Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (28 September, 1977)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on September 28, 1977 in the conference hall of the P. N. Lebedev Physics Institute. The following papers were presented:

1. *V. A. Udal'tsov, A. V. Pynzar', and A. P. Glushak*, Radio-astronomical studies of the pulsar/supernova remnant problem.

2. *Yu.P. Ochelkov, V. V. Usov, and A. I. Tsygan*, The nature of pulsar radio emission.

3. *L. M. Ozernoĭ and V. V. Usov*, The origin of the high-frequency (optical, x-ray, and gamma-) radiation of pulsars.

We publish below brief contents of these papers.

V. A. Udal'sov, A. V. Pynzar', and A. P. Glushak. *Radio-Astronomical Studies of the Pulsar/Supernova Remnant Problem.* It is now believed that pulsars and supernova remnants (SNR) are genetically related. It has been proposed that the Crab Nebula can be paired in this way with the pulsar 0532 and Vela *X* with pulsar 0833. The pulsar in the Crab Nebula has been identified by many authors with a compact blinking source of continuous longwave radio emission with a steep spectrum.

A search for such sources in SNR was made by Pynzar' and Udal'tsov in 1975/1976 with the new BSA radiotelescope of the Academy of Sciences Physics Institute (FIAN).[1] This search turned up a blinking source in the supernova remnant HB9 (G160.4 + 2.8). According to June 1976 observations, the flux density of this source at 102 MHz was 0.7 ± 0.3 jan. The source is within the nebular shell, on its eastern edge at a distance of 20 pc from the center. The relative positions of this source and the HB9 nebulosity are indicated by the radioisophots in Fig. 1. If the source is genetically related to HB9, the relative velocity of the source would be 200 km/sec if the age of the nebula is 10^5 years, it subtends an angle of 2°, and is 1.1 kpc distant. This value is not inconsistent with observed pulsar velocities. The source is apparently a young pulsar whose pulsed radiation is not observed in the meter band due to "blurring" in the medium between the source and the observer, or in the centimeter band due to the low energy flux in its steep spectrum.

Blandford *et al.*[2] indicated the possibility of formation of radiohaloes around old pulsars.

In 1976-1977, using the FIAN BSA radiotelescope, the authors made a selective search for sources of continuous radio emission in the directions of pulsars. The lowest flux density that could be detected was 1 jan. A source of continuous emission with a flux of about 4 jan at 102 MHz was observed in the course of this search in the direction of the pulsar 2217 + 47. The low resolution of the BSA ($48'\times23'$ sec θ) precluded positive association of the observed source with the pulsar. The average flux density of the pulsar during the observations was about an order of magnitude lower. Measurements[3] made in the United States on RT-92 indicate no continuously emitting source with a flux above 0.7 jan at the 40-cm wavelength in the direction of pulsar 2217. Thus, if the observed source coincides with the pulsar, its spectral index would have to be larger than or equal to 0.9.

We know that the spectra carry information on the nature and structure of the radiation sources. Thus, an inflection in the spectrum of a nebula with a 0.5 change in the spectral index can serve as a test for detection of a source of continuous relativistic-electron emission (for example, a pulsar) in a SNR. Such a spectrum is observed in the Crab Nebula. Similar spectra have been detected in recent years in old SNR—the Cygnus Loop and HB9. However, because of the low frequency of the inflection in these spectra (10^9 Hz) as compared to the corresponding frequency of the Crab Nebula (10^{14} Hz), the observed inflections in the spectra of the Cygnus Loop and HB9 are explained differently—

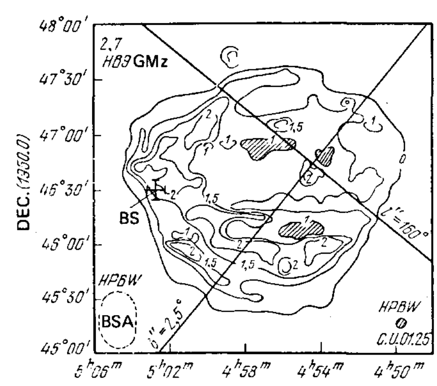

FIG. 1. Relative positions of supernova remnant HB9 and blinking source (BS). The isophots of HB9 at 2.7 GHz were taken from Willis' paper.

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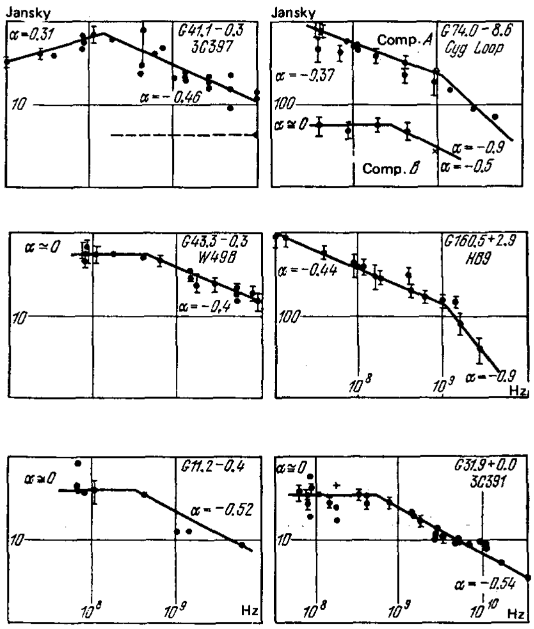

FIG. 2. Spectra of supernova remnants with inflections in the radio range.

as a feature of the synchrotron spectrum of the Galaxy. Here it is assumed that the emission of old SNR is a consequence of expansion of the shockwave from the explosion of the supernova and is governed by the piled-up magnetic field and the relativistic electrons of the interstellar medium.

In 1974-1976, Udal'tsov studied the low-frequency spectra of certain SNR. Flux measurements were made at frequencies of 60, 83, 102, and 111 MHz with the VZ DKR 1000 radiotelescope. These measurements showed inflections in the spectra of two more SNR (G 11.2 – 0.4 and G 31.9 + 0.0) and confirmed those of W49B, 3C 397, HB9, and the two components of the Cygnus Loop. Compilation spectra of these SNR appear in Fig. 2. The figure shows that the change in the spectral index at the inflection point is near 0.5 for all SNR and that the frequencies of the inflections lie in the range 0.1 – 1 GHz for all of the SNR except the Crab Nebula. The supernova remnants G 11.2 – 0.4, G 31.9 + 0.0, and G 43.3 – 0.3 are much younger than HB9, since their linear dimensions (12 pc) are one-fourth as large.[4] In these sources, therefore, the contribution of radiation from the piled-up shells should be small, and, accordingly, the inflection in the spectrum cannot be explained by the spectrum of the Galactic radiation. The question as to the nature of the spectral inflection of the SNR remains open.

The radiobrightness distribution of the central region of the Galaxy was studied in the meter band at Pushchino in 1971-1976. The region within a 2° radius from the center was investigated. Measurements were made at five frequencies with the VZ DKR 1000 radiotelescope with an 8′.7×3°.5 knife-edge directional pattern at 120 MHz. Three nonthermal radio sources were discovered near the Galactic center as a result of the first series of studies, which was carried out by Brezgunov, Dag-

R.A. (1950.0)	S (83)	S (95)	S (100)	S (110)	S (120)	α (83–120)	Source
1) 17.37.10	31±6	38±8	34±7	21±4	10±2	–2.5	
2) 17.38.45	20±4	14±3	13±3	9±2	8±2	–2.5	
3) 17.40.36	16	20±4	14±3	12±2	12±2	–1.3	
4) 17.41.49	3	4±3	4±3	5±3.5	8±5	+2	
17.42.29	ac						
5) 17.43.01	21±4	43±8	46±9	39±8	44±9	+1.5	4, 5
6) 17.44.10	13	14±3	28±6	21±4	28±6	+2.7	4, 5
7) 17.45.22	6	14±3	21±4	22±4	23±5	+2.6	4, 5
8) 17.46.34	15	13±3	16±3	10±2		–2.1	
9) 17.48.28	9±2	14±3	11±2	8±2	9±2	–1.1	

Right ascensions determined to ±5^s. All sources have declinations in the range $\delta = 28°30 \pm 2°$.

kesamanskiĭ, and Udal'tsov.[5] Downes drew attention to these sources independently and classified them as SNR.

Six more nonthermal radio sources were discovered in the second series of studies, which was made by Udal'tsov. The measured parameters of these sources—right ascension, flux density at the five frequencies expressed in jan, and the spectral indices in the 83–120 MHz range—are given in the table.

The table shows that all sources nearer to the center have inversion spectra, while peripheral sources have steep spectra (with spectral indices larger than 1). The inversion spectra result from absorption of the radio emission in the medium surrounding the Galactic nucleus. The true spectra of all of the observed sources would evidently be steep.

There is reason to believe that all nine of the observed sources are SNR, and that their specific features are due to Galactic-nucleus effects. The steep spectra of the sources also indicate the possibility of classifying them as young pulsars whose pulsed emission has been transformed to continuous emission under the influence of their environment.

It is concluded from the fact that the absorption of radio-source emission depends on the angular distance of the source from the Galactic center that the sources are actually in the region of the center and therefore 10 kpc distant.

In conclusion, we should draw attention to the fact that all nine responses of these sources follow each other in succession. This gives reason to assume that there are apparently more sources in the region studied than are observed, since some of them are not resolved by the directional pattern of the radio telescope.

The high concentration of nonthermal radio sources in the region of the Galactic center evidently indicates high supernova-flareup activity in this region of the Galaxy.

[1]V. V. Vitkevich *et al.*, Izv. vyssh. uchebn. zaved. Radiofiz. **19**, 1594 (1976).
[2]R. D. Blandford *et al.*, Astron. and Astrophys. **23**, 145 (1973).
[3]T. Velusamy, M. R. Kundu, Astrophys. Lett. **17**, 177 (1976).
[4]D. Downes, Astron. J. **76**, 305 (1971).
[5]V. I. Ariskin *et al.*, Izv. vyssh. uchebn. zaved. Radiofiz. **16**, 1334 (1973).