Detection of a strong rfi-threat in the BINGO frequency range due to the new Chinese satellite navigation system COMPASS at 1207.14 MHz

Christian Monstein ETHZ

BINGO = BAOs from Integrated Neutral Gas Observations.
BAO = Baryonic Acoustic Oscillation.
See BINGO concept paper (Battye et al.) for more details (arXiv:1209.0343)

Currently, a simple in-sensitive but cheap receiving system (which was originally designed for solar observations) is configured to receive frequencies covering BINGO frequency range from 960 MHz up to 1260 MHz. During the day the antenna tracks the sun but in the night the 5 m parabolic dish is pointing to the sky to a fixed position at azimuth 180° and elevation 80°.

According to Chinese filings with the International Telecommunications Union (ITU), Compass satellites will broadcast signals in four frequency bands: 1561 MHz, 1589 MHz, 1268 MHz, and 1207 MHz. The downlink signal at 1207.14 MHz, according to others investigations (see further reading below) is binary phase-shift keying (BPSK) which uses many MHz of bandwidth for a few minutes depending on the antenna beam width FWHM (here about 3.5°). Unfortunately we do not know if the satellite flew directly through the center of the antenna beam during the measurements described below. Figure 1 shows the observed spectrum over the range of 1195 to 1220 MHz and figure 2 shows the peak spectrum relative to the background noise. Figure 3 shows relative power measurements over time at the peak power frequency of 1207.14 MHz.

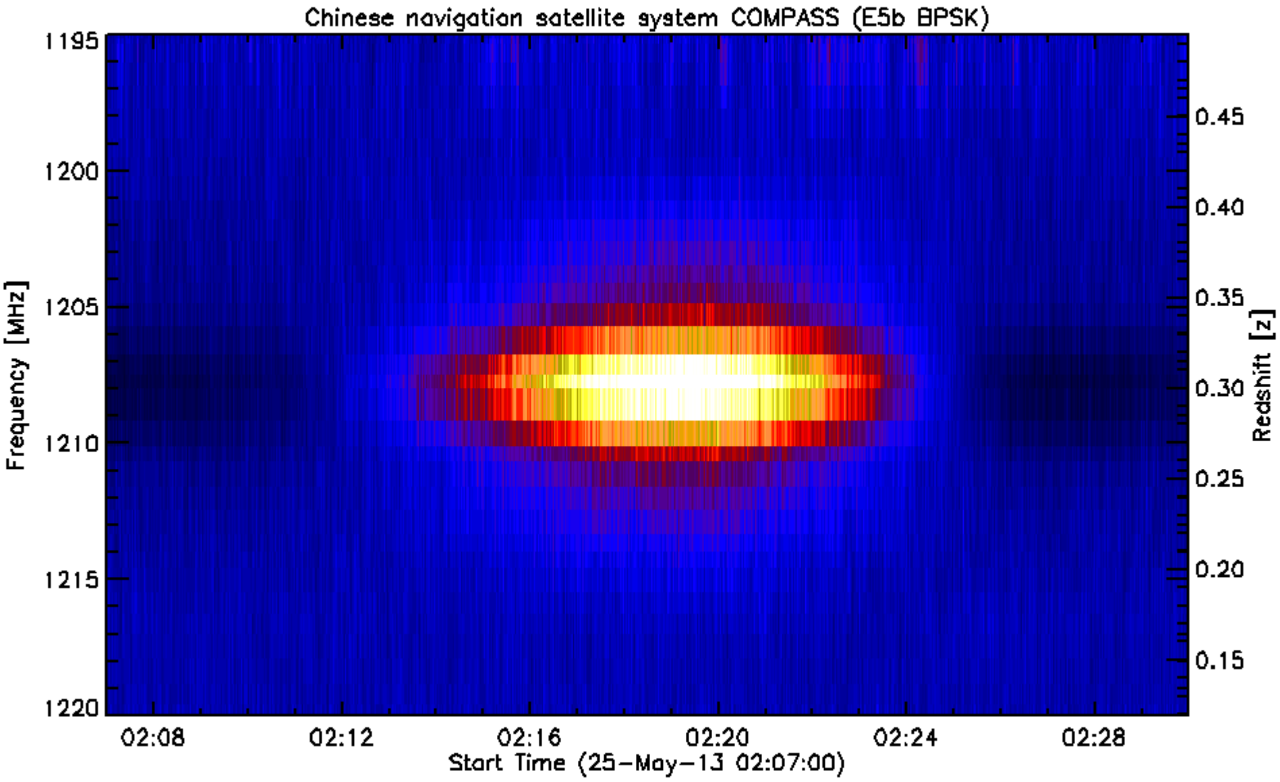

Figure 1: Strong interference about 5dB above noise floor due to Chinese navigation satellite. Time axis shows UT, blue color denotes to noisy background while red and yellow denote high flux level.

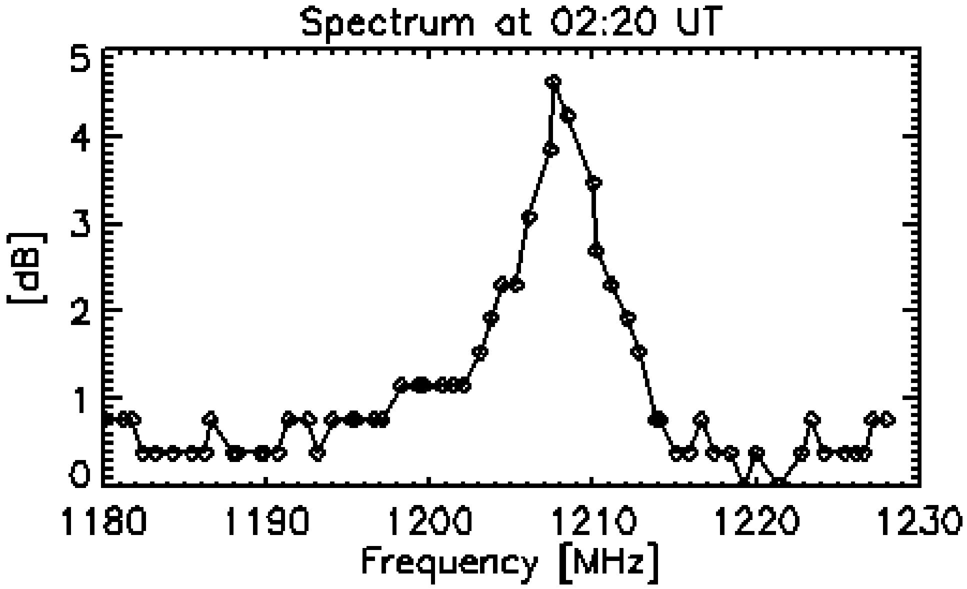

Figure 2: Single spectrum through peak time of the interference. Background is subtracted.

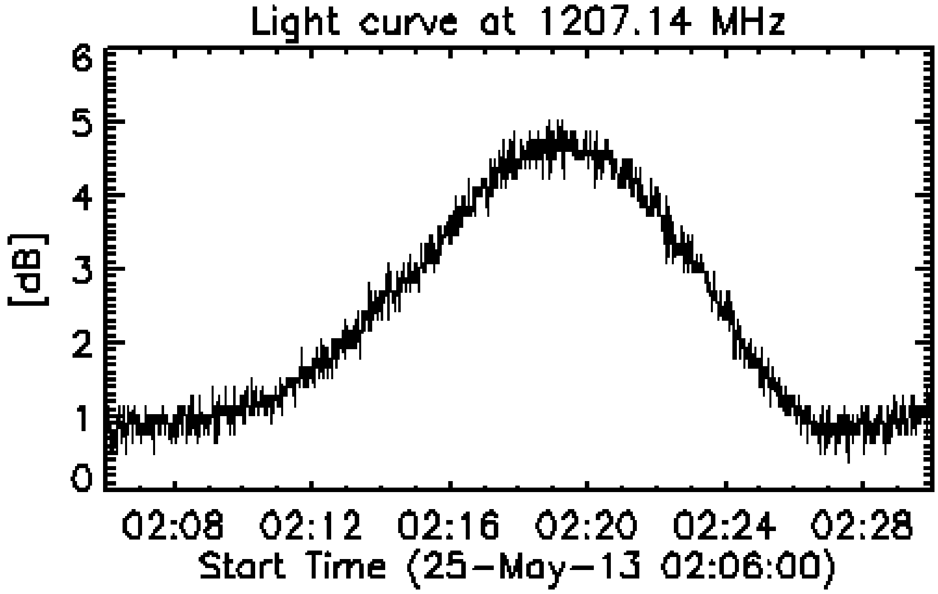

Figure 3: Light curve at the peak frequency of 1207.14 MHz. Duration of the RFI is at least 20 minutes without taking into account side lobes. Plot was produced with IDL software and slightly smoothed with IDL filter function rfi = LeeFilt(rfi,1).

Flux estimation

While the receiver is measuring the sun during the day we can roughly estimate the peak flux Srfi of the navigation satellite observed at night using Y-factors (see Further Reading for explanation of Y-factor measurements).

$$Srfi = \frac{Ssun\,(Yrfi-1)}{Ysun-1} \quad (1)$$

where Ssun can be obtained from: http://www.swpc.noaa.gov/ftpdir/lists/radio/rad.txt
to about 100 sfu on May 24th.

Ysun can be read out from real-time light curves of the Callisto spectrometer at Bleien observatory here: http://soleil.i4ds.ch/solarradio/data/status/RSG/status7m.php

Ysun factor at 1200 MHz is around 7dB above background noise, see figure 4. Putting all data into equation (1) we get for rfi a peak flux of at least 35 sfu (~35% of quiet solar flux) which is 350'000 Jansky.

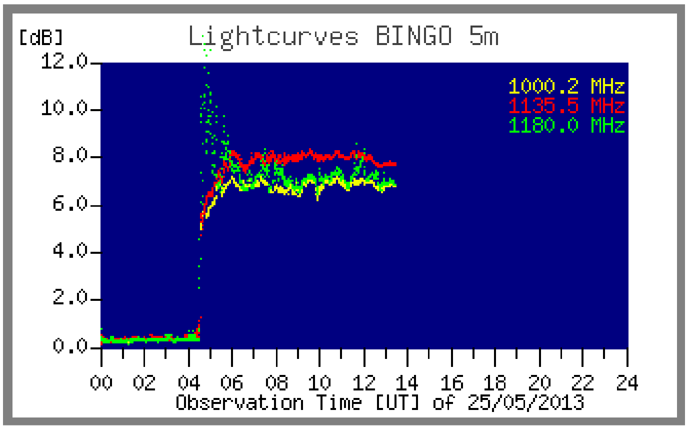

Figure 4: Real-time light curve of Callisto at Bleien observatory (5 m dish). Quiet solar flux in the order of 7 dB above background system noise.

Recommendations

It might be useful to have a separate monitoring system with a slightly larger beam-width as an alarm system to mark potentially bad or interfered observations. It would also be useful to observe as many channels as possible to better select the 'good' ones out of an interfered spectrum. Sampling and integration in the time-domain should also be performed in a way that bad or interfered spectra can be at least marked or even thrown away.

Further reading:

http://www.insidegnss.com/auto/IG0607_CompassFinal.pdf
http://forschung.unibw.de/papers/zq9eyufngj0khajqqfxtwxozhi6qx3.pdf
http://www.ion.org/search/view_abstract.cfm?jp=p&idno=7652

Noise Figure Measurement Accuracy – The Y-Factor Method, Application Note 57-2, Agilent Technologies, publication 5952-3706E, 2013 (www.agilent.com)