

ASKAP polarisation calibration and characterisation: The state of play

Craig Anderson | Bolton Fellow (for like, 1.5 more weeks) | CSIRO POSSUM busy week, Sept 2019

CSIRO ASTRONOMY AND SPACE SCIENCE, PERTH ASTROPHYSICS GROUP www.csiro.au



Fomalont+ (1995)

(FORNAX A / P / ASKAP-36 / Anderson, Lenc)







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We now have deep (~10s -- 100 uJy/b), full-pol ASKAP-36 obs 'in the can' for fields:

- The EMU pilot field
- --- The LMC, SMC
- GAMA fields: G09, G12, G23
- SHAP1
- SPARCS nth
- SCORPIO (Gal. field; 0.8, 1.4 AND 1.6 GHz)
- ERIDANUS
- FORNAX
- SN1006
- •
- •

PLUS...

- The whole southern sky (SPICE-RACS; ~250 uJy/b in Stokes I; ~100 uJy/b in pol) .

--- POSSUM pilot!



The ASKAP philosophy





The ASKAP POL CAL philosophy

- No pol/sec cals for ASKAP observations (overheads for 36 beams)

- So:

• Flux + bp + (on-beam-axis) leakage from B1934-638 primary cal

- But still need to cal:

- XY phase (1934 is unpolarised)
- Off-axis pol response
- Ionospheric Faraday rotation



Where we're at: Current methods and results for pol processing



XY-phase cal directly via beamforming



Figure 4.1: Schematic of the on-dish calibration (ODC) system (from Chippendale et al., 2018).

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XY-phase cal directly via beamforming



Uncalibrated on-axis leakages, post beamforming (we now cal these out).



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Pol data quality (post-on-axis cal)





Off-axis leakage characterisation / mitigation / correction

Angle consistency b/w beams



Credit: Cameron van Eck



Off-axis leakage characterisation / mitigation / correction

Frac. pol. vs. beam position





Where we're going: Impending/future methods and measurements for ASKAP pol. obs.



Leakage considerations (off-axis)



POSSUM Spec:

- 0.3% of Stokes I (require

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- 0.1% desirable

Fractional leakage

Leakage considerations (off-axis)

POSSUM Spec:

- 0.3% of Stokes I (required)
- 0.1% desirable



Possibility to calibrate *off-*axis leakage via beamforming





Alternative: Off-axis pol corrections in image plane



Alternative: Off-axis pol corrections in image plane



Alternative: Off-axis pol corrections in image plane



(Eventual) alternative (?): AW-projection

- The 'correct' way

- Being investigated (Chris Skipper), but too computationally expensive to implement for routine ASKAP proc?

- Certainly will not be available for RACS or the SST pilots



Current data products (probably publishable as-is)



RACS ---- peak P mosaic





RACS ---- peak P mosaic zooms

x: 3909 y: 4189 value: 0.000414442 Jy/beam

Ra 10h 50m 54.488s Dec -31d 30m 38.80s

LINEAR: 200



EMU pilot --- peak P mosaic zooms



EMU pilot --- Stokes I + peak P mosaic zooms





Practical outstanding issues



Calibration: Incorporate on-axis leakage cal. in ASKAP data proc. pipeline

- UPDATE: Done; needs QA.



Calibration: Abs. pol. angle

- UPDATE: People are considering this now.

- Sky frame conversion maths is defined (see ASKAP SOG).
- Mechanics of adding to pipeline being discussed by SDP.

Calibration: Off-axis cross-pol response

- We do not do this yet, but we soon need to

- POSSUM spec: Good to 0.3% of Stokes I across the field
- Will need a detailed plan + concerted effort to characterize, correct, and verify.

- Methods: Image plane correction most probable for RACS and pilot (as discussed above), and characterization discussed more below.



Calibration: Ion. FR

- We do not do this yet, but will eventually need to
- Currently at Solar minimum, so hard to even detect, let alone correct and verify
- Methods: As discussed in detail ~2 POSSUM bw's ago.





Data proc: Channelisation + CLEANing

- Pol. data cubes are imaged and CLEANed in 1 MHz channels, with only a limited form of masking available (two-step shallow-then-deep CLEAN; deep CLEAN at position of shallow clean comps on a per image basis)

- NOT IDEAL! (only allows for 'proper' decon. of bright-ish point sources; syn. beam. artifacts clearly visible post RM-synthesis for middle-bright sources, no 'complex clean').

- Could image in coarser channels, but trade-off with sensitivity to high RMs (esp. in low freq band; ~700 MHz low edge freq.), and is 'kicking the can down the road' in some sense

- More sophisticated methods exist or have been proposed (cf. wsclean --'broadband squared-channel + polarisation joining'; GH's 'RM synthesis CLEAN' idea) that reduce the effect of the choice of channelization, but these are not on the SDP radar right now.

- Need to decide on best (read: satisfactory + realistic) approach.



Data proc: Common-resolution convolution

- UPDATE: Wasim is working on script to do this now; unclear on timeline for addition to the pipeline.



Data proc: Polarisation DQA

Summary plots



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What we have now:

- 2 x 30 sq.deg footprints from the pilot
- 144 MHz, centred at ~1.37 GHz
- Full 1 MHz spectral resolution Stokes IQUV cubes, source finding, MFS I and V maps
- 8 MHz-averaged and zeros-removed cubes
- Peak P and peak FD maps for both



Busy week tasks:

- Calibration performance [2 Pilot fields; RACS?]
- Test and document off-axis leakage calibration [Fornax field]
- Elaborate connection between SPICE-RACS and development of POSSUM pipeline [N/A]
- Source finding [Pilot data]
- Wideband polarization deconvolution [RACS?]
- Defining science capability of SPICE-RACS and Pilot survey [N/A]

