Creating a hydrogen line (1420MHz) radio telescope from a 1.5m Solar Cooker Dish sold on eBay

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The Parabolic Solar Cooker.

Many of us at some time or other have desired a large dish to use for radio astronomy – not only will such a dish improve the sensitivity of our systems but it also appears similar in appearance to that expected by most people of a radio telescope.

Unfortunately, large dishes are expensive, unwieldy, and often difficult to source and mount.

Recently, a new breed of parabolic reflector dish has started to be sold in the USA on ebay.com as a form of solar cooker where users place a kettle or similar object at prime focus and the focused rays of the sun heat the water within it. These reflectors are 1.5m in total size, composed of 6-8 segments, relatively light-weight, and surprisingly cheap – at around 50 US dollars plus postage.

Unlike visual parabolic mirrors where the mirror surface needs to be accurate to a very precise level measured in nanometres, this level of precision is less important for radio hydrogen detection. The hydrogen frequency of 1420.405MHz equates to 21cm (0.21m) wavelength. If the parabolic surface is accurate to 1/10th lambda (1/10th of a wavelength) then this means a variation of 2cm (nearly 1 inch) can be tolerated across the parabolic surface.

These solar cooker parabolic reflectors are not sold on ebay.co.uk (I am based in the UK), but I was fortunate enough to find someone selling one second-hand from a house clearance.

So, with my new 1.5m parabolic dish, I was ready to turn it into a radio telescope.

Assembling the parabolic dish.

The dish is designed to be transported as smaller segments which are then assembled by the user.

Software for Detecting Hydrogen.

There are a variety of software options available for detecting and processing hydrogen data. My personal preference is Easy Radio Astronomy Suite (https://github.com/tedcline/ezRA). This software suite includes a group of Python scripts and will run on Windows or Linux. It is free of charge (like nearly all amateur radio astronomy software). It contains its own data collection program (ezCol) but also works well with data collected using SDR Sharp software (https://airspy.com/download/ or https://www.rtl-sdr.com/rtl-sdr-quick-start-guide/sdrsharpdownload/).

In both cases, data is collected using drift scans of the sky. Drift scan imaging, also known as transit imaging, is a method used in astronomy to capture images of celestial objects (in this case the Milky Way itself) as they move across the sky. In this technique, a telescope is fixed in position while the Earth's rotation causes the Milky Way to drift through the field of view. In professional observatories, this method can provide higher resolution images over large fields compared to traditional tracking techniques, and drift scan imaging is widely used in surveys that require continuous, wide-area coverage, making it an essential tool in modern astronomical research (https://www.vaia.com/en-us/explanations/physics/astrophysics/drift-scan-imaging/#:~:text=Drift%20scan%20imaging%2C%20also%20known%20as%20transit%20imaging%2C,objects%20to%20drift%20through%20the%20field%20of%20view).

In amateur observatories, the use of drift scans means that the mount can be set to point in one azimuth direction only without needing to be moved. The scanning process allows data to be collected over the whole 360-degree azimuth circle as the Earth rotates about its axis during the day.

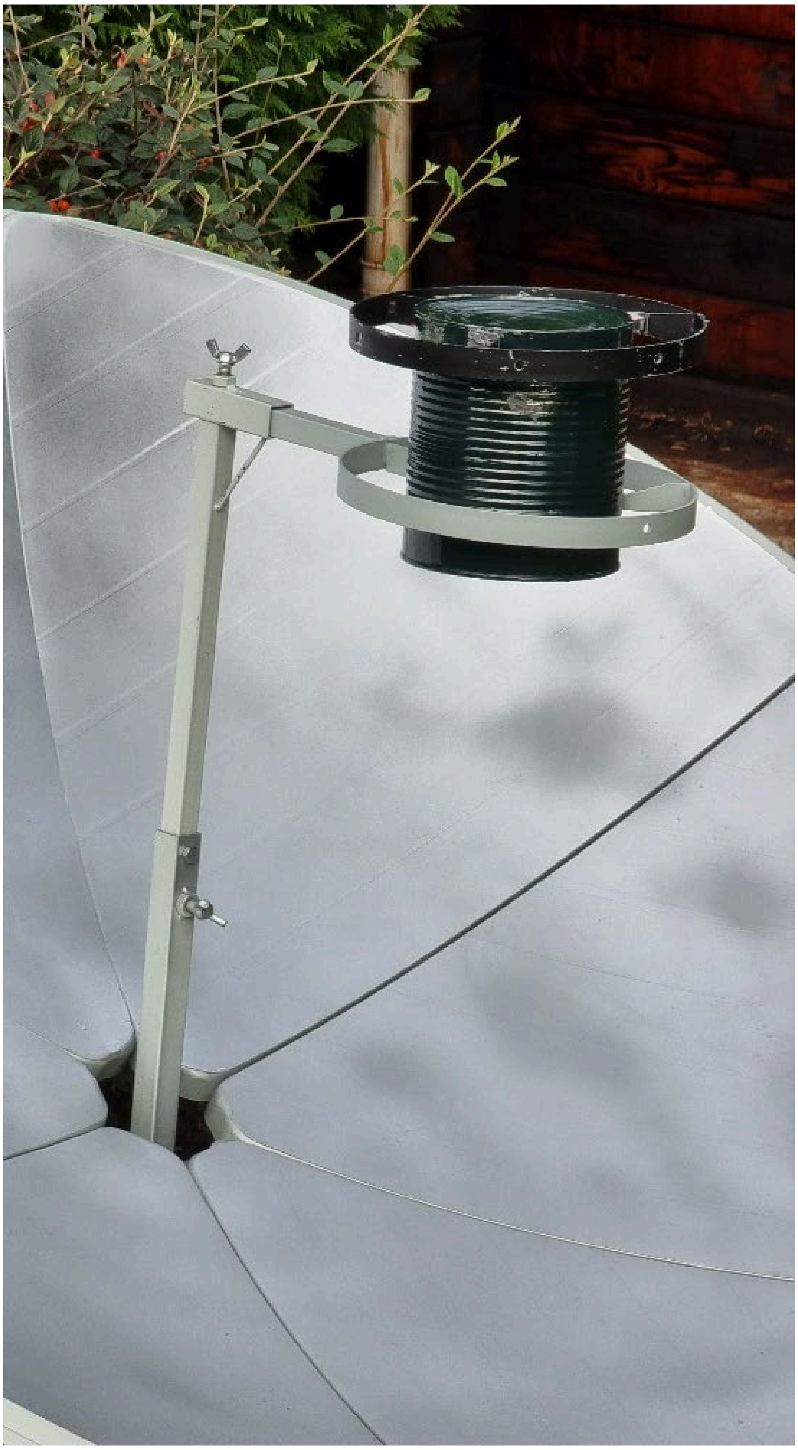
Drift scans are collected for at least 24 hours, although longer times allow a better signal to noise ratio. Then the altitude of the telescope is adjusted before a further drift scan is collected. The process is repeated until the sky is covered to the maximum extent allowed by the observer's latitude and other obstructions such as trees and houses.

Making a waveguide for the telescope.

In a previous project, I built a cantenna using an old coffee tin and straightened paper-clip. This now served to act as my waveguide, replacing the original mechanism for heating kettles and pots. I then purchase some pre-twisted pieces of metal from my local hardware store and: Voila! A new waveguide was in place! The original hole in the centre of the dish for the pole to hold the kettle at prime focus now serves as a drainage hole for water when the dish points upwards.

The reflective mylar surface of the dish easily burnt a hole in a cardboard box on a moderately sunny day – I removed that with several tins of aluminium and zinc spray paint, which also serves to give the structure some rust protection (zinc is a sacrificial metal).

In the two photos below, the cantenna is mounted on the original pole designed to hold the kettle and the dish as a whole is mounted on the original mount that came with it. This mount is rather unstable and needed replacing.



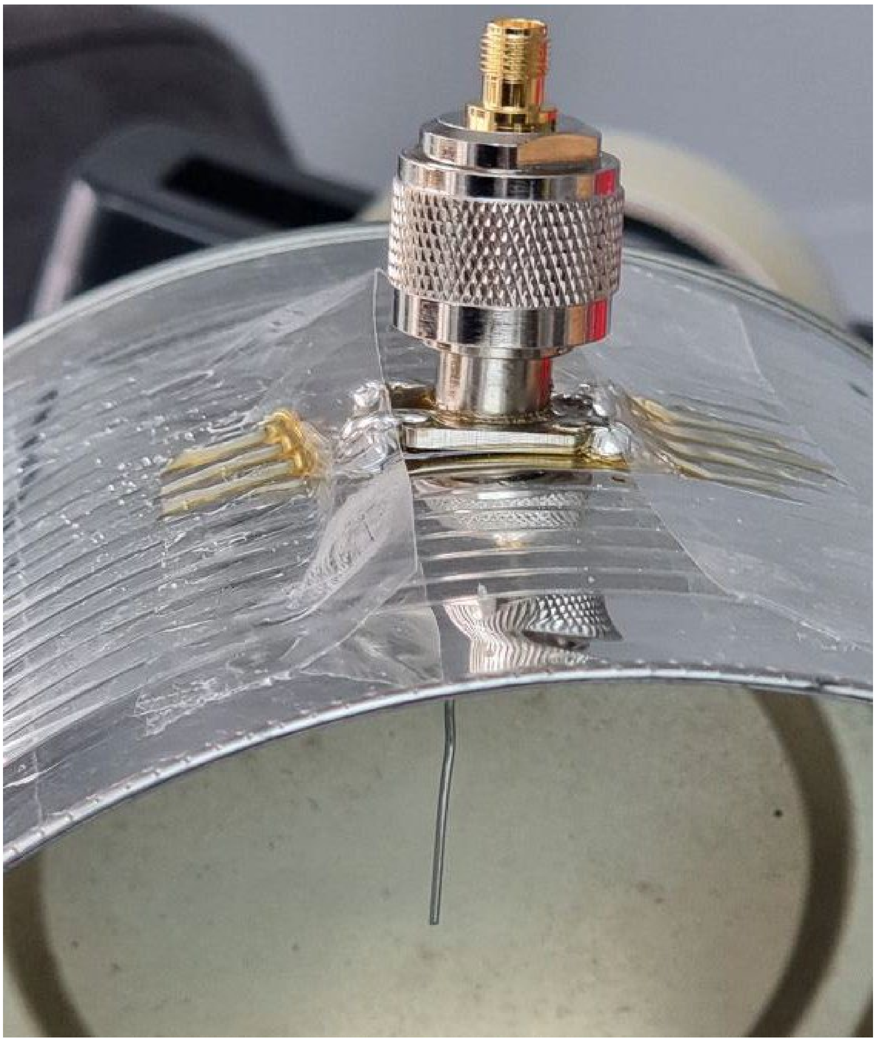
The photograph below shows the cantenna mounted in the new arrangement that is now used in the finished telescope.

Mounting the reflector.

This is a large dish and requires a solid mount. In addition, the large dish acts like a sail in strong wind, risking damage to the dish if it is blown over.

I designed a wooden mount based on a simple table design that points the dish roughly south (the software can compensate for exact direction). Altitude is varied by the use of wooden strips on either side with several holes in each of them – varying which hole is used changes the altitude. Several guy ropes and pegs improve the stability of the structure and give it protection against wind.

The cantenna I build showing the monopole inside made from a paper clip (below).



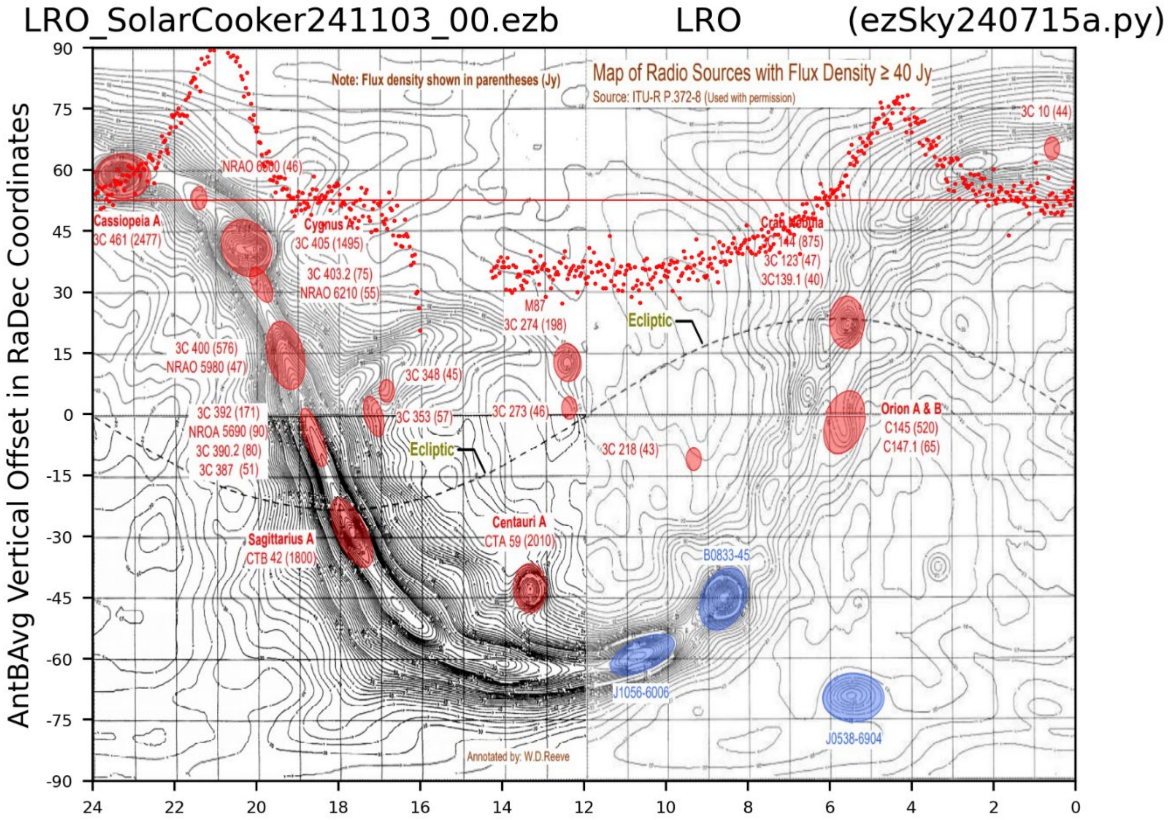
Other hardware requirements.

Apart from the dish and mount, this telescope requires a computer (requires not particularly strenuous – most old computers or laptops will serve), a software defined radio (I use RTL-SDR Blog V3 but there are alternatives), and a SAWBird H1 low noise amplifier and hydrogen filter. I keep these in a black box behind the telescope but this is an arrangement that might change as I improve the telescope in the future.

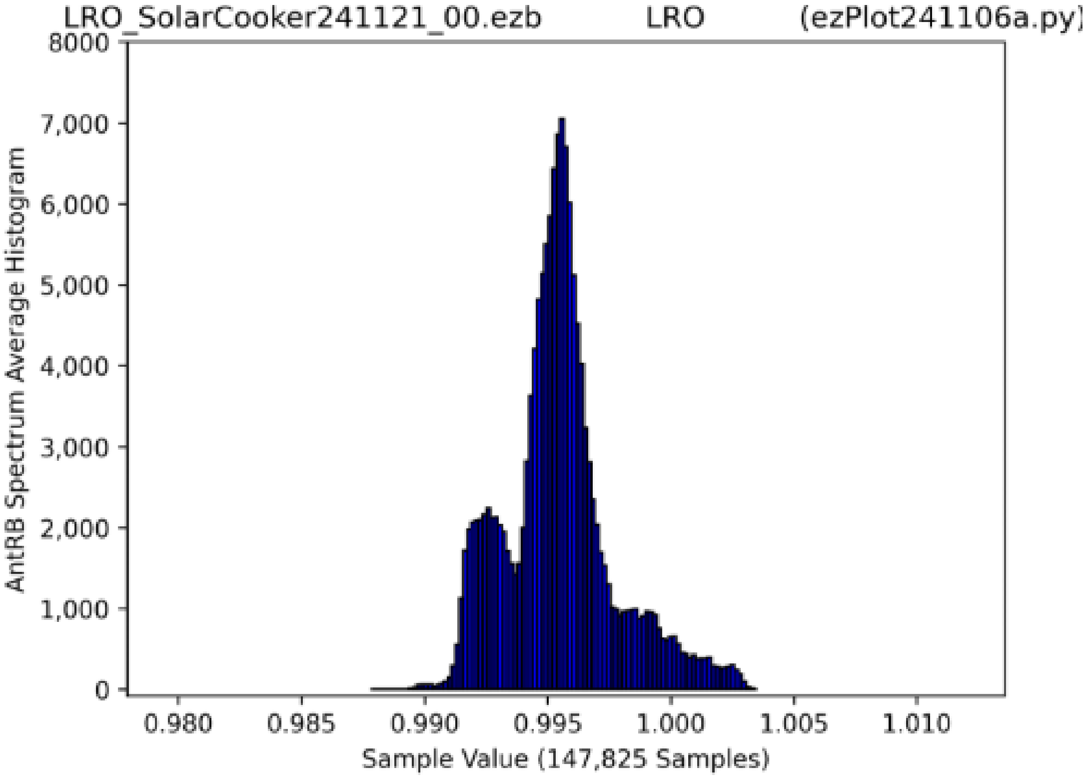
SAWBird H1 LNA Dongle (below).

First light data collection.

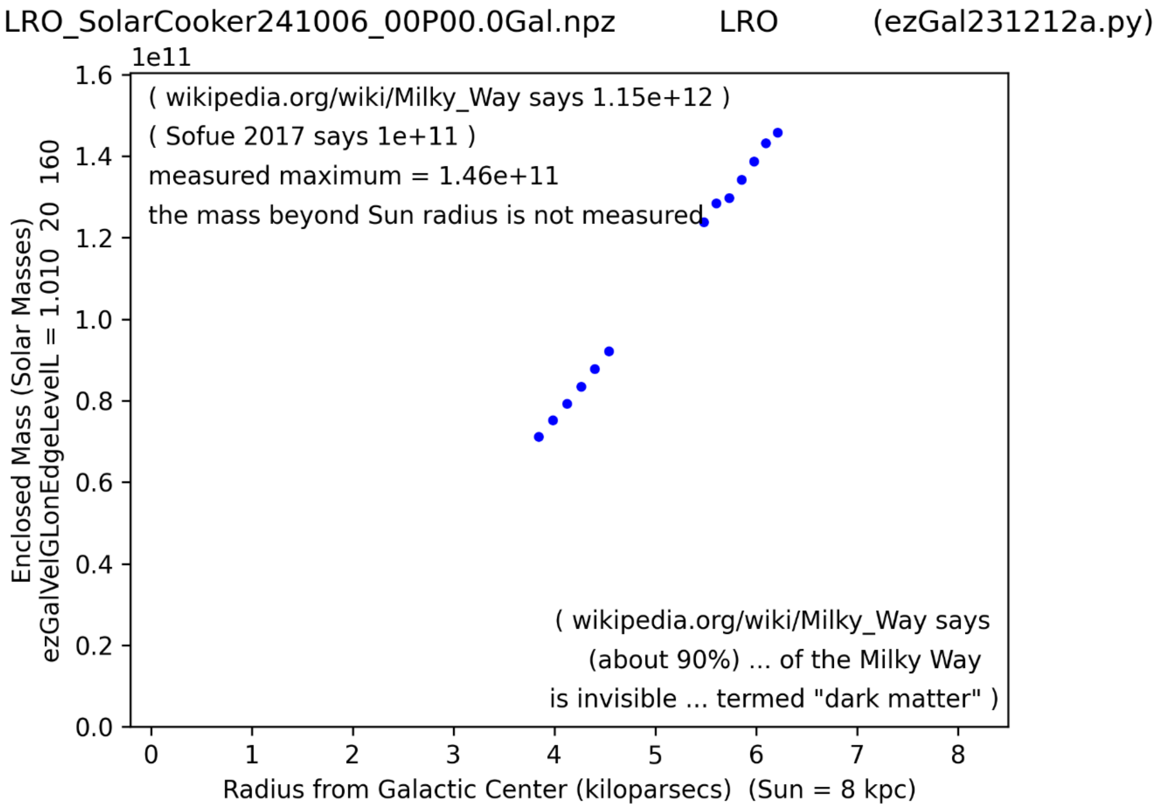
It is early days but the scope is successfully detecting hydrogen (below).



Distribution of data (below).



Even on just two elevation points from this solar cooker dish data so far, allows some measurement of mass of Milky Way (below).



Naming the telescope.

After a bit of a competition on the SARA mailing list and mailing list of my local astronomy group in the UK, the radio telescope has been named “Dishy McDishFace” or the LRO-H2 telescope.

Further information.

Further information about this project is available on the www.astronomy.me.uk website or by contacting me using the “contact us” page on that website.