To: Deuterium Array Group

From: Alan E.E. Rogers

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

\[
0.28 \times 1.5 \times 10^{-5} \times 50 \times (1/50) \times 12/14^2 \approx 0.3 \text{ ppm}
\]

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 \(4.8 \pm 0.2 \times 10^8\) \(\odot\) (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

\[
(D/H) \times N \times a \times A \times h \nu \times (gu/ gt) / (4\pi d^2 \Delta \nu 2kT_{sys}) \approx 0.3 \text{ ppm}
\]

Where

\(D/H = 20 \text{ ppm}\)
\(N = \text{number hydrogen atoms} = 4.8 \times 10^8 \times 1.2 \times 10^{57}\)
\(a = \text{antenna aperture} = 12 \text{m}^2\)
\(A = \text{Einstein A spontaneous decay rate} = 4.7 \times 10^{-17} \text{s} \) (see memo 55)
\(h = \text{Planck’s constant} = 6.6 \times 10^{-34}\)
\(\nu = \text{frequency} = 327 \times 10^6\)
\(gu = \text{cupper statistical weight} = 4\)
\(gt = \text{total statistical weight} = 6\)
\(d = \text{distance to LMC} = 50 \times 10^3 \times 3 \times 10^{16}\)
\(\Delta \nu = \text{line width} = 80 \text{ km/s} = 87 \times 10^3 \text{Hz}\)
\(k = \text{Boltzman’s constant} = 1.38 \times 10^{-23}\)
\(T_{sys} = 50 \text{ K}\)
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 $9.4 \times 12.7$ 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 $0.27 \times 20 \times 4 / 50 = 0.4 \text{ ppm}$ 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.