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The Australia Telescope 20 GHz (AT20G) Survey: The Bright Source Sample

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The Australia Telescope Compact Array 20 GHz (AT20G) blind survey has now covered the whole of the southern sky at 20 GHz, with follow-up observations of detected sources at 4.8 and 8.6 GHz. The survey began in 2004 and has a flux density limit of 50 mJy (4400 sources south of declination $\delta = -15^\circ$ and an estimated 1500 sources in the region $-15^\circ < \delta < 0^\circ$ for which the analysis is still on-going). The Bright Source Sample (BSS) is a complete and flux density-limited sub-sample of 320 extragalactic ($|b| > 1.5^\circ$) radio sources south of declination -15° which have 20 GHz flux densities above 0.50 Jy. 218 of them have almost simultaneous observations at 4.8 and 8.6 GHz. Here we present some of the results of the analysis of spectral properties in total intensity and in polarisation and redshift distribution.

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1. Motivation

Knowledge of high-frequency radio-source populations is limited and mainly based on extrapolation of low-frequency surveys, small-area surveys, and whole-sky low-sensitivity observations. High-frequency, high-sensitivity surveys are usually very time consuming.

The Australia Telescope Compact Array has recently completed a blind survey of the whole Southern sky at 20 GHz, called AT20G. The survey began in 2004 and covers the whole 2π sr of the southern sky, down to 50 mJy flux density limit of 20 GHz. It detected 4400 sources south of declination -15° and an estimated 1500 sources in the range $-15^\circ < \delta < 0^\circ$ for which the analysis is still on-going. Almost simultaneous follow-ups have been done at 4.8 and 8.6 GHz to investigate the source statistical properties.

The AT20G sample will provide information to investigate the radio source population at frequencies above 5 GHz. A set of coordinated projects is underway to study several aspects of extragalactic and Galactic sources, including: polarization properties, millimetre properties, variability. An important aspect of our characterisation of source properties is the decontamination of maps of the Cosmic Microwave Background (CMB), and the provision of samples of calibrators for upcoming CMB (Planck) and other high-frequency instruments (ALMA, SKA, VLBI). For more details on AT20G, see Massardi et al. (2007), Sadler et al. (2007) and Ekers et al. (these proceedings).

2. The Bright Source Sample

The Bright Source Sample (BSS) is a complete and flux density-limited sub-sample of 320 extragalactic ($|b| > 1.5^\circ$) radio sources south of declination -15° which have 20 GHz flux densities above 0.50 Jy as measured in the better quality observations during 2004-07 epochs. 218 of

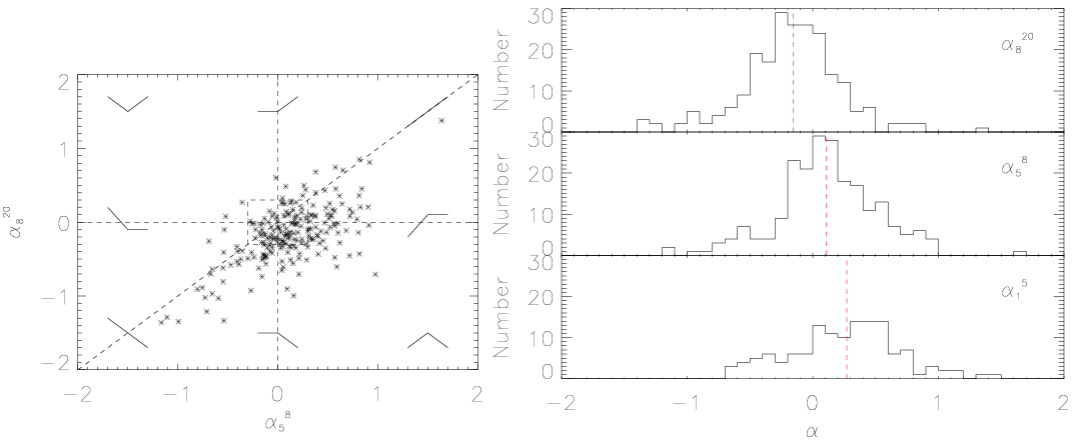

Figure 1: Left panel. Colour-colour radio plot for the 218 sources with near simultaneous observations. Right panel. Distributions of spectral indices $\alpha_{8.6}^{20}$, $\alpha_{4.8}^{8.6}$ and $\alpha_{1.4}^{4.8}$ (from the top to the bottom): data at 1.4 GHz come from NVSS and red dashed lines correspond to median values (-0.16, 0.11 and 0.27 respectively).

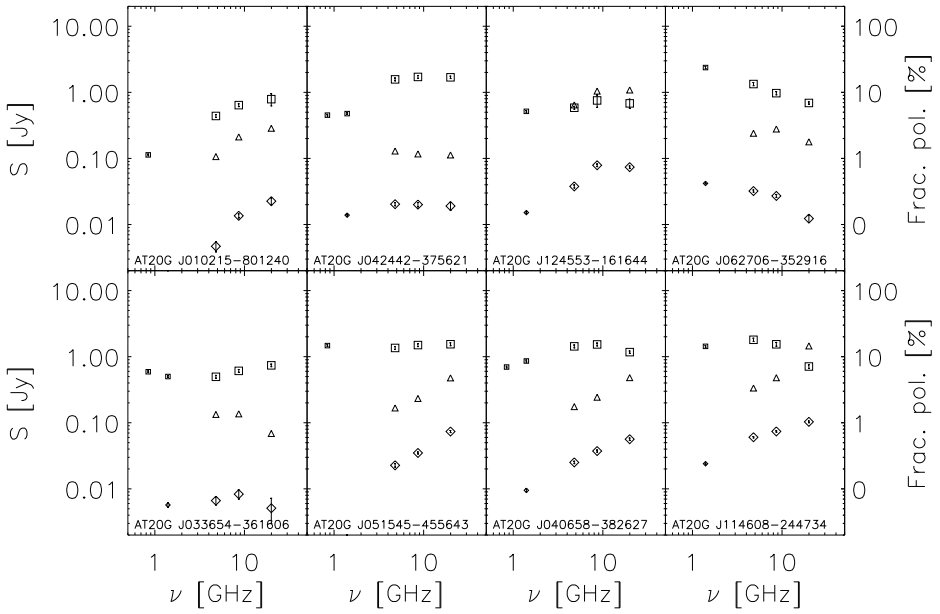

Figure 2: Example point-source spectra of the large variety of spectral behaviour in total intensity (squares) and polarisation (diamonds). We selected examples of inverted, flat, peaked and steep total intensity behaviour similar (top panels) and different (bottom panels) to the polarisation behaviour. The triangles correspond to the fraction of polarisation. The low frequency values refer to data from SUMSS (0.843 GHz) and NVSS (1.4 GHz) catalogues in total intensity (small squares) and, where available, polarisation (small diamonds).

them have almost simultaneous observations at 4.8 and 8.6 GHz (for more detailed description see Massardi et al. 2007).

The colour-colour plot (Fig. 1) is the comparison of spectral indices (α, assuming $S \propto \nu^{\alpha}$) at low and high frequencies: it shows the variety of radio source spectral behaviours. The broad distribution of the sources is a clear evidence of the unreliability of simple extrapolation to high frequency using low-frequency spectral indices only and assuming a simple power law spectrum.

The sample is composed mainly of flat spectrum sources (85% of them have $\alpha_{8.6}^{20} > -0.5$). A small fraction have normal spectra and extended lobes at 20 GHz. There is an overall steepening towards the higher frequencies (see the large number of sources with $\alpha_{8}^{20} < \alpha_{5}^{8}$ in the left panel of Fig. 1 and the right panel). This is possibly due to young sources that are still in a phase where energy loss by synchrotron radiation is the dominant process.

Polarized intensity at 20 GHz has been detected in 213 of the BSS sources. The median fractional polarisation for this 20 GHz sample increases with frequency from 1.7 and 2.0% at 4.8 and 8.6 GHz up to 2.5% at 20 GHz. The simultaneous spectra (Fig. 2) show that there is no clear relation between the spectral properties of the sources and their polarised flux density. A number of different mechanisms may be involved: Faraday depolarisation, multiple components with different spectra, and optical depth.

240 of the 251 BSS sources with $|b| > 10^{\circ}$ have an identification in optical bands (SUPERCosmos database). A measurement of redshift is available in literature for 186 sources. For 9 sources

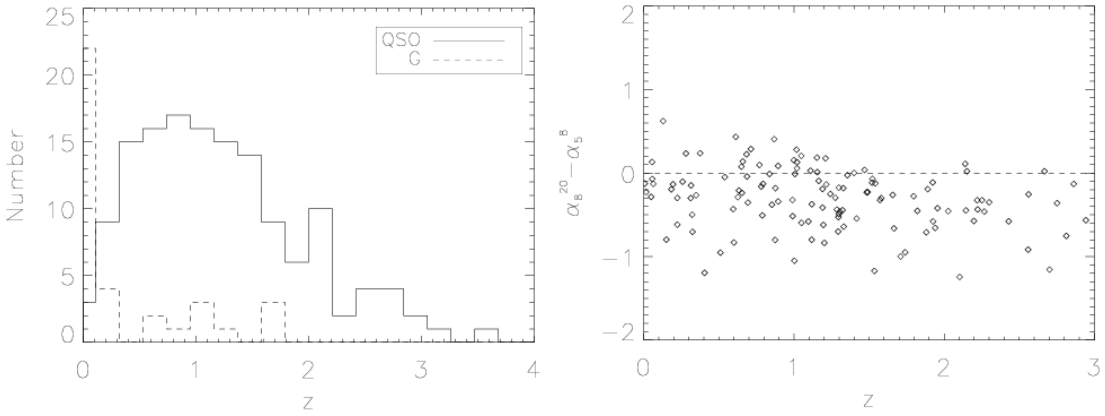

Figure 3: Left panel: redshift distribution. Right panel: plot of the difference between spectral indices α_8^{20} and α_5^8 versus redshift. The low-frequency spectral steepening increases with redshift.

we report new measures of redshift. The median redshift of BSS QSOs is 1.2 and that for BSS galaxies is 0.13 (Fig. 3). The spectral steepening is correlated with redshift, presumably because of the changing rest frame frequency.

3. Summary and Conclusions

The BSS is a complete sample of 320 extragalactic sources with $S_{20\,GHz} > 0.50$ Jy. 218 sources have almost simultaneous observations at 4.8 and 8.6 GHz. Although there is a broad range of spectral indices, the median source spectrum is flat, but steepens towards the higher frequencies. Only a few sources (radio lobes) appear extended at 20 GHz. There is no clear correlation between the polarization and the total intensity spectra. On average, the polarization fraction increases with frequency. We have a high optical identification rate and a large fraction of sources have redshift measurements.

The complete AT20G survey will greatly improve knowledge of the radio source population at lower flux densities. This will be of great interest for next-generation telescopes as it will provide a good sample of high-frequency flux density and polarisation calibrators. It will also assist CMB missions develop point source detection and extraction techniques.

References

[1] Massardi M., et al., 2007, MNRAS, submitted (astro-ph/0709.3485)

[2] Sadler E. M., et al., 2007, MNRAS, submitted (astro-ph/0709.3563)