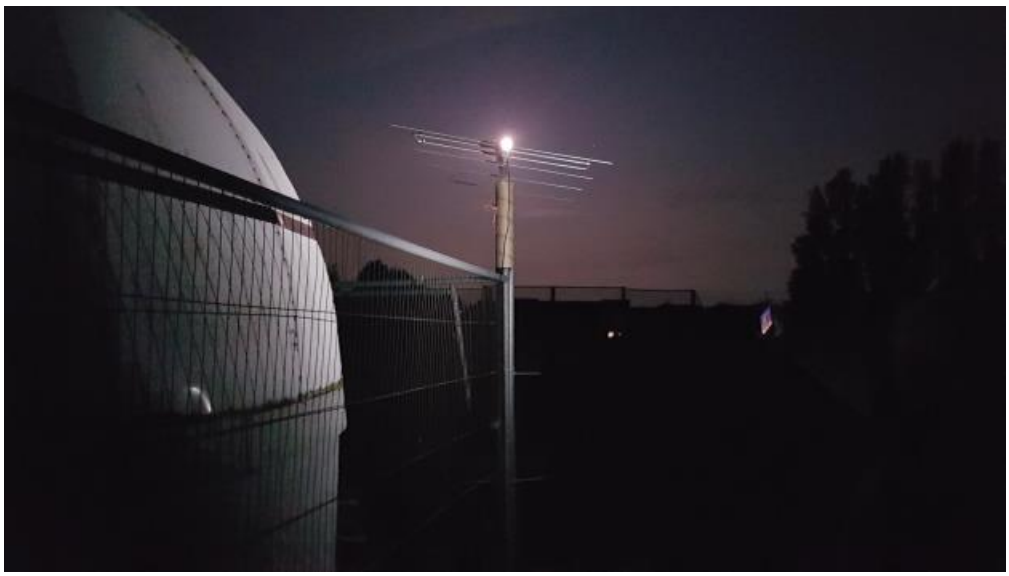
Do any of our readers in Pretoria hold an Amateur Radio Licence?

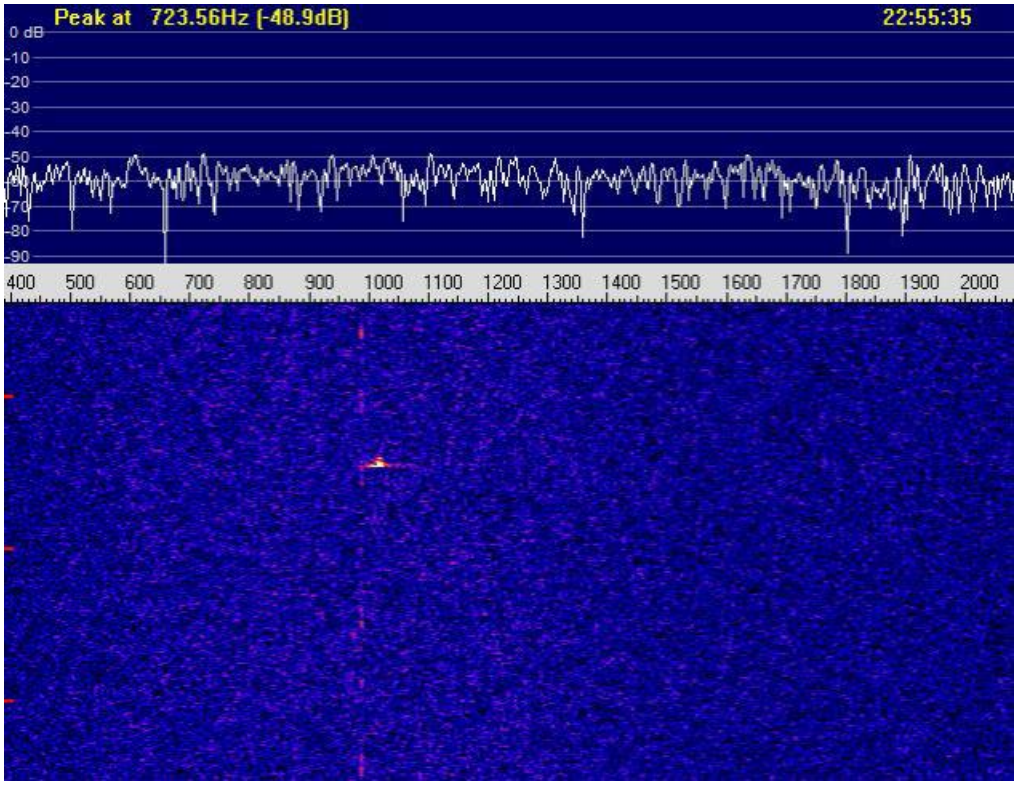
One of the great surprises that came from of our observations of the Persieds meteor shower was the detection of lunar echoes from the GRAVES radar. We certainly didn't hear the signal amongst the noise, and were only alerted to it when we noticed faint dotted lines running down our waterfall plots when examining the thumbnails of saved images in Windows 10. This discovery prompted me to go outside and take this image of our antenna with the moon in-shot!



If you search on YouTube for 'graves radar', you will find several videos of the radar signal being received around the world, from as far afield as Brazil. As the radar signal is obviously detectable within the Southern Hemisphere, I was wondering if anyone in Pretoria is interested trying this aspect of astronomy?

Graves received in Brazil - https://www.youtube.com/watch?v=QvupwtRFXcc

In order to receive the GRAVES radar, you will need a directional (Yagi) antenna and a multi-mode radio receiver (or RTL Dongle) that capable of receiving single-sideband transmissions outside of the normal 2 metre amateur band. Start by pointing your antenna towards the moon, preferably at moonrise as the reflection from the ground gives slightly more gain; your aim does not need to be exact as the antenna's beam width which may be around 45 degrees. Set your radio receiver to upper sideband (USB) and tune to 143.049 MHz, this will produce a faint on-off tone at 1 kHz in the audio passband, and should appear as a dotted line on a spectrogram plot.



The image shows both the lunar echo, as the vertical dotted line which is slightly offset due to the Doppler shift, and the transient reflection from the ionised trail of a meteor.

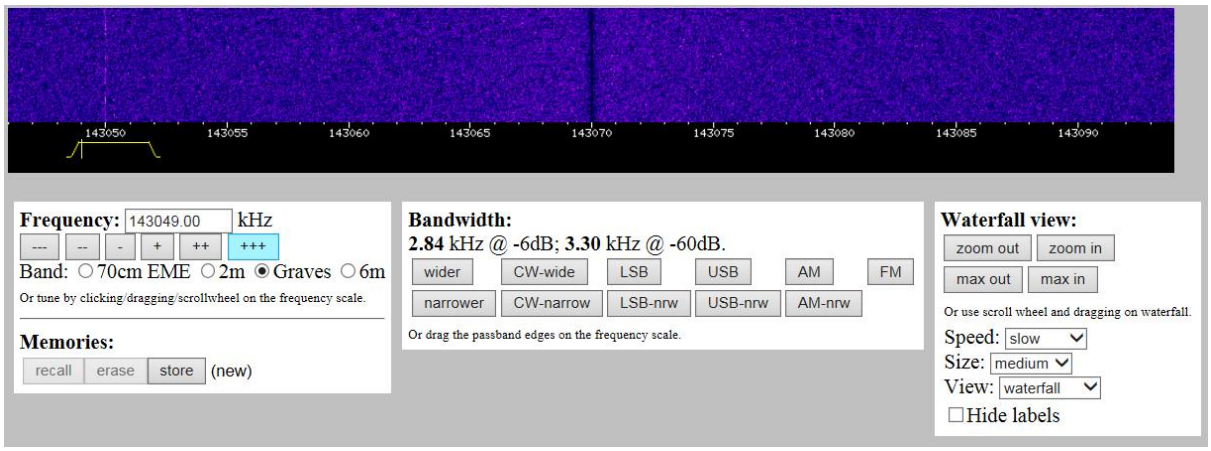
To put this into perspective, the radar signal leaves France with a transmitter power of 40,000 Watts (or +76 dBm in radio terms) it then travels the quarter of a million miles distance to the moon, before being partially reflected by the lunar surface. The lunar echo then travels back along the same path and eventually arrives, approximately 2.6 seconds later, at our antenna in Brough.

The loss along this path is approximately -252 dB for a radio signal at 144 MHz, this equates to an octillionth (or 10^{-27}) of the transmitted signal arriving back at the antenna. As dB (decibels) are a logarithmic unit, we can simply add up the values: 76 – 232 = -176dBm. We can convert this back into familiar units, and thus we expect to receive a signal of approximately 0.004 attoWatts (4×10^{-21} Watts) at our antenna – this signal is very close to the thermal noise floor at room temperature (i.e. 20 °C) with Boltzmann's Constant coming into the equation somewhere!

As an aside, I measured the minimum discernible signal on my receiver, the Yaesu FT-817ND, to be approximately -147 dBm with an RF signal generator. The difference of 29dB can be accounted for by the gain of my InnovAntennas 6-element Loop-fed Yagi antenna of 12-18 dB, the focussing of the radar beam by the antenna array in France and the averaging in the waterfall display. Whilst there is scope for incremental improvements, such as a low-noise preamplifier at the antenna and low-loss coaxial cable in place of the RG58 used, we are pretty much amazed at our results.

More information is available on the BLAS forum on Groups.IO – https://groups.io/g/BLAS

The Dwingeloo radio telescope in the Netherlands has several software defined radios that can be accessed from a web browser from http://websdr.camras.nl:8901/. There are 144 MHz and 50 MHz streams that are connected to Yagi antennas for meteor scatter (including GRAVES), and a 432 MHz stream that is connected to the main 25 metre dish and can be used to receive amateur radio transmissions reflected from the moon. However, as the dish is shared with other users – the web page has an inset which shows what object it is currently tracking and the azimuth and elevation where it is pointing!



This waterfall plot was received this morning which sometimes has a signal from graves, I'm not sure if this is lunar (possible) as there is no telescope data, or from tropospheric scatter (unlikely).

Dwingeloo telescope - https://www.camras.nl/en/blog/2019/dwingeloo-sends-heart-beat-neil-armstrong-back-to-the-moon/

Blue Dot event on YouTube - https://youtu.be/azJw7XQBbrA