LETTERS TO THE EDITORS

RADIOASTRONOMY

Spectrum of Galactic Radio Emission

THE general radio emission from the Galaxy has now been accounted for as the synchrotron radiation of high-energy electrons in a magnetic field. An unsatisfactory aspect of this explanation is the relation between the observed radio spectral index α, where radio flux is proportional to (wave-length)$^{\alpha}$, and the expected energy spectrum of the cosmic-ray electrons, the number density of which should also vary exponentially according to (energy)$^{-(1+S)}$. In these circumstances the indices are related by $\alpha = S/2$.

It has been shown by Tunmer[1] that if the electrons are supposed to be generated by the collision of cosmic-ray protons with atomic nuclei, the value of S will depend on the predominating mechanism by which the electrons lose energy. Assuming a proton number density proportional to (energy)$^{-2 \cdot 5}$, the following values of S will be expected for the various loss mechanisms:

Synchrotron radiation	$S = 2 \cdot 5$
Bremsstrahlung radiation	$S = 1 \cdot 5$
Ionization losses	$S = 0 \cdot 5$

The measured value of $\alpha = 0 \cdot 37 \pm 0 \cdot 04$ for the frequency-range 38–178 Mc./s. (ref. 2) corresponds with a value $S = 0 \cdot 74 \pm 0 \cdot 08$. This value appears to indicate that losses are primarily governed by ionization; unfortunately, Tunmer's paper indicates that the only important loss for the electrons concerned with radiation in this frequency-range is the synchrotron radiation itself. Radiation at 100 Mc./s. is produced by electrons with energy of the order of 10^9 eV. in a field of 10^{-6} gauss. The actual conditions of emission cannot be far different from these, and it seems inescapable that a value of S near 2·5 should be found, corresponding to $\alpha = 1 \cdot 25$.

If the electrons are not formed throughout the energy spectrum, but only at higher energies than those concerned, afterwards falling through the range by synchrotron losses, then a radio spectral index of 0·5 would be found. Even making this extreme hypothesis of the life-history of the electrons, the expected value of α is still greater than that observed.

It is natural to suspect the experimental evidence, and indeed this is now being checked as rigorously as possible. However, some new observations at 408 Mc./s., soon to be published by Pauliny-Toth, support the low value of radio spectral index. The experiment reported by Molozzi, Franklin and Tyas[3], in which galactic radio noise at 3·8 Mc./s. was measured by a satellite-borne radio receiver, also lends some support. Here the measured field-strength E can be related to an effective black-body temperature T by:

$$T = \frac{3\lambda^2}{8\pi k B} \frac{E^2}{Z_0} \varepsilon^{1/2} \quad \text{(Hugill, in preparation)}$$

For the northern hemisphere, Molozzi's results give $E \simeq 0 \cdot 6$ µV./m., and it seems unlikely that this result is much affected by the ionosphere. Hence $T \simeq 1 \cdot 3 \times 10^6$ °K., while the value to be expected by extrapolating Costain's results from 38 Mc./s. to 3·8 Mc./s. using $\alpha = 0 \cdot 37$ is $2 \cdot 8 \times 10^6$ °K. The indication here is of an even lower value of α at the lower frequencies.

No theory has yet attempted to resolve this problem; the purpose of this communication is merely to point out a serious discrepancy between theory and experiment, which is not apparent from the papers by Tunmer[1] and Hoyle[4]. Further examination of the processes of loss and gain of energy by the electrons of cosmic-ray energies seems to be required.

F. GRAHAM SMITH

Mullard Radio Astronomy Observatory,
Cambridge.

[1] Tunmer, H., *Mon. Not. Roy. Astro. Soc.*, **119**, 184 (1959).
[2] Costain, C. H., *Mon. Not. Roy. Astro. Soc.*, **120**, 248 (1960).
[3] Molozzi, A. R., Franklin, C. A., and Tyas, J. P. I., *Nature*, **190**, 616 (1961).
[4] Hoyle, F., *Mon. Not. Roy. Astro. Soc.*, **120**, 338 (1960).

ASTROPHYSICS

Production of Neon in Stars

WE have recently made certain measurements of the properties of some levels in neon-20 which are related to the production of neon in stars. In particular we have shown that the 4·97-MeV. level has odd parity and $J = 2$. Consequently neon-20 cannot be formed through this level by thermonuclear reactions between helium and oxygen-16 as has been suggested to explain its production in stellar interiors after the hydrogen has been consumed[1,2]. The suggestion arose from the close proximity of the 4·97-MeV. level in neon-20 to the energy of oxygen-16 + α as shown in Fig. 1. For the level to be effective the parity would have to be $(-)^J$ where J is the total angular momentum.

The first evidence that the level has $J\pi = 2-$ arose from γ–γ correlations in the neon-20 $(pp'\gamma\gamma)$ reaction that established the total angular momentum as 2 (ref. 3) and the unexpectedly long life-time of $1 \cdot 9^{+3 \cdot 5}_{-1 \cdot 0} \times 10^{-12}$ sec. found by the Doppler shift technique in our experiments[4] using the carbon-12-(^{12}C $\alpha\gamma$)neon-20 reaction. The assignment of negative parity has now been established by our investigations (to be published) of neon-20($pp'\gamma$)neon-20. In this reaction measurements of the linear polarization[5,6] of the 3·34-MeV. γ-ray by Compton scattering combined with the angular distribution of the γ-ray defined its electric or magnetic character and thereby demonstrated that the levels concerned at 4·97 MeV. and 1·63 MeV. have opposite parity. The parity of the 1·63-MeV. level is positive (ref. 7 and A. E. Litherland and E. Almqvist, D. A. Bromley, J. A. Kuehner and B. Whalen, to be published). A parity of $(-)^{J+1}$ for the 4·97-MeV. level has since been deduced (A. E. L., to be published) from measurements (E. Almqvist, D. A. Bromley, J. A. Kuehner and B. Whalen, to be published) of the α-particle angular distributions in the carbon-12(^{12}C α)neon-20 reaction, and $J\pi = 2-$ has been confirmed by α–γ correlations in this same reaction (H. E. G., A. E. L. and M. A. C., to be published).

The next available level for helium thermonuclear reactions is at 5·63-MeV. This can be formed by the α + oxygen-16 reaction (H. E. G., A. E. L. and