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To: RFI Group
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Subject: Effect of the frequency dependence of the beam patterns on EOR signature

In memo #16 I considered the possibility of observing the global EOR signature using a single antenna whose output is filtered by the subtraction of the best fit low order polynomial. The advantage of a small antenna structure is that its VSWR and beam patterns vary more smoothly with frequency than the global EOR signature. In this memo I examine the effects of the strong Galactic and extragalactic sources on the antenna output to determine to what extent, if any, the frequency dependence of the beam pattern will result in rapid changes with frequency that will mask the EOR signature. For this study I use the analytic expression for the beam pattern of a dipole over a ground plane.

The directivity D of a dipole of length ℓ and height h over a ground plane is given by

$$D = \left[\sin(2\pi(h/\lambda)\sin\phi) \left(\cos((2\pi\ell/\lambda)\cos\theta) - \cos(2\pi\ell/\lambda) \right) / \sin\theta \right]^2$$

where θ = angle to the dipole

ϕ = elevation angle

and the antenna gain is the

$$G(\phi, \theta) = 4\pi D(\phi, \theta) / \iint D(\phi, \theta) d\Omega$$

The antenna output from a source with flux density F is given by

$$\left(\lambda^2 / 4\pi \right) G(\phi, \theta) \left(1 - |\Gamma|^2 \right) F / (2k)$$

where Γ = the voltage reflection coefficient of the antenna

k = Boltzman's constant

I have run numerical simulations using the analytic approximation for the beam pattern of a "fat" half-wave dipole 0.2 wavelengths above the ground plane at a frequency of 200 MHz. The voltage reflection coefficient was calculated at each frequency using EZNEC. If I add a source with the following parameters:

Flux density	1.4×10^6 J at 100 MHz (100 times CasA)
Spectral index	-0.77

I get residuals to 7 term polynomial of about 2 mK in the antenna temperature before the miss match loss. Any real source I added had effects well below 1 mK. The following table gives the results for various azimuths and elevations of the source.

Az (relative to dipole) (deg)	Elevation (Deg)	Residual (mK)	T _{ant} K at 100 MHz
90	5	0.04	12
90	15	0.37	105
90	45	2.54	740
90	85	4.7	1360
0	45	1.2	330

From these simulations I conclude that the change in antenna pattern with frequency will result in an entirely negligible effect on the residuals to a polynomial fit of the receiver power. Only if I generate an artificially strong source or increase the height of the dipole can I start to produce significant effects. With a doubling of dipole height a source equal to Cas A in strength and spectral index produced a 0.4 mK residual at 45° elevation.