Description of VLBI Frequency Detections

Ralph Lorenz   September 30, 2012

This dataset was produced by the Huygens VLBI Team, principally Sergei Pogrobenko and Leonid Gurvits. It comprises a record of the Huygens radio signal frequency as received at Earth by the DSN stations plus other radio telescopes. Although the signal is the same as that analyzed in the Doppler Wind Experiment (DWE) investigation, these data used a different set of receivers, and are recorded at a higher time resolution and therefore are useful in understanding the short-period variations of the range-rate. A detrended and averaged version of this dataset has been included in the integrated timeline product

The VLBI experiment is described in more detail in S. Pogrobenko et al., VLBI TRACKING OF THE HUYGENS PROBE IN THE ATMOSPHERE OF TITAN, and Proceedings of the International Planetary Probe Workshop, Lisbon, Portugal, and October 6-9, 2003 and in

Gurvits, L.B. et al., VLBI Observations of the Huygens Probe, ESA-ESTEC Contract No. 18386/NL/NR Final Report, JIVE Research Note #0011, 15 October 2008

The following notes on the dataset have been compiled from email communications from S. Pogrobenko.

First column - time stamp (seconds UTC after midnight at geocenter,
Second - power in units of Tsys, or SNR in other words,
Third - frequency (after bulk frequency trend removed)

If you plot the power you'll see how GBT was slewing on Titan/Huygens, with its 3 arcmin (half power) beam and slewing rate ~3 arcmin per second, a first detection was made at 37160s +/- 2s = 10h 19m 40s by GBT after some 20 ms correction to geocenter and our 2 s Fourier window. 0.5 s Fourier window gives first detection (at 3 sigma) at 37159s.

One way light time (from center of Titan to geocenter) was 67.140 minutes or 67 m 8.4 s in UTC

1. Sensitivity of GB is some 3-4 times better than Parkes, that allowed us to achive ~2s time resolution with GBT and 4s with Parkes, so the SNRs for both GBT and Parkes are at about the same level of 10-15.

2. Frequency residual are formal residuals, they are not noise. Actual noise margins for frequency detections can be estimated as 1/(SNR*T) where T is a Fourier window, 1 s for GBT and 3 s for Parkes, so it should be at the level 50 mHz for GBT and 30 mHz for Parkes. Some noise is absorbed into detected frequency, residuals are less than expected noise.

3. Noise on power detections does not look like a thermal noise.
For GBT it's more or less clear that power deviations are mainly caused

by small scale motion, while for "after landing" phase at Parkes I have no clear explanation of this power behavior. Tried to explain it by interplanetary scintillations but experts say that spectrum and structural function of Parkes power behavior does not look like that caused by scintillations in interplanetary media.

4. Note that formally, for quasi-monochromatic signal SNR ~ T (Fourier length), so it's safe to say that if frequency noise can be estimated as 50 mHz on a time scale 2 seconds, deviations of 100 mHz on a scale 5 seconds are for real.