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Astronomy

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Fig. 1

Figure 1: Fig. 1

Abstract

Full Text

Astronomy

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A NEW SOURCE OF RADIO EMISSION AT CENTIMETER WAVELENGTHS

(Presented by Academician V. A. Ambartsumian, 28 IX 1960)

In March 1959, observations of the background radio emission of the Galaxy in selected regions of the Milky Way at a wavelength of 9.4 cm were carried out on the large Pulkovo radio telescope ⁽¹⁾. At declination $\delta = 1^{\circ}15'$ a new source of radio emission was detected, located in the plane of the Galaxy. The transit curve determined from four measurements is shown in Fig. 1.

The coordinates of the source proved to be: $\alpha_{1950} = 18^h53^m38^s$, $\delta_{1950} = 1^{\circ}15'$. The high resolving power of the radio telescope made it possible

Fig. 1

to determine the angular dimensions of the source, $\varphi_i = 31'.5$. The coordinates of the source agree excellently with source No. 44 in Westerhout's catalog ⁽²⁾, 2C1607 in the second Cambridge catalog ⁽³⁾, and with 18 + 011 in the catalog of Mills et al. ⁽⁴⁾. The radio flux at a wavelength of 9.4 cm is $(200 \pm 20) \cdot 10^{-26}$ W/m²Hz, $185 \cdot 10^{-26}$ W/m²Hz at a wavelength of 22 cm ⁽²⁾, and $1500 \cdot 10^{-26}$ W/m²Hz at a wavelength of 3.5 m ⁽³⁾. In contrast to ordinary class II radio sources, the spectrum of the source is flat in the short-wavelength region of the spectrum. This indicates the presence of a thermal component, which is dominant in the centimeter range. For a flux $P = 200 \cdot 10^{-26}$ W/m²Hz and an angular size $\varphi_i = 31'.5$, this thermal emission corresponds to an emission measure $ME = 1.6 \cdot 10^4$.

In photographs of this region of the sky in H_{α} light with long exposure, obtained by G. A. Shajn and V. F. Gaze in Simeiz, gaseous nebulae are absent, i.e. the visible emission measure of this object does not exceed 400, and the absorption to it exceeds

$$2.5 \ln \frac{1.6 \cdot 10^4}{400} = 6^m.3.$$

On the other hand, the mean photographic absorption in this direction, according to (5), is $4^m \cdot 1$ per 1 kpc, i.e. 3^m per 1 kpc in the H_α region. Thus, the distance to the radio source r exceeds 2100 pc. For $r > 2100$ pc we find (6) that $M/M_\odot > 700$, $N_e < 50$.

The position of this source relative to the plane of the Galaxy indicates that it is a Galactic object. Even if one assumes,

that such a position is due to the chance projection of some galaxy, invisible in the optical region because of strong absorption, then the mass of ionized gas of such a galaxy would exceed by several orders of magnitude the masses of the galaxies richest in gas.

In the meter wavelength range this source has a spectrum typical of magnetobremstrahlung radiation. Recently it has repeatedly been suggested that a considerable number of galactic sources of nonthermal radio emission are remnants of supernovae that once exploded.

Of interest is the magnitude of the minimum energy required to explain the luminosity of the new source in the radio range. If one assumes that the spectrum of the source is $P_\nu = \nu^{-\chi}$, where $\chi = 0.55$, and that at the frequency $\nu = 100$ Mc/s $P_\nu = 1000 \cdot 10^{-26}$ W/m² c/s, then its radio luminosity

$$P = 4\pi r^2 \int P_\nu d\nu > 3 \cdot 10^{34} \text{ erg/sec}$$

for $r > 2100$ pc. The energy of the relativistic electrons is determined by the quantity

$$\mathcal{E}_e = \int_{E_1}^{E_2} N(E) E dE, \quad N(E) = \frac{k}{E^\gamma}, \quad \gamma = 2\chi + 1.$$

The values E_1 and E_2 are determined by the expression

$$\nu_{1,2} = 4.19 \cdot 10^6 H \left(\frac{E_{1,2}}{mc^2} \right)^2, \quad \text{where } \nu_1 = 10^7, \nu_2 = 10^{10}.$$

The radiating relativistic electrons and positrons are the product of the decay of mesons formed in collisions of relativistic protons with atoms of the interstellar medium. The energy of the primary protons is $\mathcal{E}_p \cong 100 \mathcal{E}_e$. The value of \mathcal{E}_p needed to explain the observed radio emission depends on the magnetic field H .

As is usually assumed (7), the most probable physical conditions in the nebula are those which require the minimum energy expenditure to explain the observed radio emission. It can be shown that these conditions occur for $\mathcal{E}_p = 3 \cdot 10^{50}$ erg, $H = 1.7 \cdot 10^{-4}$ gauss, when the magnetic energy is equal to the energy of the

primary cosmic particles. The total energy (particles and field) will therefore be more than $6 \cdot 10^{50}$ erg.

Thus, the energy contained in the volume of the radio nebula at the present time is substantially greater than the energy released in the explosion of an ordinary supernova (type I). The only source known to us of so large an energy is the explosion of a type II supernova. In Table 1 we have given the physical conditions in the new source for comparison with the Loop in Cygnus and with 1 C 443, which, according to ^(8,9), are also remnants of type II supernovae.

Table 1

Object	\mathcal{E}_p , erg	H , gauss	$\mathcal{E}_p^0 \times$ volume of radio source	Linear size, pc
New source	$> 3 \cdot 10^{50}$	$1.7 \cdot 10^{-4}$	$1.7 \cdot 10^{47}$	> 20
1 C 443	$6 \cdot 10^{49}$	$4 \cdot 10^{-5}$	$1.5 \cdot 10^{48}$	40 (?)
Loop in Cygnus	$1 \cdot 10^{48}$	$5 \cdot 10^{-4}$	$1.5 \cdot 10^{48}$	40

It is essential that in our case the observed radio emission can already be explained by compression of the magnetic field in the expanding shell of the nebula with the ordinary density of primary cosmic particles in the inter-

stellar space (1 eV/cm^3), since the energy of the primary cosmic particles \mathcal{E}_p^0 will be only $1.7 \cdot 10^{47}$ erg. Therefore an internal source of high-energy particles is necessary. This confirms the hypothesis of I. S. Shklovsky¹, according to which supernovae are the principal supplier of primary cosmic particles in the Galaxy.

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Note: Figure translations are in progress. See original paper for figures.

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¹I. S. Shklovsky, *DAN*, **91**, 475 (1953).