Detected Sources from the Sensitive Survey at the Declination of the Crab Nebula (22^o)

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Abstract. As by-product of the search program of fast radio bursts(FRB), which is conducted with the RATAN-600 radio telescope, we have detected about 1500 radio sources at frequency 4.7 GHz, identified with sources from other catalogs, as a rule from the NVSS catalog at 1.4 GHz. From 28 May 2018 to 30 May 2019 the strip (width $\sim 30'$) of sky on the declination of the Crab nebula pulsar (Dec = $+22^o01'$) was observed with a three-beam complex of four-channel sensitive radiometers, established in focus of the antenna 'Western sector' of RATAN-600. Most sources have been identified with galaxies and quasars.
Some supernova remnants were detected in cross-sections of the Galactic plane. For the first time with RATAN-600 radio telescope, working in a mode of fast radiometry, several giant pulses (up to 100 Jy) have been detected from the pulsar PSRJ0534+22 in the Crab Nebula.

Keywords: techniques: radar astronomy; surveys

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Blind Radio Surveys

The blind sky radio surveys are the traditional method of the studies from the pioneer 3C, 4C, Parkes, GB6 to modern low-frequency surveys TGSS. RATAN-600 was used for some surveys: Zelenckuck survey in region $0^o <$ DEC$< 14^o$, or so called the "Cold" deep survey at 3.9 GHz (Bursov et al. 2007).

Now during the 3-year sky survey with the Western sector of RATAN-600 on a three-beam four-channel complex of radiometers at 4.3-4.9 GHz we are looking for short bright pulses from the fast radio bursts (FRB) (Trushkin et al. 2018).

Such pulses must be effected by the cosmic dispersion in ionized interstellar and intergalactic media (Trushkin et al. 2018). Since May 28, 2018 to May 30, 2019 sky survey was carried out on the 24-hour strip at the Declination of $+22^o$ of the supernova remnant the Crab nebula. We have summarized the data received in narrow channels in order to obtain the maximum sensitivity of the flux ($\sim$ 2-3 mJy/beam) in the wide frequency band of 600 MHz at center frequency 4.7 GHz. This limited value is constrained only by the effect of confusion for an antenna beam with dimensions of about $1' \times 35'$. We obtained about 20-25 high-quality hour records during every month and in general finally 12 average hour drift scans. We measured the light curves for bright variable sources during 365 days. So the distant quasar J1021+22 (z=4.27), the blazar J1103+22, the flat-spectrum source 0152+22, the gamma-ray source J1807+22 and many else were studied in daily measurements.

We identified the detected sources with the objects from CATS database (Verkhodanov et al. 2005) in order to plot compiled radio spectra of the sources. We would like to detect and indeed we have detected the some giant pulses (GP) with fluxes of up to hundreds Jy from the Crab Nebula 33ms-pulsar PSR0534+22. We divided of the total annual volume of data into 12 parts, and data processing was carried out for each of their parts: coordinate (RA) and flux adjustment using the most bright sources, averaging the signals for each 20-30 days. We obtained of the calibration curve, produced convolution with the calculated beam and averaging for each RA-hour of the survey. Since the survey was conducted with antenna 'Western sector' directed exactly to the East the sources have the oblique transit of the sky through the fixed a diagram of the radio telescope. Data processing was involved with the FADPS software [Verkhodanov, 1992]. We created the list of 1500 radio sources with reliable identifications with NVSS catalog sources at 1.4 GHz. The flux density distribution of these sources (up to flux density 150 mJy) is shown in Fig.1, in comparison with the NVSS detected sources.

Discussion

About half of the detected sources have fluxes less than 10 mJy at 4.7 GHz, and the realized sensitivity of it was about 2-3 mJy. During the year of observations fluxes of some sources have noticeably changed. The strongest changes in the flux density for the blazar B2 1324+22. In the survey area, 62% of sources have the measurements of the flux densities only at the frequency 1.4 GHz (NVSS), 30% of sources have low frequency spectra ($\leq$ 1.4 GHz) and only 8% of sources have high frequencies measurements, mostly from GB6 Green Bank radio telescope survey.

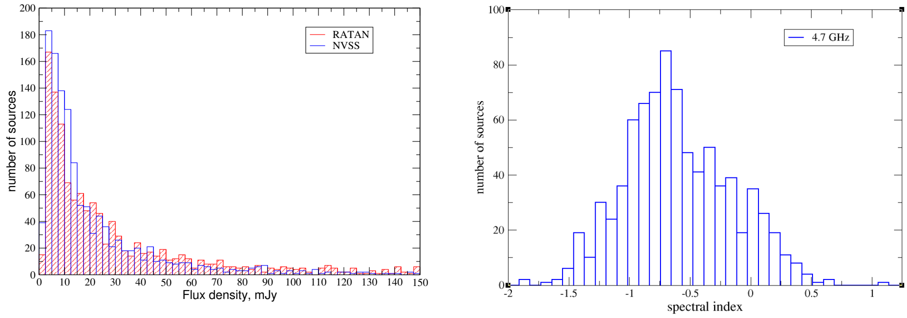

Fig. 1. *left* : The flux density distribution for detected sources from this survey and the NVSS survey; *right*: Distribution of the two-frequency spectral indices.

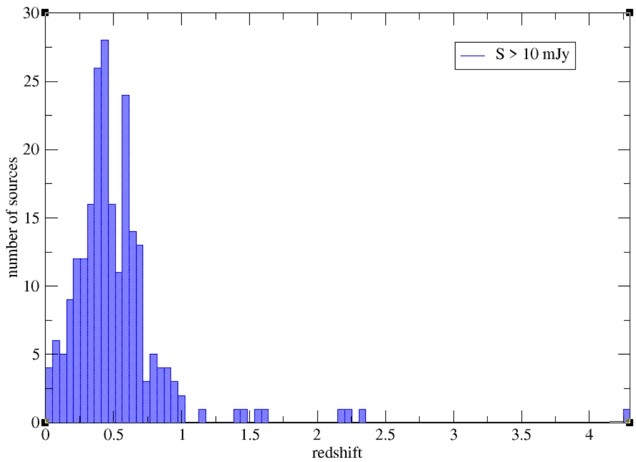

Fig. 2. Histogram of distribution of the detected sources with flux higher than 10 mJy from redshift, according to SDSS

Spectra of all detected sources are plotted: for 26% of sources spectra are constructed for the first time, 34% of spectra are refined. The distribution of spectral indices is shown in Fig.1 on two frequencies: 1.4 and 4.7 GHz. You see an excess of sources with steep spectra ($\alpha \leq -0.8$) in accordance with the general spectral distribution of the extra-galactic sources. The plotted distribution have significant fraction on the right side – positive spectral indices, that could be explained by selection effect from more higher frequency of the survey. Possibly that the extended NVSS-sources within the Galactic plane contribute to the distribution.

For 70% detected sources optical identifications with SDSS were made. Of these, 56% were identified with galaxies, rest ones with quasars and unresolved objects. The distribution of the detected sources from redshift, according to SDSS is shown in Fig.2. We have found the X-ray counterpats (2RXS) for 192 sources (13%). Possibly interesting radio and Gamma-ray source FIRST J125433+221102 is identified with a distant quasar on measured $z > 6.2$.

We have detected the bright giant pulses from Crab nebula pulsar PRS 0534+22 on 30 June (03:55UT), on 1 October (20:46UT) and on 12 December 2018. All of them had effected by the interstellar dispersion measure DM$\sim$57 pc cm^{-3} and very high fluxes, estimated from 8 to 100 Jy. All detected pulses are probably are the inter-pulses, not main pulses of the pulsar.

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