3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Radio frequency interference mitigation for astronomy with phased array feeds

Liroy Lourenço[1,2]
Aaron Chippendale[2]

Sydney Institute for Astronomy, University of Sydney, Sydney, Australia
Space and Astronomy, CSIRO, Sydney, Australia

Index Terms — RFI, Spatial Filtering, ASKAP, phased-array feeds, adaptive beamforming

Despite promising progress in radio frequency interference (RFI) algorithms in radio astronomy, much work remains to implement these algorithms as part of a holistic strategy in routine, large-scale telescope operations. Radio astronomers currently mark and throw away RFI affected data so that it does not affect scientific conclusions. Unfortunately, this reduces measurement sensitivity as the discarded data contain valuable information from astronomical sources. Furthermore, at the instrument's sensitivity limit, the availability of an entirely interference-free spectrum is expected to degrade over time due to growth in population and spectrum usage. Active RFI mitigation will become necessary for radio astronomy in a crowded spectrum.

The CSIRO's ASKAP radio telescope is the first synthesis imaging array designed explicitly from its outset to use phased array feed (PAF) technology. The pattern of each digitally formed PAF beam is the linear combination of each PAF element pattern, i.e. beamforming. Varying beamformer weights allows for the optimisation of beam shape and sidelobes. Indeed, beamformer weights can be adjusted such that there is a near-zero (or null) response of the resulting beam in the direction of the RFI source. Previous work has shown interference suppression down to the instruments noise floor for some RFI scenarios [1].

For astronomers to embrace active RFI mitigation, we must help them understand the impact of mitigation on the astronomical response and calibration of a telescope. I will present validation of spatial nulling techniques via PAF beamforming with telescope data on astronomical figures of merit, comparing subspace-projection-based algorithms with attention to impacts on sensitivity (noise), bandpass (gain), and beam shape.

Mitigating self-generated interference, internal to an astronomy receiver, is a practical initial use case of ASKAP's RFI mitigation capabilities via PAF beamforming that could readily be made operational. Because self-generated receiver interference remains static throughout an astronomical observation, it can be suppressed at the beginning of the observation, at the time of beamformer weight calibration. This static use case is a logical intermediary step before implementing the dynamic case - adjusting beam weights continuously throughout the observation - which is required to mitigate RFI from moving sources, e.g. signals from satellites and aircraft. I will present some experimental results form an ASKAP PAF for this static scenario and describe ongoing work to extend this to the dynamic scenario.

[1] Chippendale, A. P. and Hellbourg, G., "Interference Mitigation with a Modified ASKAP Phased Array Feed on the 64 m Parkes Radio Telescope", *arXiv e-prints*, 2017.