Effect of Leakage in the Polarisation Reversal Switch

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16 May 91

The Polarisation Reversal Switch is a four port device whose inputs are the electric fields corresponding to the two orthogonal modes from each antenna and outputs are the same fields with the facility that the polarisation appearing at each field can be selected by the user. The isolation between the two ports, as currently implemented, is about 30 db, and the question has been raised whether this is adequate for astronomical observations. The purpose of this note is to examine the effect of this leakage on astronomical observations.

Let us assume that the two othogonal modes of the antennas are left and right handed circular polarisation. Let $\mathbf{E}_L^1$ and $\mathbf{E}_R^1$ be the fields corresponding to the left and right hand polarisations from antenna 1 and $\mathbf{E}_L^2$ and $\mathbf{E}_R^2$ the corresponding quantities for the second antenna. Because of poor isolation at the Polarisation Reversal Switch, the measured field for each mode will have in it a trace of the orthogonal mode. If the leakage factor is α, the measured field for a given mode is given by

$$\mathbf{e}_L^1 = \mathbf{E}_L^1 + \alpha\, \mathbf{E}_R^1$$

$$\mathbf{e}_R^1 = \mathbf{E}_R^1 + \alpha\, \mathbf{E}_L^1$$

$$\mathbf{e}_L^2 = \mathbf{E}_L^2 + \alpha\, \mathbf{E}_R^2$$

$$\mathbf{e}_R^2 = \mathbf{E}_R^2 + \alpha\, \mathbf{E}_L^2$$

For interferometric studies involving polarisation, 4 products - $< \mathbf{E}_L^1\, \mathbf{E}_L^{2*} >$, $< \mathbf{E}_L^1\, \mathbf{E}_R^{2*} >$, $< \mathbf{E}_R^1\, \mathbf{E}_L^{2*} >$ and $< \mathbf{E}_R^1\, \mathbf{E}_R^{2*} >$ are required. However, what is given by the correlator are the products involving the corrupted fields. Considering the individual terms,

$$< \mathbf{e}_L^1\, \mathbf{e}_L^{2*} > = < (\mathbf{E}_L^1 + \alpha \mathbf{E}_{R1})(\mathbf{E}_L^2 + \alpha \mathbf{E}_R^2)^* >$$

$$= < \mathbf{E}_L^1\, \mathbf{E}_L^{2*} > + \alpha\, (< \mathbf{E}_L^1\, \mathbf{E}_R^{2*} > + < \mathbf{E}_R^{1*}\, \mathbf{E}_L^2 >) + O(\alpha^2)$$

The measured 30 db isolation implies that α is about 0.03 implying that the error in this measured product is about 4% which is marginally acceptable. In practice, the error is much smaller, since, for most astronomical sources, the cross polarisation visibilities ($< \mathbf{E}_L^1\, \mathbf{E}_R^{2*} >$ and $< \mathbf{E}_R^{1*} \mathbf{E}_L^2 >$) are typically one or more orders of magnitude smaller than the visibility in the same polarisation mode (here $< \mathbf{E}_L^1\, \mathbf{E}_L^{2*} >$). Thus, in an actual astronomical situation the error in the measured visibilities involving the same polarisation at both antennas would me much smaller that 0.5% and so quite acceptable.