Reports

Supernova Remnant W-44: Observations at 8350 Megacycles per Second

Abstract. *The region of W-44 was mapped at 8350 megacycles per second. The degree of linear polarization of the most intense portion of W-44 integrated over the 10.8-minute-of-arc beam was 11 ± 2 percent at position angle 45° ± 5°. This high degree of polarization is further evidence that W-44 is a supernova remnant. The integrated flux density of* $(95 \pm 25) \times 10^{-26}$ *watt per square meter per cycle per second for this source is consistent with measurements at lower frequencies extrapolated with the use of a spectral index of −0.44, obtained by other observers. In addition, the compact source 3 minutes of right ascension west of W-44 was unpolarized, within the error of measurement. The flux density of* $(23 \pm 6) \times 10^{-26}$ *watt per square meter per cycle per second determined for it along with the results of other observers indicate that this source has a thermal spectrum.*

The radio source known as W-44 (*1*), 3C 392 (*2*) or MSH 18+0 11 (*3*) lies near the galactic plane in a heavily obscured region, making optical identification impossible. Leslie (*4*) has observed the source with a fan beam and with an interferometer at a frequency of 178 Mc/s and has shown that her observations are consistent with a thin spherical shell structure having a diameter of 22.5 minutes of arc. The shell structure, relatively large size, and nonthermal spectrum led her to suggest that it is an expanding supernova remnant. Investigations by Kuz'min (*5*) indicate that the structure, spectrum, size, total energy, and magnetic field strength are similar to IC 443, a type II supernova remnant. Brightness contours obtained by Scheuer (*6*) from observations at 3000 Mc/s with a 7-minute-of-arc pencil beam show only a rough circular symmetry. However, the sharp outer edge and bright crescent, forming the eastern boundary, show that a shell interpretation is sensibly correct.

The predominant radio emission of supernova remnants is believed to be generated by the synchrotron mechanism, and hence may be expected to be partially linearly polarized. As noted by Korchakov and Syrovatskii (*7*) the integrated radiation from a spherical source should be unpolarized. For this reason, it is important to have sufficient resolution to observe different parts of the source. In addition, polarization is most likely to be observed at higher frequencies because the apparent polarization will diminish with decreasing frequency owing to differential Faraday rotation throughout the region of emission.

For these reasons, observations of W-44 were made at 8350 Mc/s in June 1965 with the U.S. Naval Research Laboratory's 50-foot (15 m) reflector. These observations are part of a linear-polarization survey of weak discrete sources. The radiometer consisted of a maser preamplifier followed by a conventional Dicke-type crystal-mixer receiver. The 15-Mc/s bandpass and an integration time constant of 2.3 seconds, used along with a system temperature of 70 degrees Kelvin, resulted in a root-mean-square output fluctuation of 0.015 degree Kelvin. The

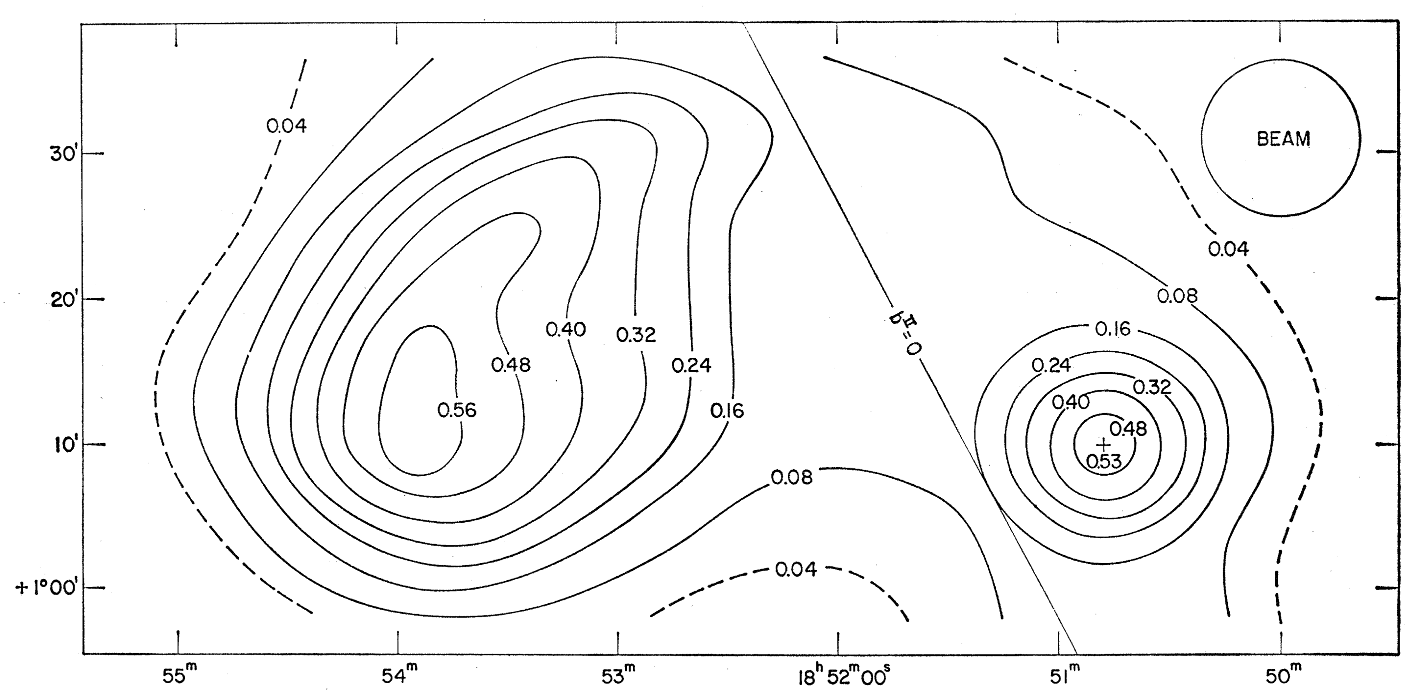

Fig. 1. The region around W-44 at 8350 Mc/s. The contours represent antenna temperature in degrees Kelvin. The accuracy is ±0.04 degree Kelvin. Main-beam brightness temperature may be obtained by multiplying by 1.42 ±0.22 percent. The map contours are measured from an arbitrary zero taken at 18^h56^m.

plane of polarization to which the equipment was sensitive could be varied by rotating the linearly polarized feed horn at the focus of the 50-foot reflector by means of a coaxial rotating joint. The beam-width of the reflector was 10.8 ± 0.5 minutes of arc between half-power points from drift scans of Virgo A.

The observations consisted of drift scans of the region taken at declination increments of 3 minutes of arc at a fixed position of the feed horn and of linear-polarization measurements made by continuously rotating the feed horn while tracking the position of highest intensity (*7a*).

The contour diagram of the region constructed from the drift scans is given in Fig. 1. Absolute position measurements were not made. The map was located by taking the position of the west source as $18^h50^m48^s$ right ascension, + 1°10′ declination epoch (1950.0), obtained from the observations of Scheuer (*6*), Gol'nev, Lipovka, and Pariiskii (*8*), and Pauliny-Toth, Wade, and Heeschen (*9*). Relative positions are good to ± 2 minutes of arc in both coordinates. Since the 50-foot reflector is altazimuth-mounted, the position angle of the plane of polarization to which the equipment was sensitive changed with local-hour angle. The total range in position angle over which observations were made was 39°, and the weighted average of the map is at position angle 11°. Considering the polarization integrated over the 10.8 minute-of-arc beam to be as high as 11 percent, the maximum possible error in the antenna temperature contours due to the above change in position angle during the observations is 7 percent and is reflected in the accuracy of the map of ± 0.04 degree Kelvin.

From the present observations W-44 is seen to be an extended crescent shape with a sharp eastern boundary closely resembling its appearance at 3000 Mc/s as observed with a 7-minute-of-arc resolution (*6*). The degree of linear polarization of the radiation, for the most part integrated by the 10.8-minute-of-arc beam, was measured to be 11 ± 2 percent at a position angle of 45° ± 5°. This is the first detection of linear polarization of the radiation from W-44 and strongly supports the interpretation of it as a supernova remnant. Since the polarization was integrated over a 10.8-minute-of-arc region of the source, smaller regions may be more highly polarized than 11 percent. For example, linear polarization in a 2-minute-of-arc portion of the Crab Nebula has been determined to be as high as 17.5 percent at 9400 Mc/s (*10*), probably over 20 percent at 5000 Mc/s (*11*) and 8 to 10 percent at 2830 Mc/s (*12*) whereas present observations at 8350 Mc/s of the integrated radiation from the whole source give 7 percent polarization. The total flux density of W-44, obtained by integration of the antenna temperature contours and corrected for the measured polarization, was $(95 \pm 25) \times 10^{-26}$ watt m^{-2} $(c/s)^{-1}$ based upon an assumed flux density of $(45 \pm 5) \times 10^{-26}$ watt m^{-2} $(c/s)^{-1}$ for Virgo A. This value is consistent with measurements at lower frequencies extrapolated with the use of a spectral index of −0.44 as determined by other observers (*5, 13*).

The source 3^m west of W-44 in Fig. 1 was first observed by Scheuer (*6*) and closely approximates a point source with the present resolution. The linear polarization and integrated flux density were measured to be 0.3 ± 1.5 percent at 72° ± 90° position angle and $(23 \pm 6) \times 10^{-26}$ watt m^{-2} $(c/s)^{-1}$, respectively. This flux density, and the absence of linear polarization, at 8350 Mc/s along with the flux density measurements of other observers (*8, 9*) indicate that this is a thermal source.

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References and Notes

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A Differential Anemometer for Measuring the Turning Tendency of Insects in Stationary Flight

Abstract. *A pair of thermistors forming part of a direct current bridge circuit was mounted in the wake of a moth in stationary flight. Differential changes in the thermistors' resistance provided a sensitive index of changes in the direction of the airstream as the insect made attempts to turn away from a source of ultrasonic pulses.*

Field observations (*1*) show that some moths of certain families, when in free flight, turn and take a course directly away from a source of faint ultrasonic pulses. Reception of pulses at higher intensity causes nondirectional diving and looping. These reactions increase the insects' chances of evading detection and capture by insectivorous bats (*2*) and have been the basis of a number of neurophysiological and behavioral studies (*3*). The differential anemometer was developed in an attempt to bring these behavioral responses into the laboratory for closer scrutiny. It proves to be extremely sensitive to changes in the location of a small stream of air, and it may have other applications.

The lift and forward thrust of a flying insect vary with the velocity and direction of the airstream ejected downwards and backwards by its moving wings. Detection of changes in the position of this wake relative to the body axis of an insect in stationary flight should provide an indication of attempts to change the direction of its flight path.

Moths were collected at light. Forty specimens belonging mostly to the genera *Feltia, Leucania,* and *Amanthes* have so far been studied. About one half of these showed stationary flight of reasonable duration, although in many cases its direction was too erratic for present purposes. Eight specimens showed consistent and repeated attempts to turn away from a small capacitative loudspeaker emitting ultrasonic pulses.

Each moth was mounted under carbon dioxide anesthesia with a small drop of Tackiwax applied to an insect pin whose tip just penetrated the notum. The pin was inserted in a crystal phonopickup in order to record changes in the frequency and amplitude of thoracic movement and hence wingbeat.