

Things That Go Hump in the Night – A Fun Experiment

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With the close of a Jupiter observing season, the question is always, “okay, now what?” The end of the recent season is no exception. Here is an easy analysis of the galactic background, a fun experiment that can be done at any time by anyone with a Radio Jove telescope or similar equipment.

Background on the Background

The field of radio astronomy was kicked off in 1933 by Karl Jansky’s discovery of the galactic background emission at 20.5 MHz. [1] He realized that a strong, constant source of shortwave radio static was moving across the sky every day – but not like the Sun. It moved like the stars – that is, it crossed the local meridian not 365 times per year, but 366 times per year. This meant the source was very unlikely to be local to our solar system and most likely from parts beyond. With today’s equipment, this is a very easy experiment that anyone can perform – and we shall.

Our galaxy is not a lumpy amorphous blob, but a relatively thin disk of stars, dust, gas, and charged particles. The plane of this disk is currently inclined about 63° to the celestial equator. As such, the galactic plane passes overhead twice a day – once for the inner plane and once for the outer plane – unless one’s observatory is close to one of Earth’s poles.

Our galaxy is besotted with charged particles flying around all over the place. These particles interact with the galactic magnetic field, in so doing emit noise across most of the radio spectrum. Within the HF band (3 to 30 MHz), this galactic background emission is strongest at the lowest frequencies. At Earth’s surface, however, most of the galactic background below about 15 MHz or so is absorbed and/or reflected back into space by the ionosphere. At 20 MHz, where the Jove receiver operates, the galactic background is strong and the ionosphere is relatively transparent at night. This makes the galactic background very easy to observe with a Radio Jove radio telescope.

So much for the cosmos, now let’s talk about hardware. The Jove antenna array does not see the whole sky evenly. It has a “beam.” That is, it has a preferred area of the sky to which it is most sensitive. This, after all, is the whole point of an array: to make the antenna more sensitive in one direction and less sensitive in all other directions.

Since the array is connected to a Jove receiver and then to Radio Sky Pipe software, a record is made of the amplitude of the radio noise captured by the array as Earth’s rotation sweeps the beam across the sky. The beam sweeps at a stately pace, completing one circuit of the heavens every 24 hours. Since Earth lies within the galaxy, the Jove array’s beam sweeps across the plane of the galaxy twice a day. As the beam sweeps across the portion of the galactic plane nearest the galactic core, a broad hump-shaped peak is generated in the strip chart trace. This is called, naturally enough, the galactic hump. Twelve hours later, the beam sweeps across the portion of

the galactic plane towards the outer rim of the galaxy, whereupon a much smaller hump is produced in the chart. These humps are most easily visible when they happen in the middle of the night. They are not normally visible during the daytime unless the eleven-year solar cycle is at its minimum.

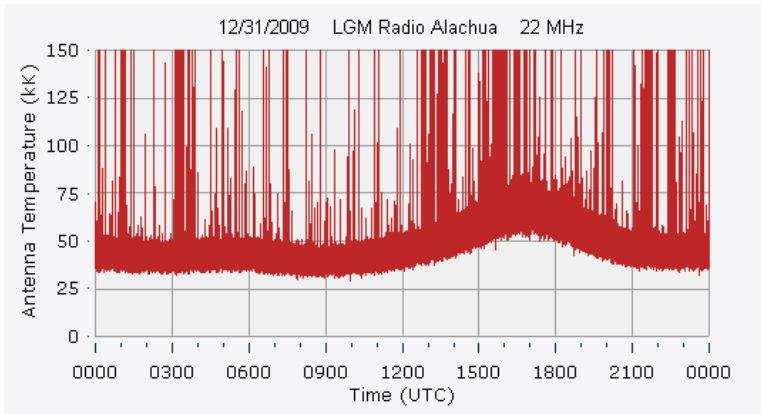


Figure 1 – A relatively clean record of the galactic background emission observed by Wes Greenman on Dec 31, 2009 at 22 MHz. Strip charts made in the HF band almost never look this nice for an entire day. The galactic hump in this figure is centered at about 1700 UTC. The spiky features are most likely all local interference.

Procedure

Using the Radio Jove receiver and the Radio Sky Pipe (RSP) software, record data in continuous 24-hour runs over the course of a year. This can be done every day, or just once a month. If a day is missed, simply record the following day. A few days either way each month won't make any difference. Indeed, this may be necessary to escape periods of strong interference.

Recording all this data is much easier than it sounds. RSP can be configured to do it automatically. Simply set the options to save data automatically and to restart the chart every 24 hours at 0000 UTC. These settings may be found on the Logging tab of the Options menu item.

Once the data has been recorded, the next step is to do some data smoothing to knock down the worst of the interference as shown in Figs 2A and 2B. This makes the galactic hump easier to see. The charts here have been smoothed using averaging with a window width of 3,000 samples. Since the data was recorded at ten samples per second, a window of 3,000 samples represents five minutes. RSP can do this in review mode. Load a file for review, then go to the Tools menu item and select Smooth by Averaging.

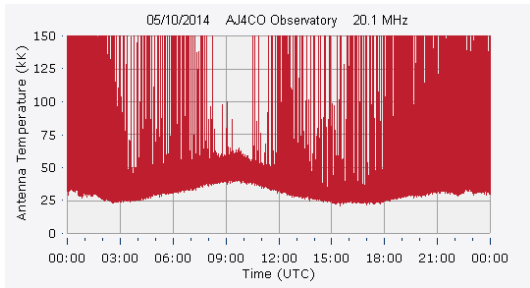


Figure 2A – A typical 24-hour strip chart prior to averaging, complete with real-world interference.

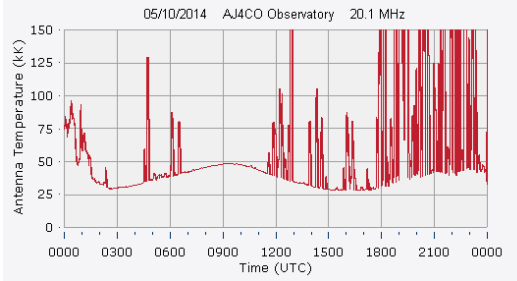


Figure 2B – The same data shown in Fig 2A after application of smoothing by averaging using a 3,000 sample (five minute) window. Some of the interference has been knocked down.

After the data has been smoothed, the next step is to save some graphics of the strip charts. One can then see the galactic hump move from right to left as the galactic core transits earlier each day due to Earth's orbit about the Sun – the shift is about two hours earlier per month. This motion is explained well in *Listening to Jupiter* by Flagg. [2] To make Fig 3, some sky maps from Radio Jupiter Pro can be placed next to the strip charts, then the whole stack of images may be converted to an animated GIF using Photoshop.

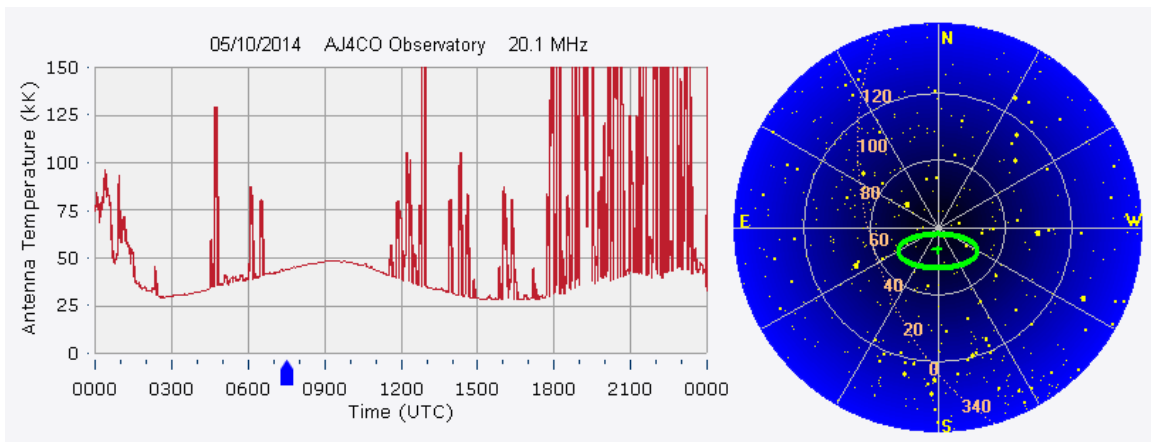


Figure 3 – Animation of twelve months of 24-hour strip charts, one frame per month. The galactic hump moves right to left due to Earth's orbit, appearing two hours earlier each month. The images at the right were generated using Radio Jupiter Pro and represent the sky as seen from High Springs, Florida at 0730 UTC (the blue marker on the horizontal axis of the strip chart) on the date of the associated strip chart. The orange numbers in the sky view lie along the galactic plane and represent galactic longitude where 0° is the galactic core. If you are viewing the PDF version of this article, please see the June 2015 Jove Bulletin to view the animated version of this graphic at <http://radiojove.gsfc.nasa.gov/library/newsletters/2015Jun/>

But Wait, There's More

Pictures and animations are nice, but there is more. The time between successive transits can be calculated from these images. The Julian date of each transit is an easy way to do this. Some charts will have obvious humps, others will not – just ignore them. The time between successive

transits is simply the number of days elapsed divided by the number of transits. The result is converted to hours, minutes, and seconds. Averages should be weighted by the number of transits.

Date	Time (UTC)	JD	Days	Transits	Transit Timing
Inner Galactic Plane Beam Crossing					
10-May-2014	0930	2456787.895833			
			30.9167	31	23:56:08
10-Jun-2014	0730	2456818.812500			
			301.1563	302	23:55:59
08-Apr-2015	1115	2457120.968750			
			31.9271	32	23:56:43
10-May-2015	0930	2457152.895833			
				Weighted Average:	23:56:03
Outer Galactic Plane Beam Crossing					
10-Oct-2014	0930	2456940.895833			
			30.9167	31	23:56:08
10-Nov-2014	0730	2456971.812500			
			29.9167	30	23:56:00
10-Dec-2014	0530	2457001.729167			
			34.9063	35	23:56:09
14-Jan-2015	0315	2457036.635417			
				Weighted Average:	23:56:06
One Year: Inner Galactic Plane Beam Crossing					
10-May-2014	0930	2456787.895833			
			365.0000	366	23:56:04
10-May-2015	0930	2457152.895833			

Table 1 – Transit time analysis.

The calculated transit timing is right on the money with the length of one sidereal day, which is 23 hours, 56 min, 4.09 seconds. This means the source of the galactic background emission moves through the sky with the stars, not with the Sun.

This experiment would make a fun laboratory exercise perfect for the classroom. Students cannot take a year's worth of data in a few weeks, but they can easily do a few day's worth. The instructor can supply the rest of the required data and the students can make the images and do the timing analysis based on their own interpretations of the strip charts.

References and Further Reading

[1] Jansky, K, *Electrical Phenomena That Apparently are of Interstellar Origin*, Popular Astronomy (1933)

http://adsabs.harvard.edu/cgi-bin/nph-data_query?bibcode=1933PA....41..548J&db_key=AST&link_type=ARTICLE

[2] Flagg, R., *Listening to Jupiter, 2nd Ed.*, RadioSky Publishing (2005), pp. 4-17 & 4-18. Available on the Radio Jove Reference CD. http://radiojove.gsfc.nasa.gov/office/order_form.html

Emerson, D., et al., *Repeating Jansky's Experiment*, NRAO (2008)

http://www.gb.nrao.edu/~fghigo/JanskyAntenna/RepeatingJansky_memo10.pdf

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