

WIDE FIELD IMAGING WITH THE MAURITIUS RADIO TELESCOPE

SANDEEP SACHDEV

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Declaration

I hereby declare the work presented in this thesis has been done by me. The subject matter presented in this thesis has not previously formed the basis of the award of any degree or qualification.

Date: Feb 14, 1999.

Sandeep Sachdev

Abstract

Wide field imaging with the Mauritius Radio Telescope

Sandeep Sachdev

The present work describes various aspects of wide field imaging with the Mauritius Radio Telescope (MRT). The hardware systems and the tools developed for wide field imaging with the MRT are described along with their application to the observations made with the new system.

At the MRT we normally use a bandwidth of 1 MHz. Since the east-west groups have a narrow primary beam of two degrees in RA, this bandwidth does not pose a problem for synthesizing the primary beam in this direction. However both the east-west and the north-south groups have wide primary beams in declination extending from -70° to -10° . The thesis describes the problems of imaging this wide field of view with the MRT. The need for a hardware system (recirculator) to efficiently image this large field of view is described. The design aspects of the recirculator along with a description of the hardware systems developed and the observations made with them are given. Calibration and imaging of the recirculator data for wide fields are discussed. As part of data analysis, interference detection and their handling in the images are also discussed.

The thesis discusses various results obtained. Images of a one hour region with a resolution of $4' \times 9'.2 \sec(\delta + 20^\circ.14)$ covering the entire declination

range of the MRT, $-70^\circ \leq \delta \leq -10^\circ$, are presented. Noise in the images and estimation of positions and flux densities of unresolved sources in the images are also discussed.

Principal symbols

Listed below are the symbols and abbreviations used in the thesis.

AGC Automatic Gain Control.

A_N Normalized antenna/interferometer response function.

b_o Synthesized beam pattern; Point source response.

B Brightness distribution.

$C(\tau)$ Correlator response.

DAS Data acquisition system.

DSB Double sideband.

DFT Direct Fourier transform.

erf Error function.

E Eastern group.

EW East-west group.

FFT Fast Fourier transform.

F Image volume.

f_{os} Degradation factor.

f_s Sampling frequency.

f_h Highest frequency in the bandpass.

f_l Lowest frequency in the bandpass.

FWHP Full width half power

G Complex gain.

H, HA Hour angle.

HPBW Half power beam width.

$H(\nu)$ Power spectrum.

IF Intermediate frequency.

k_b Boltzmann constant.

L Length.

LO Local oscillator.

LST Local sidereal time.

MEM Maximum entropy method.

MRC Molonglo Reference Catalog.

MRT Mauritius Radio Telescope.

MST Mauritius standard time.

NS North-south group.

os Oversampling factor.

P Probability distribution; Period.

PSF Point spread function.

RA Right Ascension.

RBC Redundant baseline calibration; Roger, Bridle and Costain flux density calibration.

RF Radio frequency.

S Southern group or trolley.

S Flux density.

S_{conf} Confusion noise power.

S/N Signal-to-noise ratio.

SIPO Serial-In-Parallel-Out.

SS Surveying sensitivity.

SSB Single sideband

T_α Temperature spectral index.

T_{sys} System temperature.

V Complex visibility. Voltage pattern of an antenna(s).

V_{th} The threshold voltage of the quantizers.

VSWR Voltage standing wave ratio.

W Weighting function of the visibilities (Spectral sensitivity function).

W Western group.

x spatial frequency in the east-west direction.

y spatial frequency in the north-south direction.

z spatial frequency along the vertical (height).

za Zenith angle.

Z Characteristic impedance.

α Spectral index defined by $S \propto \nu^{-\alpha}$; The ratio of threshold voltage to the RMS voltage.

δ Declination; (Dirac) Delta function.

λ Wavelength.

ν Frequency.

$\Delta\nu$ Bandwidth.

ϕ Latitude; General angle.

ρ Correlation coefficient.

ρ_D Output of the digital correlator.

ρ_c Normalized correlation coefficient.

ρ_a Equivalent analog correlation coefficient.

a Standard deviation; RMS noise level.

τ Time delay.

$\Delta\tau$ Uncompensated delay.

τ_g Geometrical delay.

τ_i Instrumental delay.

ξ Direction cosine w.r.t. the east-west direction.

η Direction cosine w.r.t. the north-south direction.

ζ Direction cosine w.r.t. the zenith direction.

$\star\star$ Convolution in two dimensions.

$\star\star\star$ Convolution in three dimensions.

\rightleftharpoons Fourier transform relationship.