LETTERS TO THE EDITORS

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Absorption of 3·5-m. Radiation in the Optical Emission Nebula, *NGC* 6357

In the course of a radio survey of bright emission nebulæ with the 1,500-ft. Sydney cross-aerial, some fourteen nebulæ were studied at a wave-length of 3·5 m. Six were probably observed in emission, seven were undetectable, and one, *NGC* 6357, was observed in absorption. The observation of *NGC* 6357 is the first reported case of absorption of radio waves by an emission nebula; it leads to an estimate of the electron temperature of the nebula based almost entirely on radio data. In this preliminary communication the observation and its consequences are discussed briefly; a more complete account of the survey will be given elsewhere.

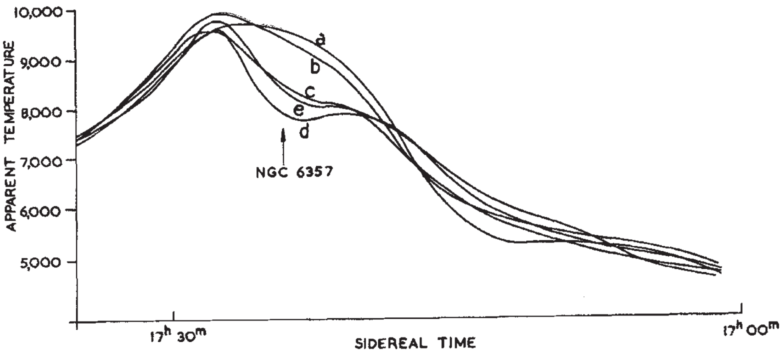

Fig. 1. Tracings of records obtained at five declinations superimposed to display the absorption effect at the position of *NGC* 6357. Declinations: (*a*) – 35° 11′; (*b*) – 34° 51′; (*c*) – 34° 31′; (*d*) – 34° 11′; (*e*) – 33° 51′

The radio telescope has a pencil-beam response, 50′ between half-power points, and is used as a transit instrument. It may be used to scan through a small angle in the meridian plane, recording five separate declinations quasi-simultaneously. In Fig. 1 are shown tracings of five such records straddling the nebula position and superimposed to display the effects of absorption. The position of the nebula is 17h. 18·4m., – 34° 03′ (1900), and the angular size is 63′ × 43′ [1]. Maximum absorption is estimated to occur at a position of 17h. 18·7m. ± 0·2m., – 34° 05′ ± 5′ (1900), in good agreement with the nebula position and in even better agreement with a radio measurement at 9·4 cm. by Haddock, Mayer and Sloanaker[2].

It is easily seen that the electron temperature of a mass of ionized gas observed in absorption must normally be less than the apparent brightness temperature at its centre (if both the nebula and background are irregular, with comparable scale factors, this is not necessarily true, but it appears safe to ignore such a possibility here). The brightness temperature at the nebula position is 7,800° K., with an estimated maximum calibration error of ± 20 per cent, or 1,600 deg. K. Thus the electron temperature of the nebula is probably less than 7,800° K. and almost certainly less than 9,400° K. An estimate of the actual temperature may be made if some other properties of the nebula and the galactic radio emission are known. It can be shown that if absorption between the nebula and observer is negligible, the electron temperature T_e is given by the equation:

$$T_e = T_a - (T - T_a)\left\{\frac{\Omega_0}{\Omega_n(1 - \varepsilon^{-\tau})} - 1\right\} - \alpha D$$

where T_a is the apparent brightness temperature measured at the nebula position; T is the brightness temperature in the absence of the nebula, estimated by interpolation; Ω_0 is the equivalent solid angle of the nebula after smoothing with the aerial beam; Ω_n is the actual solid angle and τ the optical depth (assumed uniform) of the nebula; α is the apparent brightness temperature of the galactic radio emission per unit distance in the direction of the nebula, and D is the distance to the nebula.

We take the following values: T_a = 7,800° K.; T = 8,800° K.; $\Omega_n = 1{\cdot}9 \times 10^{-4}$ steradian (corresponding to a size of 63′ × 43′); $\Omega_0 = 3{\cdot}6 \times 10^{-4}$ steradian (obtained by smoothing Ω_n with the aerial beam); $\varepsilon^{-\tau} \approx 0$ (consistent with the measurements of flux density at 9·4 cm.); $\alpha \approx 0{\cdot}5$ deg. K./parsec (estimated from the integrated brightness through the galaxy); D = 1,000 parsecs (distance of the assumed exciting star, – 34° 11671).

The corresponding electron temperature is 6,500° K., which is of the same order as, but rather lower than, 10,000° K., the temperature usually assumed for such nebulæ; the value could be even lower if the nebula were 'patchy'. A quantitative optical study of the nebula might prove very interesting.

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[1] Bok, B. J., Bester, M. J., and Wade, C. M., "A Catalogue of HII Regions in the Milky Way for Longitudes 250°-355°", Harvard Report (1954).
[2] Haddock, F. T., Mayer, C. H., and Sloanaker, R. M., *Nature*, **174**, 176 (1954).

Frequency Variations in New Zealand of 16 kc./s. Transmissions from *GBR* Rugby

We have made comparisons of the received frequency of the British Post Office Station at Rugby (*GBR*), distant 19,000 km., with the frequency of one of our standard crystal oscillators, following the receipt of information[1] that *GBR* is controlled by the British Standard Frequency source.

Equipment for this purpose consists of a narrow-band tuned amplifier on 16 kc./s. followed by a mixer to which is also fed a large 16 kc./s. signal derived from one of our oscillators. Any beat frequency present in the mixer output is recorded continuously on a paper chart. For convenience, our oscillator is adjusted to be about 3 parts in 10^7 fast; thus the beat frequency recorded is about 17 c./hr.