ASKAP update for September 2021

In this issue we report on the latest off-axis polarisation leakage calibration improvements, SWAG-X data validation and Pilot Survey Phase II progress.

Off-axis polarisation leakage calibration

For the last few months, a group consisting of ASKAP staff and POSSUM Survey Science Team members have been working to commission the final components of ASKAP's polarisation calibration scheme. This month, we report that testing of the last stage is underway!

Polarisation calibration is a challenging task for any radio telescope. ASKAP's Phased Array Feeds have multiple beams to calibrate, but they also possess generally good polarisation properties, and have the power to build some of the calibration into the beamformer weights.

During early science, we developed a system that links the phase of the X and Y polarisation beams together using the on-dish calibration system. For Pilot Surveys Phase I, we developed the capability to calibrate the leakage of Stokes I into the other Stokes parameters using our bandpass observations of PKS B1934-638 and ensured that ASKAP delivers polarisation products consistent with international astronomical standards.

The scheme described above works well, but it can only correct for leakage at the nominal centre of each beam because that is where we measure the calibrator source. POSSUM requires less than 0.3% polarisation leakage across ASKAP's entire 30 square degree field of view, and analysis of Pilot Survey Phase I observations confirmed that we would need an additional correction for off-axis leakage to achieve this goal.

The Rapid ASKAP Continuum Survey also demonstrated that circular Gaussian primary beam models do not represent ASKAP's maximum sensitivity beam shape very well. We found residual flux errors of about 10% near the edges of each RACS field. To address this issue, we decided to incorporate holography measurements of ASKAP's true beam shapes into the linear mosaicking process. Our initial efforts focused on Stokes I, but we quickly realised that holography observations contain the information required to correct polarisation leakage across the full field of view as well.

However, interpreting holography polarisation data has proven to be quite a challenge. The POSSUM team provided a crucial benchmark by deriving leakage surfaces from the properties of sources in Pilot Survey Phase I images. Members of POSSUM then worked within the ACES team to develop better processing and flagging systems for holography, leading to a viable pipeline.

Subsequent verification efforts highlighted several issues with the holography data products. These included unexpected changes in sign across the frequency band. We investigated several possible explanations including intrinsic source polarisation and baseline conjugation errors. Eventually, with the help of ASKAP's science data processing team, we determined that the normalisation used to remove residual delays in the holography data needed to be adjusted. Upon making this change, the behaviour across the band was greatly improved.

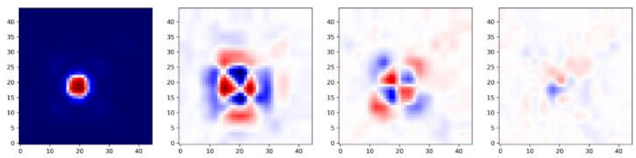

Figure 1: Holography images of a single offset beam showing the response in Stokes I, Q, U and V from left to right. 16 MHz of bandwidth has been averaged and the reference source was PKS B1934-638. These images will be used by ASKAP's mosaicking tool to correct for off-axis polarisation leakage as well as the primary beam shape. Figure by David McConnell.

We still have a global sign flip in Stokes U and V, but the source of this should be easier to track down.

Final tests to be conducted over the next weeks will determine whether the calibration scheme now meets POSSUM's specifications. If so, we will be a big step closer to commencing Pilot Survey Phase II quality gates for POSSUM and the 3-way commensal fields.

SWAG-X validation update

After an earlier release of continuum-only data from the SWAG-X region, our goal has been to process, validate and release spectral line data covering two frequency bands to a depth comparable with ASKAP's full survey plans. This required two observing passes in both bands. Although we have been able to process one pass in both bands, issues with data quality in three tiles of SWAG-X High have been preventing validation and release.

The quality concerns trace back to inclusion of one antenna that should have been flagged. Although this would normally be easy to fix, ASKAP's spectral line data rate is so high that we are unable to keep the raw visibilities for re-processing after the output of the pipeline has been deposited in CASDA. In this case, the mosaicked images are marginal but potentially still useful, which makes it difficult to decide whether to reject and re-observe or release anyway. In the end, we decided that the artefacts in some parts of the field were too detrimental to allow validation and release.

We attempted to process replacement data taken for the second pass, but this had been observed earlier (and archived to tape) and had quality concerns of its own compared to more recent observations. Ultimately, we are re-observing the impacted fields. Observations were completed last weekend and are currently being processed, with preliminary analysis of the associated calibration tables showing positive results.

Raw data diagnostics and flagging directives

ASKAP's original real-time processing model was necessitated by the inability to store raw data for any significant length of time. In practice, we have found that some caching and pre-processing is essential to meet data quality requirements, such as raw data diagnostic plots.

Due to the large number of antennas, beams, and active elements in the system, we often need to flag a beam or two across the array for various reasons. It is very difficult to predict the exact flagging strategy needed in advance (though detailed analysis of beamforming diagnostic information can provides some hints).

We currently conduct a round of "pre-flagging" based on statistical analysis of the bandpass calibration observation (which is smaller than the full science field and therefore easier to process), but this does not catch all issues, especially ones arising during the science observations.

Investigation is underway to determine whether machine learning techniques (e.g. outlier detection) can help in identifying bad antennas/beams in the autocorrelation waterfall plots and data used to produce them. This exploratory project (SAMWISE) will aim to eventually produce additional flagging directives as input to the pipeline, and test resulting data quality.

Pilot Survey Phase II progress

Observation and processing of quality gate fields remains our primary focus, and EMU recently joined VAST in conducting their first science observations for Phase II.

We are also discussing the best way to merge existing processing parameters into a single, unified strategy that will be used for the 3-way (EMU, POSSUM and WALLABY) commensal fields. These discussions have been an excellent opportunity to revisit past processing decisions, informed by the most recent results.

The VAST Survey Science Team recently secured an agreement with the other SSTs for access to pre-validation data, for the purposes of prompt transient searching. Although we do not yet have a short timescale imaging mode in the standard ASKAP pipeline, VAST have built an external system that can perform this task using the archived continuum visibility data.

MRO computing system upgrade

Starting on the 27th of September, we will be upgrading the servers that host key monitoring and control software for ASKAP. This is a big job that involves significant architecture and operating system changes, as we are moving from several physical machines to one large high-availability server that can run several virtual machines.

Plans for the switch-over are in place and we have allocated two weeks for the work itself as well as testing and verification. We will pause Pilot Survey Phase II observations during this upgrade.

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