DEUTERIUM ARRAY MEMO #065

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To: Deuterium Array Group

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Subject: Expected signal from the LMC

Ideally we should have the H1 data in machine readable form so that we can use the method of memo #52 to estimate the expected D1 line profile. Lacking digital data I use 2 methods as follows:

1] Half power size of the H1 emission in Fig. 2. The half power size is about 3×4 degrees. The peak H1 temperature for the region is about 50K. Using the method of memo #11 the peak D1 signal is estimated to be

$$0.28\times1.5\times10^{-5}\times50\times\left(1/50\right)\times12/14^{2}\approx0.3\,ppm$$

The last factor of ($12/14^2$) accounts for the beam dilution. A 50 K system temperature in the direction of the LMC is assumed.

2] Using the total estimate H1 mass

The total H1 mass in the LMC is estimated to be $4.8\pm0.2\times10^{8}\odot$ (Staveley-Smith et al., *Mon. Nat. RAS*, **39**, pp87-104, 2003). If we assume all the Deuterium is in the beam of a station then the D1 emission fraction is expected to be

$$\left(D/H\right)\times N\times a\times A\times h\upsilon\times\left(gu/gt\right)/\left(4\pi d^{2}\Delta\upsilon 2kT_{sys}\right)\approx0.3\text{ ppm}$$

Where

D/H = 20 ppm

N = number hydrogen atoms = $4.8\times10^{8}\times1.2\times10^{57}$

a = antenna aperture = 12m^2

A = Einstein A spontaneous decay rate $=4.7\times10^{-17}\,s$ (see memo 55)

h = Planck's constant $=6.6\times10^{-34}$

ν = frequency = 327×10^{6}

gu = cupper statistical weight = 4

gt = total statistical weight = 6

d = distance to LMC $=50\times10^{3}\times3\times10^{16}$

$\Delta\nu$ = line width = 80 km/s = $87\times10^{3}\,Hz$

k = Boltzman's constant = 1.38×10^{-23}

T_{sys} = 50 K

The accuracy of the first method can be improved by using the integrated H1 line profile in Fig 7 of Staveley-Smith et al. Fig 7 shows a peak flux of 9500 J with a half power width of 80 km/s. This was obtained from a spatial integration over 9.4×12.7 degrees. This flux density will result in an antenna temperature of 4K from an antenna with 100% beam efficiency and a 12 degree beam. If we now assume a 50 K system and a D/H of 20 ppm then expected fractional signal is $0.27 \times 20 \times 4 / 50 = 0.4\,ppm$ while a final estimate will require convolving the D station beam with the H1 data cube the final result is likely to be in the range 0.3-0.5 ppm. If we assume a 10 kHz resolution and 24 dual polarization stations it will take 7 years of continuous observing to get a 5 sigma result from 0.5 ppm signal