IN 1965, there appeared in the *Astrophysical Journal* (**142,** 419) a paper bearing the somewhat dry and unpretentious title: "A Measurement of Excess Antenna Temperature at 4080 Mc/s". Its authors, Arno A. Penzias and Robert W. Wilson, when they first discovered this 'excess' temperature, would scarcely have imagined that their discovery would one day lead them to the Nobel Prize. The 1978 Nobel award is an indication of the importance that the physics community attaches to this observation. Many would rank its cosmological significance as next to Edwin Hubble's discovery, in the late 1920s, of the nebular redshift which led to the result that "the universe is expanding".

Penzias (45) was born in Munich, Germany, but is a US citizen. After doing his master's degree from Columbia University, he joined the Bell Telephone Laboratories at Holmdel, USA, in 1961 and got his PhD in 1962.

Wilson (43), who joined the Bell

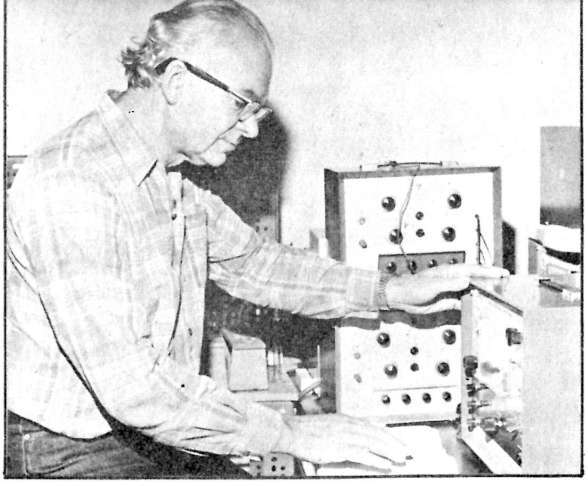
Labs in 1963, was born in Houston, Texas, USA. After graduating from Rice University in 1957, he went to the California Institute of Technology where he took his PhD in 1962. The work for which the Nobel Prize was awarded was done jointly by them at the Bell Labs.

The discovery of the excess temperature by Penzias and Wilson was quite accidental (by hindsight, it turned out to be not unexpected, but more of that later). In 1964, the Bell Labs was in possession of an antenna which had been built for communications via the *Echo* satellite. The instrument had a 6·5-m horn reflector with ultra-low noise, and Penzias and Wilson decided to use it for radio-astronomical observations. They wanted to measure the intensity of radio waves coming from our galaxy from directions well out of the plane of the Milky Way. In order to eliminate any possible 'electrical noise' within the antenna structure itself, they first decided to conduct their measurements at a wavelength where they expected very little 'noise' from the galaxy. For this, they selected the wavelength of 7·35 cm, that is, a frequency of 4080 Mc/s lying in the microwave part of the electromagnetic (em) spectrum. To their surprise, they found that, after correcting for various possible effects, including atmospheric noise, there remained a residual noise which was *isotropic* — that is, independent of direction. This residue could not, therefore, be identified with any particular source. In technical jargon, this noise had a temperature of $3 \cdot 5° \pm 1°$.

Although they had obtained this result in the spring of 1964, Penzias and Wilson did not immediately publish it, mainly because they could not think of any possible explanation for this excess temperature. Through the astronomical grapevine, the news of their finding reached Princeton where a group of physicists at the Palmer Physical Laboratory began to see its possible significance. There, a theoretician named P. J. E. Peebles had been engaged in the calculations of thermonuclear reactions taking place in the first few seconds after the origin of the universe in a gigantic 'hot' explosion, or a 'big bang'. Peebles had expected a remnant of the early hot era as radiation which should be seen today in a black body form with the spectrum peaking possibly in the microwave region. The Princeton physicist Robert H. Dicke had also expected, from different considerations, to find something interesting in the microwave part of the em spectrum. At Dicke's suggestion, his colleagues P. G. Roll and D. T. Wilkinson had set up their own instrument to look for such radiation when news came of the discovery by Penzias and Wilson. The two groups compared notes and the 'relic-radiation' explanation became a distinct possibility to account for the observations. The Princeton group published this cosmological interpretation in a paper immediately preceding the paper of Penzias and Wilson.

The story does not end, nor, in fact, begin there. Back in the 1940s, long before the work of Peebles and Dicke, George Gamow and his colleagues, Ralph A. Alpher and Robert Herman, had done similar calculations about the early big bang universe. Their prediction of a relic microwave radiation was somehow either ignored or forgotten. It is surprising that even in the post-war era of quick communication, the scientific community (including the Princeton group) was unaware of Gamow's prediction. If Gamow were alive today, he would probably have been a co-recipient of the Nobel Prize.

Work subsequent to that of Penzias and Wilson has shown how closely this background radiation follows the predicted black body spectrum for wavelengths longer than about 1 mm. The black body character at the crucial short wavelengths still needs to be established. For these, space astronomy will be needed, because observations will have to be done above the Earth's atmosphere.



Mitchell

So far no other satisfactory explanation of this radiation has been put forward, and this has led to the growing belief among cosmologists that the universe did start with a big bang. This is a profound conclusion to draw and explains why the work of Penzias and Wilson is considered so important.

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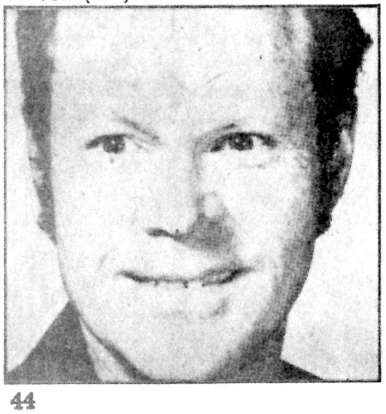
Wilson (left) and Penzias



CHEMISTRY

THE 1978 Nobel Prize for Chemistry has been awarded to a British scientist, Peter Mitchell, for his work in biological energy transfer. Mitchell (58), who is Research Director at the Glynn Laboratories in Cornwall, England, since 1964, was cited by the Swedish Academy of Sciences for his contribution in the formulation of the chemiosmotic theory. Typically, much of the chemistry these days relates to biology, and Mitchell's research concerns the chemical processes responsible for the energy supply in living organisms, a field often called "bioenergetics"

In cells, respiratory energy, released by the oxidation of organic substrate such as glucose, is conserved in the ATP (adenosine triphosphate) molecules which act as their energy currency. ATP is synthesised in the cell by the mitochondria from ADP (adenosine diphosphate) and P_i (inorganic phosphate). The enzyme ATPase is responsible for this synthesis, known as oxidative phosphorylation; the enzyme is present in the small knob-like portion (often called the coupling factor) of the electron transport particles which are studded along the inner membrane of the mitochondrion. In this process, sugars are broken down and the energy released is transferred to ATP.

$$ADP + P_i \rightarrow ATP + H_2O$$
$$\triangle G = +7 \cdot 3 \text{ Kilocals}$$