Bristol Astrophysics Group

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MEMORANDUM

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To: AMiBA team

From: Mark Birkinshaw

Subject: Correlator lag data

The correlator output at lag τ_a for a "perfect" correlator should take the form

$$c(\tau_a) = A\,\cos\phi\,\frac{\sin(\pi\tau_a\Delta\nu)}{\pi\tau_a\Delta\nu} \tag{1}$$

where $\Delta\nu$ is the bandwidth of the correlator, and $Ae^{i\phi}$ is the complex visibility that the correlator is processing (here I take the visibility and input spectrum to be flat over the frequency range $\nu = \nu_0 - \frac{1}{2}\Delta\nu$ to $\nu_0 + \frac{1}{2}\Delta\nu$).

If (1) is valid, then a plot of $c(\tau_a)$ against $c(\tau_b)$ for any two lags τ_a and τ_b will be a straight line, parameterized by the values of A and ϕ of the visibility data. In such a system it will be possible to extract the visibilities from the input data with a minimum of ambiguity or error.

Now suppose that there is a phase offset between correlator data taken with lags τ_a and τ_b. In that case, if we ascribe a phase offset ϕ_a to lag τ_a, equation (1) is modified to the form

$$c(\tau_a) = A\,\cos(\phi+\phi_a)\,\frac{\sin(\pi\tau_a\Delta\nu)}{\pi\tau_a\Delta\nu} \tag{2}$$

and now a plot of $c(\tau_a)$ against $c(\tau_b)$ will not be a straight line, but rather an ellipse with an orientation and shape that depend on the relative complex responses at lags τ_a and τ_b. In practice this means that a plot of the signal at one lag against the signal at another is a useful indicator of the properties of the correlator.

I have performed this test for lags 1 to 4 on the 1L-2L baseline for the Sun data taken on 2006 May 09 starting at 23:07:47. There are seven plots accessible from this WWW page. The first shows all the pairs of lags plotted against one another, and the remaining six plots show independent plots for each pair.

It can be seen that for no lag pair is the plot close to (1), but rather the plots take the elliptical form implied by (2), with distinct phase offsets and gains that differ by a factor of order 2. These phase offsets change somewhat as the Sun transits across

the telescope (the shapes and orientations of the ellipse change with the ellipse sizes). While this suggests that the simple model used to obtain (2) is imprecise, plots of this type may be useful diagnostics for the quality of the visibilities that may be extracted, since the visibilities depend on additional, perhaps not well known, parameters when the lag/lag plots differ from the straight line relation (1).