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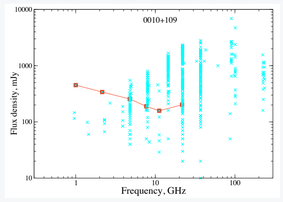
RATAN-600 Observations of Radio Sources that are Bright at Millimeter Wavelengths

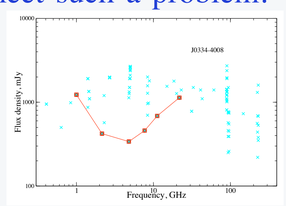
Sergei Trushkin, satr@sao.ru, Special Astrophysical Observatory of R.A.S, Nizhnij Arkhyz, Russia,

Heinz Andernach, heinz@astro.ugto.mx, Argelander-Institut fuer Astronomie, Univ. Bonn, Germany and Departamento de Astronomía Univ. Guanajuato, Mexico

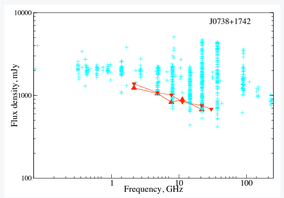
From WMAP we know that in the 23–90 GHz band there are no new populations of extragalactic sources brighter than 1 Jy. However, many bright cm-wave sources were not detected with WMAP. Many more fainter sources will be detected with the PLANCK mission. We selected a large sample of likely mm-bright sources, in order to study how the different source types (AGN, BLLac, etc.) are distributed among them. We estimate that probably at least 1500 sources on the whole sky may be brighter than 400 mJy at 22 GHz. As a rule these are variable sources with inverted or flat spectra. We chose a sample of 330 extragalactic sources in the declination range -42° to $+49^\circ$ for simultaneous observations at 7 frequencies in the 1–30 GHz range. The main selection criterion for this sample was a lack of flux measurements above ∼10 GHz and a flat or inverse radio spectrum, making them likely to emit >400 mJy at 22 GHz. Observations were carried out with the RATAN-600 radio telescope during 10 days in March and 10 days in December 2008. Many data were also obtained during some telescope technical time over the past years. We present instantaneous spectra for this frequency range for some epochs. Comparing these spectra with former flux measurements, compiled from literature in our CATS database, we detected different high or low states of the sources.

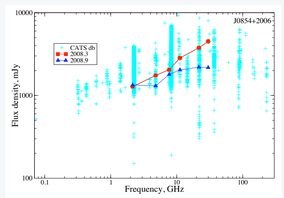
The problem of discrete foreground sources in the CMB experiments is one of the most important because their contamination may strongly influence final results on the CMB anisotropies. The ongoing WMAP and PLANCK missions meet such a problem.



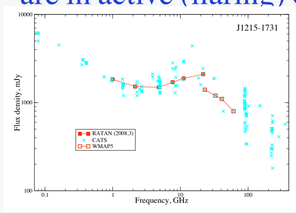


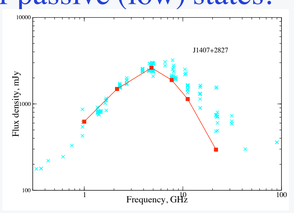
The WMAP catalog of discrete sources (Hinshaw et al. 2007) was found to lack quite a few strong sources, probably because of confusion effects or/and not-optimal filtering of the maps to detect these sources (Nie et al. 2007; Lopez-Caniego et al. 2007). Trushkin (2003) compiled radio spectra for the WMAP first-year catalog sources. He used the public domain CATS database to identify all but 3 sources with previously known radio sources. CATS (www.sao.ru/cats/) is maintained at SAO RAS and allows to prepare lists of potentially bright mm-sources and obtain their radio spectra online. Based on thousands of various former radio measurements we estimate



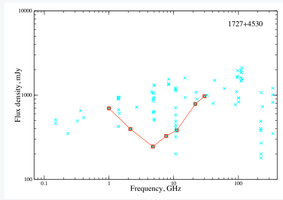


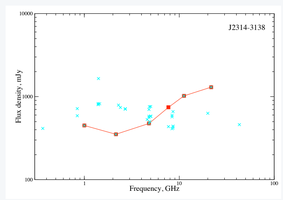
that at least 1500 sources in the whole sky may be brighter than 400 mJy at 22 GHz. As a rule these are variable sources with inverted or flat spectra. However, these spectra often lack high-frequency data (ν >10 GHz). We chose a sample of ∼330 extragalactic sources in the declination range -42° to $+49^\circ$ for simultaneous observations at 7 frequencies in the 1–30 GHz range. The main selection criterion for this sample was fast radio variability, and a lack of high-frequency flux measurements and a flat radio spectrum, making them likely to emit >400 mJy at millimeter wavelengths. Observations were carried out with the RATAN-600 radio telescope during 10 days in March and 10 days in December 2008. Data were also obtained during some technical telescope time over the past years. We present instantaneous spectra for this frequency range for some epochs. Indeed we found that most of sources (330) have flat or inverse spectra. Most sources (300) have measured 22-GHz fluxes above 400 mJy. Obviously many sources are variable even on time scales of half a year, and on longer time scales if we compare our data with early measurements, collected from CATS. These data show clearly that often now studied sources are in active (flaring) or passive (low) states.





In some sample figures we show radio spectra of 8 of our sources where our RATAN measurements are marked by red points connected with straight lines (no fit was applied). WMAP J0334−4008 was in bright state at high frequencies with inverse component of the mm-spectrum. For the IDV-blazar J0738+1742 and the blazar J0854+2006 (OJ 287) we measured instantaneous spectra at two epochs. J1407+2827 was in a typical GPS state with flux peak around 5 GHz. J1727+4530 showed a two-components spectrum: negative spectral index at low frequencies and positive one at high frequencies. J2314−3138 showed a high-peaked spectrum, meanwhile its earlier spectrum was rather flat.





About 50 sources were resolved with RATAN-600 at 1 cm wavelength with resolutions of 7″–15″ in right ascension (much larger in DEC). 211 sources are identified with optical objects from the 12th ed. of the QSO-AGN catalog by Veron-Cetty & Veron (2006): 162 are QSOs, 31 blazars and 18 AGN. Only for 26 sources there don't seem to be optical counterparts as yet.

We proved that generally the extrapolation of earlier radio data, mostly obtained in centimeter and decimeter bands, allow us to estimate properties of the source at millimeter wavelengths. This research is supported by Russian Foundation of Basic Research grant N 08-02-0504. H.A. thanks CONACyT for sabbatical grants 81356 and 118295, and partial support from the German grant TRR33 "The Dark Universe".

RATAN-600 spectra of Radio Sources that are Bright at Millimeter Wavelengths