THE STRUCTURE OF A TYPE-II SUPERNOVA REMNANT
G 160.5+2.8 (HB-9) OBSERVED AT $\lambda = 12$ m

E. P. ABRANIN and L. L. BAZELYAN
Division of Radio Astronomy, Institute of Radiophysics and Electronics,
Ukrainian SSR Academy of Sciences, Kharkov, U.S.S.R.

(Received 4 May, 1982)

Abstract. A two-dimensional brightness distribution of the old supernova remnant G 160.5 + 2.8 (HB-9) has been measured at a frequency of 25 MHz with the T-Shaped UTR-2 radio telescope, with the resolution $29' \times 27'$. The source has a distinctly pronounced, almost spherical envelope. At the same time, individual features located near the internal boundary of the source are observable. Certain considerations are put forward to validate a suggestion that the brightest feature in the decameter range (maximum at $\alpha = 4^h 55^m 3$ and $\delta = 46^\circ 37'$) might be of an extragalactic origin.

From structure considerations, the velocity of the pulsar PSR 0459 + 47 projected on HB-9 is estimated. The estimate does not contradict the hypothesis of Damashek et al. (1978) concerning a possible genetic relation between HB-9 and PSR 0459 + 47.

1. Introduction

The objects which are possible supernova remnants are generally distinguished from among other cosmic sources of radio emission. They are located near the galactic plane and are, on an average, characterized by apparently larger diameters and rather flat nonthermal spectra. Since the supernovae are located in areas with high optical absorption (Shklovsky, 1960), they cannot always be identified with filamentary nebulae. According to available theories (Shklovsky, 1960, 1962; Laan, 1962a,b), the radio source born in a supernova explosion is related to the expansion in the galactic space of the envelope released. Anisotropy of the explosion and the inhomogeneity of the interstellar gas density can result in a violation of the initial spherical symmetry and the formation of a fine structure in the source.

Lately, much effort has been spent on the search and investigation of supernova remnants. To date, over 130 such objects have been observed in the radio-frequency range. For the overwhelming majority of these, only integrated characteristics are known. Investigation of the fine structure of the older remnants is hampered primarily by their low surface brightness. At longer wavelengths of the shortwave band, at decameter wavelengths in particular, this difficulty is aggravated by the interference of the Earth ionosphere and the high temperature of the cosmic background. In view of these difficulties, the accumulation of experimental data is exceedingly slow; just a few of the 40 objects known at high frequencies have been mapped. Meanwhile, there are no reasons to suppose that longer-wavelength studies could not reveal some structural features unknown at high frequencies.

Copyright © 1982 by D. Reidel Publishing Co., Dordrecht, Holland, and Boston, U.S.A.
Below, we present the two-dimensional radio brightness distribution of the old supernova remnant G 160.5 + 2.8 (HB-9) measured at 25 MHz (Abranin and Bazelyan, 1979).

2. Observations

The measurements were performed with an UTR-2 multi-beam radio telescope (Megn et al., 1978). Three pencil beams, separated by 22.5' in declination, were used. When directed to the source, their half-power width was 27' in declination and 29' in right ascension. The output signal from each beam was passed to two phase-modulated radiometers. Their high-frequency pass bands were, respectively, 14 and 300 kHz, the time constant being 30 s. For further treatment, the records obtained with the wide band radiometers were preferred. The narrow band recordings were used when those of the wide band deteriorated through interference from broadcasting stations. The signals received were recorded simultaneously in analog and digital form. The source was observed three times during each session, namely at hour angles of 0 and ±1h. The sky area occupied by HB-9 was covered by seven scans in right ascension, each 1h long. Their declinations are indicated in Figure 2 with arrows. The scan records were repeated up to about 10 times. Then respective scans were averaged, as was done by Abranin et al. (1977), with an account of the refraction component in right ascension.

The T-shaped radio telescope employed for these observations is characterized by a relatively high-sided lobe level. Hence, an estimation of the interference of other cosmic sources and their contribution into the measured antenna temperature is needed.

The list of interfering sources was compiled taking into account the sensitivity and side-lobe level of the radio telescope. It includes over 100 objects with flux densities at 178 MHz exceeding 2 Jy. They are all located within a circle 30° in diameter, centered at the source HB-9. The sources lying within the radio boundaries of the supernova remnant are not included in the list.

The confusion effects were reduced by subtracting the calculated responses of the telescope to all the interfering sources. Estimates show that from the corresponding averaged scan records, confusion effects slightly distort those parts of the records which correspond to the passage of HB-9 through the major lobe of the reception pattern. The apparent flux density due to the confusion is generally less than 3 Jy, reaching the value of 6 Jy at some isolated points which is approximately the telescope sensitivity level.

Our T-shaped radio telescope does not contain dipoles at the intersection two of its antenna arrays. Therefore, operating as a correlation interferometer, the telescope fails to receive the d.c. component and its adjacent low-frequency components of the spatial spectrum. As a result, the entire record is shifted towards lower amplitudes, and a region of negative counts appears which is wider than the side lobe width (Figure 1). For the same reason, measurements of