ASTRONOMY

A Cosmic Anomaly?

The discovery in 1965 by Arno Penzias and Robert Wilson of the microwave background radiation is considered to be the most significant cosmological observation since Hubble's discovery of nebular red-shift. This radiation has been measured at several wavelengths and its remarkable isotropy (to one part in 10^3) is taken to confirm the cosmological principle that the universe is homogenous and isotropic in the large.

However, anisotropies on a smaller scale, at a few parts in 10^4, are expected in this radiation background because we are looking at it from a frame which is not 'at rest'. The planet Earth moves round the Sun, which in turn moves round the centre of our Galaxy, the Milky Way, which itself is believed to have a velocity relative to the cosmological frame. Measurements of anisotropies on such a small scale will therefore tell us about these motions — if they exist.

Owing to interference from galactic emissions, these directional measurements have been difficult to make. The first indications of positive effects from such attempts were reported in the last 12 months. However, it is only recently that detailed findings have been published. G. F. Smoot, M. V. Gorenstein and R. A. Muller from the Lawrence Berkeley Laboratory and the Space Sciences Laboratory of the University of California at Berkeley (USA) have reported positive measurements of anisotropy in the cosmic microwave background (*Physical Review Letters*, **39,** 898, 1977). Their findings will generate considerable discussion among astronomers and cosmological theorists.

The experiment was conducted in a series of eight flights aboard the NASA Ames Earth Survey (U-2) aircraft. Anisotropy was detected at 33 GHz with a twin-antenna Dicke radiometer. This instrument measures the difference in the radiation intensities in the sky between two regions 60° apart and on opposite sides of the zenith. Precautions were taken to reduce all systematic errors well below the level corresponding to a temperature of 10^{-3} K.

Some 21 hours of data were statistically analysed and a temperature-direction curve was fitted in the following form:

$$T = T_o + T_1 \cos \alpha$$

[The main part (T_o) of the total temperature (T) is the same in every direction, whereas a small part de-

pends on the angle α between the measured direction and a fixed direction in space.] The best fit was obtained by using $T_o = 2 \cdot 7°K$ (the average background temperature) with $T_l = 3 \cdot 2 \pm 0 \cdot 6$ $(10^{-3}K)$ and the fixed direction lying along a galactic latitude $\sim 54° \pm 10°$ and galactic longitude $\sim 245° \pm 15°$.

A cosine-anisotropy is explained by the motion of the Earth through the background space (the cosmological frame). In this case, these authors estimate the Earth velocity 390 ± 60 km s^{-1}, in a direction towards the constellation Leo. If we take into account the rotation of the solar system across the Milky Way, the velocity of the galaxy relative to the cosmological frame comes out to be 600 km s^{-1}, in the direction of galactic latitude 33° and longitude 261°.

While anisotropies of this order are not unexpected, these results are nevertheless disconcerting. The velocity of the Galaxy seems to be twice as large compared to previous estimates of galactic velocities in the local cluster. Furthermore, the direction of anisotropy seems to be unrelated to another anisotropy associated with the Hubble law of motion of galaxies. This is the Rubin-Ford effect which suggests that our Galaxy is moving with a velocity 454 ± 125 km s^{-1} in an altogether different direction!

These results, therefore, indicate conflicts with optical extra-galactic astronomy. The authors do not rule out the possibility of intrinsic variation in the microwave background. Another implication — considered sacrilegious by most astronomers — is that the microwave background is a galactic and not a cosmological phenomenon! Because of the profound cosmological conclusions drawn from the microwave background, it is highly desirable to conduct more such experiments on it as the technology advances.

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