so modern cosmology provides a natural mechanism for the origin of matter: it was created from the explosive energy associated with the primaeval violence. Paul Dirac gave a very heuristic explanation of how this happens. The equation that describes a particle such as an electron possesses two sets of solutions: one describing 'ordinary' electrons and the other mysterious states in which electrons have negative mass-energy. As all systems tend naturally to seek out their lowest energy, nothing apparently prevents ordinary electrons from descending into these enigmatic negative energy states. As the energies can be limitlessly negative, there is a sort of bottomless pit into which all matter can disappear amid a shower of energy.

To preclude this apocalypse, Dirac proposed that the pit is blocked with an infinity of invisible electrons. If one of these invisible negative energy electrons is given enough energy it will be promoted to a real, observable, positive energy electron. Thus, a new electron will suddenly materialise in space. Furthermore, the 'hole' left behind represents the absence of an invisible negative energy electron, which Dirac reasoned is equivalent to the presence of a visible positive energy anti-electron, or positron as it is now called. The positron is a sort of mirror image to the electron; like the latter, but with all its physical attributes (for example, charge, spin, magnetic field) reversed.

Positrons were discovered among cosmic ray debris in 1932, and since then, antiprotons, antineutrons and a host of other antiparticles have been identified. Until recently it was supposed that the creation of matter must always be accompanied by an equal quantity of antimatter of the corresponding type. This inevitably implies that for every atom of ordinary matter that we see, somewhere in the Universe lurks its opposite number. Because any contact between matter and antimatter results in the matter falling back into the 'holes' and disappearing from the Universe, it must be supposed that somehow the matter and antimatter have got themselves well separated. It is fashionable to suggest that there are whole galaxies made of antistars and antiplanets and, one may conjecture, antipeople. An antigalaxy would look, on the face of it, indistinguishable from an ordinary galaxy.

When matter and antimatter annihilate each other their mass gets converted back into energy in the form of gamma rays, so by measuring the flux of gamma rays from space, limits may be placed on the amount of mixing that occurs between the two species of material. This seems to imply that almost complete separation has occurred, even on the scale of galactic clusters. Presumably they were put asunder in the earliest epochs of the big bang but just how this could have happened is still not completely clear.

In the past few years an exciting alternative picture has emerged. Ambitious new theories that seek to unify three of nature's four forces into a single mathematical description have predicted that perhaps matter can be created without an exactly compensatory quantity of antimatter. If this is so, it opens up the possibility of a lopsided Universe in which most of the antimatter has been annihilated, leaving a small residue of unbalanced matter that constitutes all the observed Universe.

To test which of these theories is closest to the truth, physicists can search for antimatter in space. Although the nearest antigalaxy may be millions of light years away, perhaps high energy subatomic antiparticles can stream across the gap and pepper the Earth. Cosmic ray showers have long been known to contain some antimatter (that is how the positron and antiproton were first discovered), but it has not hitherto been known whether these are merely by-products of high energy collisions between ordinary particles among the cosmic rays and the Earth's upper atmosphere. Now an experiment has been performed by a group of physicists from Texas and New Mexico to search for antiprotons among the primary rays (*Phys. Rev. Lett.* **43**, 1199; 1979). From a high altitude balloon flight last 21 June, the group detected 46 such particles, of which only about 18 are attributable to reactions with the atmosphere.

The ratio of antiprotons to protons coming from space works out at $5 \times 10^{-4}$ in the energy range explored, which accords well with theoretical estimates based on the assumption that no external flux of antiprotons is bathing the Galaxy. They can all be accounted for as by-products of collisions between ordinary cosmic rays and the tenuous interstellar medium in deep space.

This experiment not only provides important information for understanding the origin and behaviour of cosmic rays in the Galaxy, but it tightens up further the evidence against a matter-antimatter symmetrical Universe. If matter really can be created and annihilated alone, it will open up whole new chapters in both cosmology and subatomic physics. □

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## 100 years ago

In his last report from Saigon, Mr. Consul Tremlett alludes to his having been ordered by the Foreign Office to procure and send home a quantity of the bark known as *hwang-nao*, which during the past four or five years has been exported from Tongking to Trinidad, and there seems to have proved efficacious in cases of leprosy. The tree from which it is obtained is hardly known except to the missionaries, and is only found in the mountain forests of the north of Annam.

From *Nature* **21**, 6 Nov., 19; 1879.

0028-0836/79/450130-01$01.00