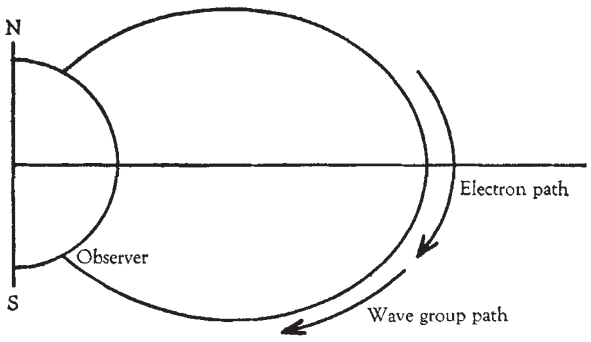

Fig. 2. Electron and radiation paths

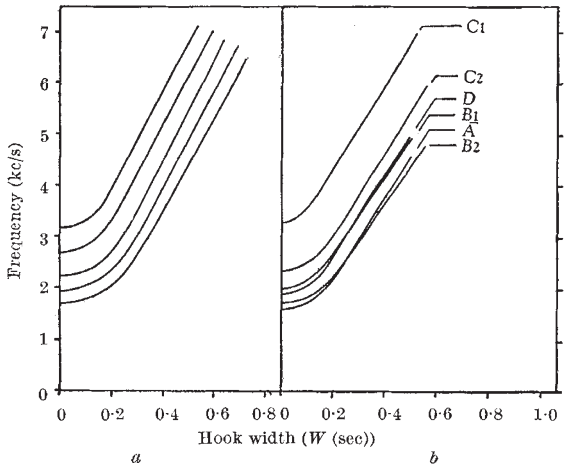

Fig. 3*a*. Theoretical variation of hook width with frequency for different values of scale frequency $F = f_0^2/f_H$. $L = 4{\cdot}0$; $\varphi_0 = 30°$; $V = 0{\cdot}3$ c. Scale frequency, left to right: 1,000 kc/s; 1,100 kc/s; 1,200 kc/s; 1,300 kc/s; 1,400 kc/s

Fig. 3*b*. Observed variation of width with frequency of hooks in Fig. 1. 1, recorded on September 23, 1957; 2–6, recorded on October 6, 1959

It was found that exact agreement with observation may be obtained with realistic values of the different parameters and it is suggested that this radiation is responsible for hooks like those of Fig. 1. The theoretical width-frequency slope is constant as is observed and in addition is found to be almost invariant with respect to changes in the electron energy, pitch angle or the plasma density, providing the field line latitude is kept constant. Fig. 3*a* shows the effect of changing the plasma density while Fig. 3*b* shows some observed $W - f$ curves.

It is not suggested at this stage that anomalous Doppler radiation is the cause of all other types of very-low-frequency emissions. There is a small proportion of hook-like phenomena, for example, in which the leading edge appears to coincide with a whistler. It is reasonable to assume that for these the leading edge is generated before the trailing edge rather than the opposite as would be the case for anomalous Doppler hooks, and they are most easily explained on a basis of whistler electron coupling through the backward Doppler mode as suggested by Hansen[4]. The $W \sim f$ curve is observed to be parabolic, as would be expected.

G. R. A. Ellis

University of Tasmania,
Hobart.

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Association of the Galactic Radio Spur with the Scorpio X-ray Source

It has been proposed[1] that the extended belt of radio emission known as the North Polar Spur is a shell source derived from a supernova explosion. If this hypothesis is true, the Spur is expected to resemble the Cygnus Loop, since the radio surface brightnesses are similar. So far there is no evidence[2] that the Spur is associated with optical emission similar to that observed in the Cygnus Loop. However, on the basis of the recent discovery[3] of an X-ray source within the loop defined by the Spur, Shklovsky has suggested that the source may be interpreted as a neutron star which is the relic of the original supernova. It is possible to check this idea by reference to radio observations.

It has been shown[4] that between the points $l^{II} = 28°$, $b^{II} = 10°$ and $l^{II} = 315°$, $b^{II} = 75°$, the Spur may be described by a small circle, centred on $l^{II} = 330°$, $b^{II} = 19{\cdot}5°$, and having a radius of 56°. The goodness of fit is such that the Spur nowhere departs from the circle by more than 3° and the possible margin in choosing the co-ordinates of the centre is not greater than $\pm 2°$ of arc. A recent radio survey[5] indicates that another part of the Spur lies on the same small circle between the points $l^{II} = 268°$, $b^{II} = +25°$ and $l^{II} = 268°$, $b^{II} = 44°$. The circle is therefore defined by observable radio emission over two arcs of length 88° and 21°.

The X-ray source lies at the position $l^{II} = 359°$, $b^{II} = 24°$. The error in this position is not clearly stated, but since the field of view of the detector was about 10° to half-power points the uncertainty should be about $\pm 3°$. The quoted position is displaced from the centre of the Spur by about 27° of arc, which is much greater than the sum of the errors in the determination of the positions. It is true that the geometry of an expanding supernova shell can be influenced by the structure of the interstellar medium, but it seems implausible that the Spur shell should be decelerated in such a way as to shift its apparent centre by more than half its radius and yet retain a good circular shape.

The Spur is known not to be a unique object in the sky[4] and the existence of two or three such objects in the sky renders it improbable that they are examples of the relatively short-lived type I supernova remnants. On the other hand, a comparison of the Spur with radio data on known type II remnants shows that, if the Spur is such a remnant, it is situated at a distance in the range 15–50 pc., and has an age of 5×10^4 yr or greater. Morton[6] has computed the cooling times for a neutron star model of the Scorpio X-ray source, assuming it to be at various distances. For all distances between 2 pc. and 900 pc. the time constant for cooling is in the range 320–1,500 yr, which is less than the derived expansion time of the Spur by at least a factor of 30.

It is concluded that although the X-ray source may have been the seat of a supernova explosion, and the Spur may be the expanding shell from such an event, it is unlikely that the two objects are associated in this way. Until the true natures of the objects have been ascertained we cannot, of course, rule out the possibility that there may exist some quite different connexion between them.

M. J. S. Quigley
C. G. T. Haslam

University of Manchester,
Nuffield Radio Astronomy Laboratories,
Jodrell Bank, Macclesfield.

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