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RATAN-600 as Multibeam Radio Telescope for CMBA Observations

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Abstract. The characteristics of the RATAN-600 radio telescope in multibeam mode for CMBA observations are presented. First results of 8-element MMIC focal array testing are given.

1. Introduction

Multibeam mode seems to be an unavoidable solution for the existing and the next generation reflector radio telescopes where high sensitivity (or high speed) mapping is the main goal. In some observation modes RATAN-600 aberrationless focal zone may be significant enough to locate a feed array consisting of 500-3500 receiver elements. It will give us new possibilities to study CMBA at sub-degree scales with high integrated sensitivity, polarisation and in a wide field of view. SZ effect with high brightness temperature sensitivity and resolution may be studied efficiently as well.

2. Multi-beam mode for CMBA observations at RATAN-600 radio telescope

Prospects in patch focal array architecture (Khaikin et al. 1999) and significant progress in LNA MMIC technologies (Weinreb 1998) give us a chance to fully realise a multibeam mode at the RATAN-600 radio telescope. Our first focal array prototypes receive one linear (Y) polarization. Two linear (X/Y) or circular (L/R) polarizations will be available in the near future as well.

To fully sample the cosmic source distribution we must use a spacing equal to or less than Nyquist power sampling interval in the telescope focal plane. The field of view of a radio telescope is mainly limited by aberrations as a receiver element is moved to off-axis positions. Both the field of view and sensitivity of a large radio telescope strongly depend on the number of independent receiver elements located in the aberrationless focal zone. A multibeam mode may significantly (one-two orders) increase integrated RATAN-600 sensitivity and the field of view in CMBA investigations at subdegree scales ($\ell > 100$) (Parijskij et al. 1998).

In some observation modes the RATAN-600 aberrationless zone along the focal plane may exceed 3 m for the largest RATAN-600 secondary mirror (12 m size). Our calculations show that up to 500 independent receiver elements may be placed along the focal line. Cross direction of the focal plane is also available for the tightly packed patch feed array in some observational modes (Khaikin et al. 1999). So if we fully occupy the available focal surface a total number of RATAN-600 beams can reach 3500 (7×500). A fan-shaped RATAN-600 beam may be used primarily to widen the CMBA survey strip by factor 7. Extra high space resolution may be very useful to investigate the polarization of the CMB (Naselsky et al. 2000).

It was shown by Pulkovo group, that atmospheric problems can only be successfully solved with a very big reflector and sensitivity of the ground based CMBA observations will then be equivalent to the spaced based ones (Parijskij & Tcibulev 2000). All atmospheric heterogeneities arise in the near field zone of a big reflector. In multibeam mode aperture averaging effect and dual (multi-) beam filtration will be especially effective as neighbouring dual beam directions pass through the same heterogeneities and residual atmospheric fluctuations in dual beams $(1,n)$ and $(2, n+1)$ will be strongly enough correlated.

3. First results of 8-element receiver array testing and perspectives

The first 8-element patch MMIC array prototype is being tested now. Noise outputs of most of the channels were recorded in clear sky and worse weather conditions. We estimate channel receiver sensitivity to be 6-7 mK per second in short intervals ("total power" mode in room conditions). Power spectrum of noise outputs shows the "knee frequency" to be close to 10 Hz in "total power" mode. We are testing now an external scheme with a VHF monochromatic signal to compensate gain variations and reduce the "knee frequency" in final recordings up to 0.1-0.01 Hz. It may improve receiver sensitivity up to 2-3 mK per second per channel at long enough intervals. In this case the integrated sensitivity of 400 element patch receiver array may be 100-150 micro K per second and the first/second CMB Doppler peaks (ℓ=200/500) can be distinguishable with S/N ratio 1-2 after 1/10 day experiments.

4. Conclusion

The RATAN-600 in multibeam mode may be an effective instrument for CMBA observations. High integrated sensitivity in intensity and polarization, effective atmospheric filtration, wide field of view and practically unlimited resolution will provide a real ground support for future space experiments (Bersanelli & Mandolesi 1998) at low frequencies where resolution of all space instruments is limited.

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