

**Amateur Radio Astronomy
Observation of the Milky Way at 1453.5MHz
from the Northern Hemisphere**

Dr David Morgan February 2011

Introduction

The measurements reported here were made in March and April 2007 from an observatory in South Wales in the UK and covered the region of the sky within the range 17 to 22 hrs RA and -10 to +60 degrees Dec.

This work was carried out at 1453.5MHz* to observe the broad spectrum radio emission from the galactic plane. This frequency is close to, but separate from, the neutral Hydrogen spectral line emission that occurs at 1420 to 1421MHz. These measurements are required to enable a comparison between the two very different radio emission mechanisms in our Galaxy.

A report of the Hydrogen line results is produced in a separate paper¹.

The broad spectrum radio emissions are produced by a number of mechanisms:

- Free electron scattering in ionised Hydrogen resulting in a thermal emission spectrum that is either constant or falls off with wavelength depending on the gas temperature.
- Synchrotron emission is generated by electrons moving at near relativistic speeds in a magnetic field and result in a non-thermal spectrum where intensity increases with wavelength.

Both these mechanisms produce broad radio spectra – see Figure 1 and are quite distinct from the narrowband ‘spectral line’ emission of neutral Hydrogen. The aim of measuring the broadband emission at 1453.5MHz and the line emission at 1420MHz is to examine how these sources vary in intensity and position in our galaxy.

*This frequency was chosen as being sufficiently separated from the Hydrogen line frequency that there would no contribution from this source, but close enough that the same antenna feed and receiver configuration can be used to measure the both the line and broadband emissions. It is also a “quiet frequency” at the observatory location i.e. free from radio interference.

Radio Observation of Milky Way at 1453.5MHz

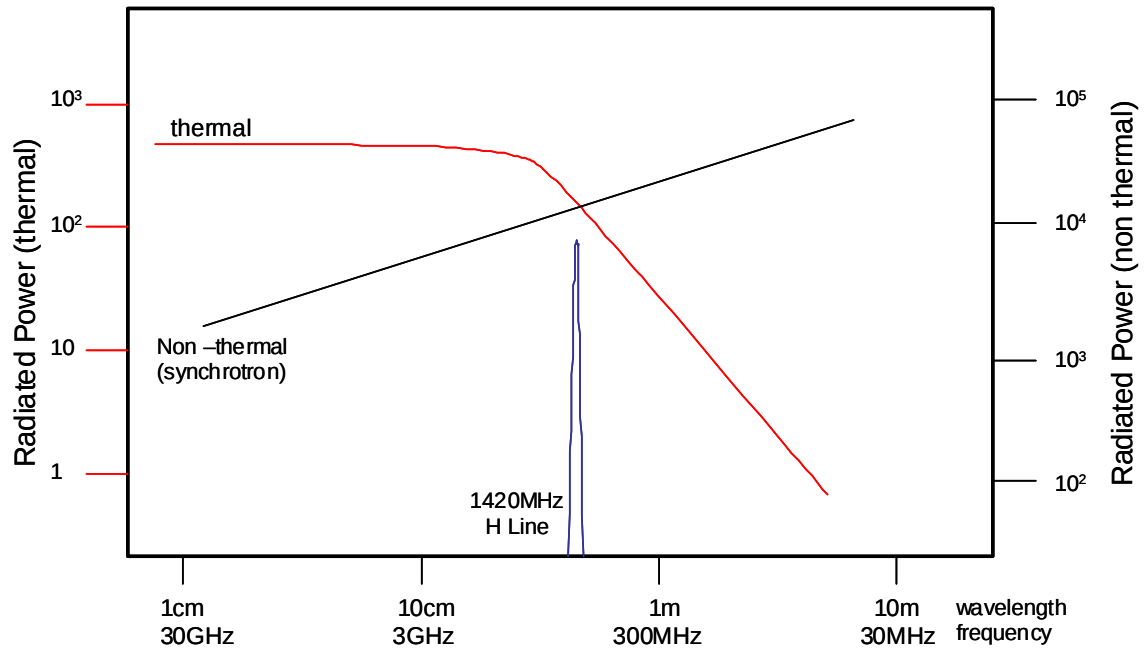


Figure 1 - Typical Radio Emission Spectra (following Hay 1971) ²

Measurement Equipment

Measurements were made using equipment available to an amateur radio enthusiast or radio astronomer. The antenna employed was a 3m diameter parabolic dish with $F=0.28$, a 3dB beamwidth of $\sim 8^\circ$ and a circular waveguide feed and low noise amplifier (LNA). See Figure 2.



Figure 2 - 3m' Dish with 1420MHz Cylindrical Waveguide Feed

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The details of the feed electronics including the low noise amplifier (www.radioastronomysupplies.com), BGA616 line amplifier (www.infineon.com) and temperature control equipment can be seen in Figure 3.

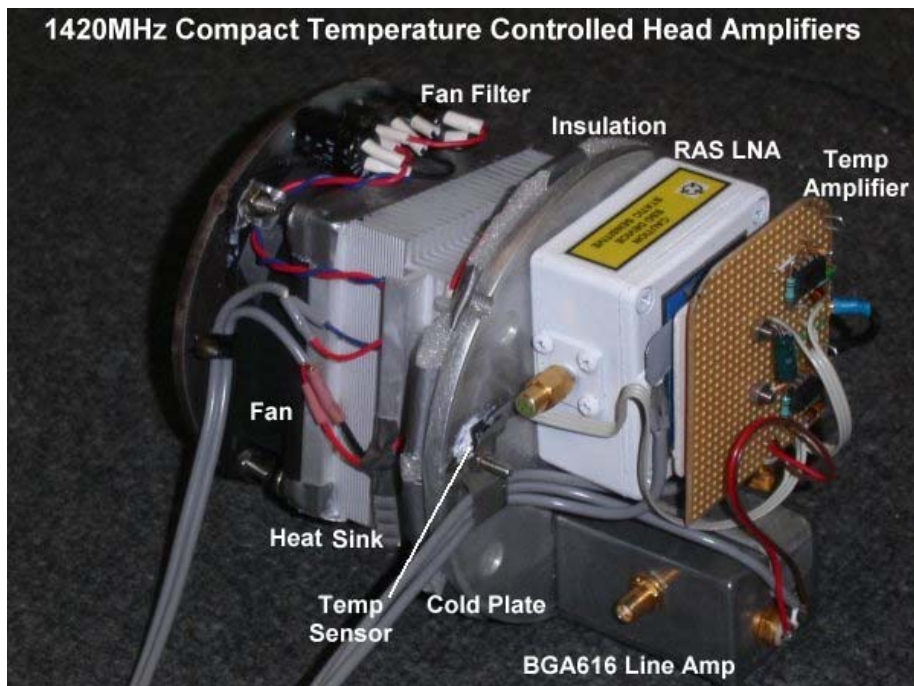


Figure 3 - 1420MHz Cylindrical Waveguide Feed electronics

The signal from the feed is sent to the equipment in the receiving room as shown in Figures 4 & 5 via 20m of good quality coaxial cable ([URM67](http://uk.rs-online.com)) <http://uk.rs-online.com>



Figure 4 - Instrumentation in receiving room



Figure 5 - PC for Data logging & Analysis
[Temperature control equipment of head amplifiers is also shown]

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The block diagram of the system can be seen in Figure 5.

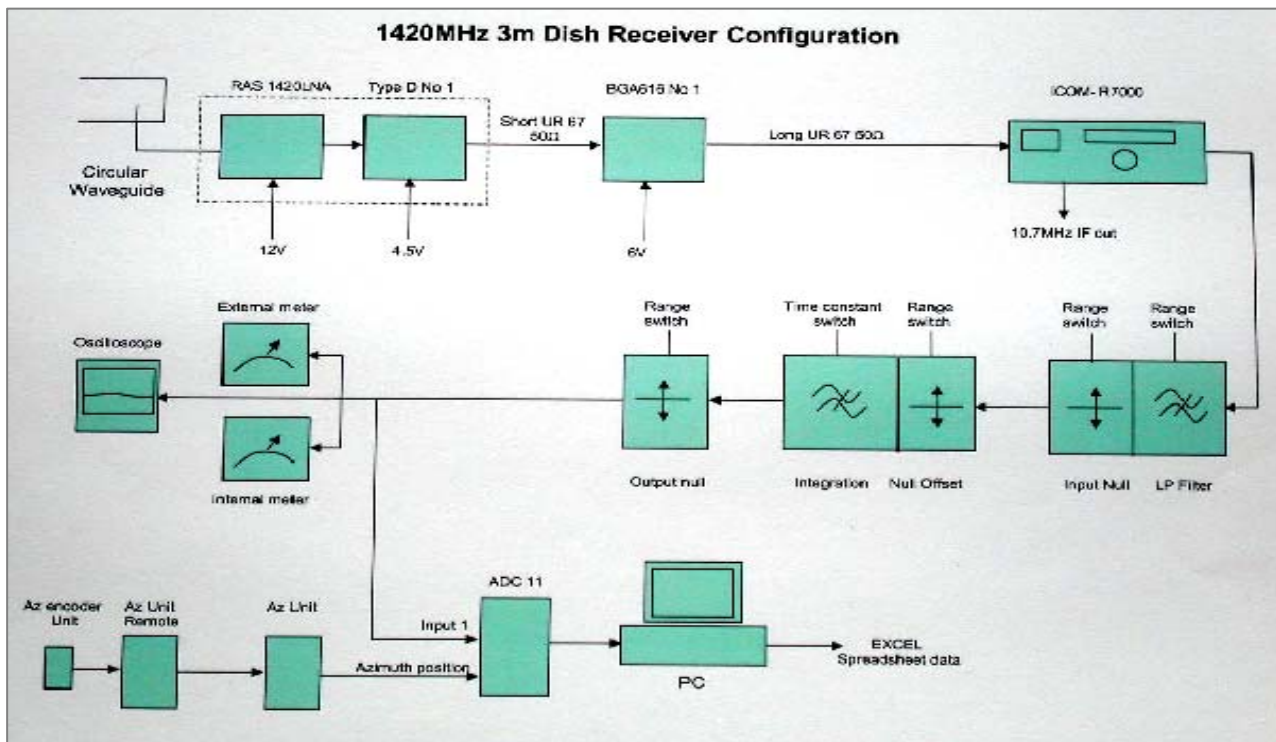


Figure 5 - The Receiving System

One of the most difficult aspects of operating a very sensitive system of cascaded high gain amplifiers is that of temperature stability. The 40dB gain antenna head amplifiers and the 18dB gain RF line driver amplifier are out of doors and are sometimes subject to temperature variations in excess of 20°C over the period of some observations.

Active temperature control of these critical gain stages is essential and is achieved using closed loop temperature sensor I.Cs and Peltier Cooler / Heaters mounted on heat conduction plate (see Figure 3) on to which the amplifiers are fixed. The baseline sensitivity of the system has to be carefully maintained over the whole period of the observations.

Data Collection

The data were assembled from transit scans of the sky over a number of days. The received signal was recorded and processed using a various software tools:

Picolog data logger recorded the base data from the receiver together with substantial 'meta data' information incorporating the temperature of all sensitive components including the receiver and the room in which it was housed. This enabled the compensation of any small residual temperature drifts that occurred from day to day.

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Microsoft EXCEL was used to process the raw signal data into a form that could be used by *Stanford Chart* software to generate false colour maps.

Stanford Chart enabled the production of both false colour maps and superimposed contour lines showing the received signal intensity as a function of position on the sky.

An intermediate stage of signal processing is demonstrated below in Figure 6 where the collection of scans in RA is shown for the range of declinations observed.

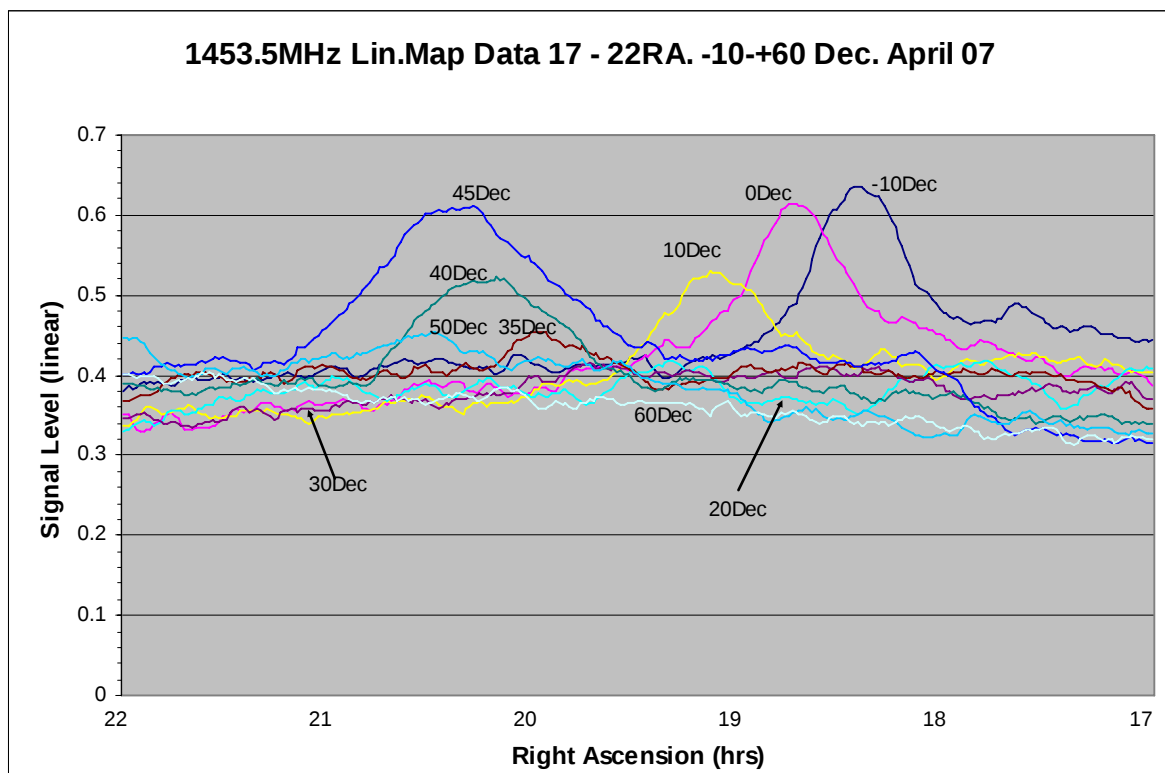


Figure 6 - Sequence of transit scans in RA for a range of Declinations

The above set of graphs shows that there are two separated regions of emissions – both in RA and DEC. This is easily seen when the data are converted to a map form as shown in Figure 7. These correspond to the galactic core region and the Cygnus spiral arm.

The map is plotted in RA & DEC but also has galactic longitude markings to facilitate registration with optical images of the galaxy. The coordinate conversion is made using standard formulae available on the internet. (<http://scienceworld.wolfram.com/astronomy/GalacticCoordinates.html>)

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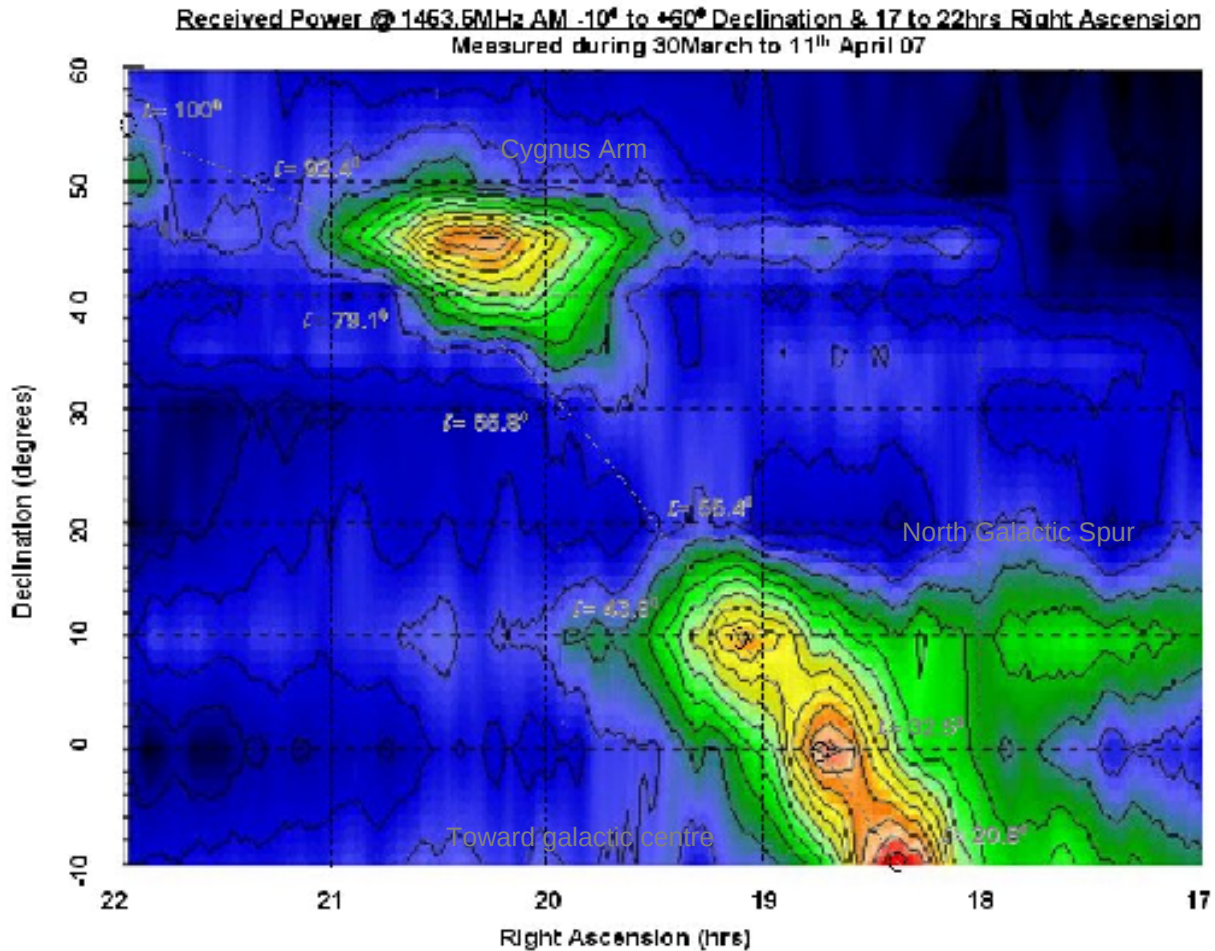


Figure 7 - Map of signal intensity @ 1453.5MHz along Galactic Plane
(at a frequency away from H Lines)

The received power shown here measured at a frequency 1453.5MHz is considered to be predominantly from synchrotron emissions – not from Hydrogen ground state spin transitions, as these are confined to frequencies from 1420 to 1421MHz. Note the indication of the North Galactic Spur on the right of the map. This is thought to be the remains of an ancient supernova explosion and is consistent with synchrotron emission generated by fast electrons moving in the magnetic field of the debris.

The radio map in Figure 7 has been overlaid on an optical view of the same region of the Milky Way and shows good correlation. See Figure 8.

1453.5MHz Received Radio Intensity map

(Power Map Compiled Mid April 07)

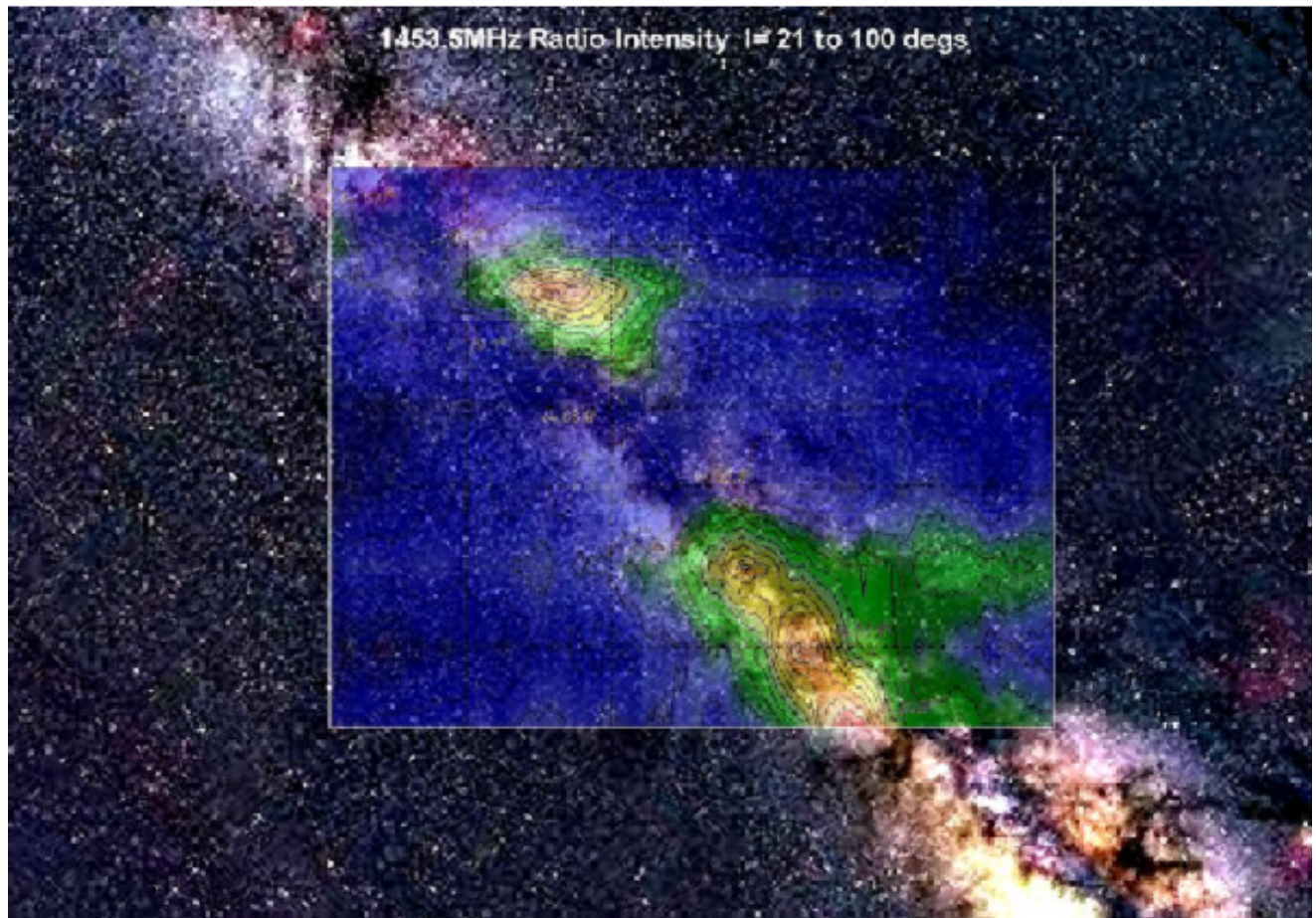


Figure 8 - 1453.5MHz Radio Intensity overlaid on Optical map of Milky Way

References

- 1 Amateur Radio Astronomy Measurements of Galactic Neutral Hydrogen Distribution (to be published on BAA RAG web site)
- 2 The Radio Universe pp14-30 J.S.Hay Pergamon Press
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