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Analysis of Baseline-Dependent Averaging for the Square Kilometer Array

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1 Extended Abstract

The planned SKA1 aperture synthesis radio telescope will have baselines ranging in length from 157 km down to 29 metres. At present, our undersanding is that the planned dump time of data from the correlator will be 0.14 seconds regardless of baseline length. This dump time is derived from specification of the field of view at a given observing frequency such that interferometer fringes on the long baselines from a source near the edge of the field of view are sampled at least at Nyquist frequency. However, as a consequence, interferometer data on the shorter baselines are highly oversampled. Since aperture synthesis imaging requires convolution of incoming visibility data on to a regular grid prior to doing an FFT to the image plane, averaging to reduce the amount of incoming data sent to the gridder can have a significant impact on the amount of computing that is required.

Here we report the results of an on-gaing analysis of baseline dependent averaging (BDA) effects, especially on simulated data. An earlier document [1] includes a detailed theoretical analysis of the applicability and benefits of baseline dependent averaging (BDA). Our simulations show that we can shrink the amount of data to be gridded by 85 to 90 percent yet attenuation from BDA at a distance of 1 degree from the field centre (the nominal distance from the field centre at which we might expect to do useful science at 1400 MHz) remains less than 1 percent. Correspondingly, wall-clock time for actual gridding and imaging shrank by 80 percent. This latter value can probably be improved by a more efficient I/O scheme than was used in the simulations.

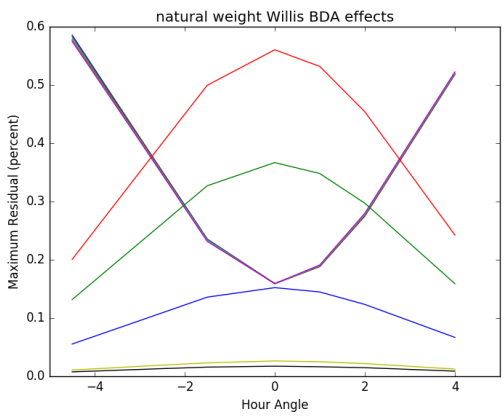

Figure 1. The V-shaped plots show attenuation for a source offset from the field centre by one degree in direction cosine l. They are almost independent of declination. The hill-like plots show attenuation for a source offset from the field centre by one degree in direction cosine m (for declinations -70 deg, -50 deg, -30 deg, -10 deg, 10 deg - top to bottom).

One subtle effect emerges from these simulations. The amount of attenuation is strongly dependent on the hour angle, declination, and direction of a source with respect to the field centre (see Figure 1). Since SKA images may reoutinely require dynamic ranges of a million or more, even variable attenuation of a percent or so will almost certainly need to handled as a direction dependent effect (DDE).

References

[1] S. J. Wijnholds, S. Salvini, R. Dodson, B.Mort, F. Dulwich, A. Willis, and J. Stil, "Feasibility analysis of baseline-dependent averaging, " SKA Document no. SKA-TEL-SDP-0000017, April 2016