
JODRELL BANK OBSERVATORY 7-M RADIO TELESCOPE

EXERCISE 1: BEAM PATTERN OF A RADIO TELESCOPE

Exercise 1: Aim

You will scan the 7-m telescope across a bright radio source (Cassiopeia A) in order to measure the telescope's beam-width. This defines the region of the sky from which the telescope is sensitive to radio waves. It depends on the telescope diameter and the frequency of observation. You will compare the measured beam-width to the expected value for the 7-m telescope.

Scanning with the 7-m Radio Telescope

Click on [Setup Obs](#) (entering your username and password if required) and then on [Total Power Scan](#). In this experiment we will use the 7-m telescope to measure the total power received in a 5MHz band centred on the hydrogen line at 1420MHz. Follow the instructions by entering your username again on the web form (and a password if you wish) for identifying your observations. Then click the button labelled *Equatorial*. This will enable us to pick radio sources from the list under *Target Details* in the Equatorial Coordinates box. Select the radio source 'Cassiopeia A'. This is the remnant of a supernova explosion in our Galaxy and is always visible above the horizon. You can check visibility by clicking on *Target Track* in the navigation bar, selecting the *Equatorial coordinate* button, clicking on the *Cas A* button, and entering today's date. Then click on [Submit](#). You should then see a graph showing the elevation of Cas A above the horizon at Jodrell Bank Observatory during the day.

Leave the next button checked as an *Azimuth scan*. This means the telescope will scan through the target in one axis only, one that is parallel to the horizon. Now select the number of degrees to offset by before the telescope starts scanning. We will use -5 degrees as a reasonable starting value. We also need to say how long we want the scan to take. In effect this sets the scan rate. So for example if we say the *Integration Time* is 300 seconds and we'd asked for a scan starting at -5 degrees then the whole scan will cover -5 to +5 degrees i.e. 10 degrees in total in 300 seconds, so the scan rate is 2 degrees per minute. Select 300 for the *Integration Time*.

Now select the time slot in which you wish the observation to take place. These are every 10 minutes, so either pick the nearest next slot or one sometime in the future (try to avoid picking one in the past!). The time is Universal Time at Jodrell Bank Observatory so you can find out the current time from clicking the [Monitor](#) link in the navigation bar. You also need to say how many 10 minute slots you'll need. You are able to pick more than 1 to ensure a longer observation is completed, but setting this to 1 should suffice, as long as the telescope isn't scheduled to be on the other side of the sky when your observation begins! Then click [Add to Queue](#).

If all the details were correct, a screen will appear saying your observation has been added to the queue. However you must now actively submit it to the telescope for observation. Click on [Show Queue](#). Your observation should appear as status 0 with a red exclamation mark. If you are happy the details are correct you can click on [Submit](#) (entering the password you supplied on the [Setup Obs](#) screen; if indeed you did supply one, otherwise leave password box blank). If something was wrong you can delete it before submission. The observation will now appear in the queue at status 1. If you manually refresh the queue you should see the status change to 2 once the telescope control computer has received the information. It is now just a matter of waiting until the observation takes place.

The Observation

Watch the [Monitor](#), [Skymap](#) and [Webcam](#) when the time approaches for your observation. At the allotted time these should show the telescope slewing towards the demanded coordinates. Note that the telescope will first be sent to the offset position of -5 degrees from the Cas A coordinates. When the telescope pointing error reaches zero, the observation begins. As you watch, the telescope will scan through Cas A from -5 degrees to +5 degrees of its position in the azimuth axis. After about 5 minutes (assuming you set *Integration Time* to be 300 seconds) the Acquisition status will change to *Done* and after some calibration the scan is complete. Refresh the telescope queue to see that your observation has now changed to status 4 and you can click on the *Data* link to see the results. Alternatively, look under the Archive list after the observation completes and click on the [Data](#) link for your observation.

Measurements & Analysis

In the resulting data plot, you should see a scan showing the total radio power rising and falling as the source moves through the beam. If the source is unresolved i.e. a point source, then this effectively maps out the beam shape. The plotting applet allows you to click on a point either side of the peak and subtract a sloping background - the colour of the curve changes from red to blue. You can then estimate the full width of the beam at half the peak power - the half-power beam-width (HPBW) in degrees. Measure it directly from this graph by eye. You can redisplay the original data by selecting the appropriate box. You can also click on the graph and drag out a box to zoom into any region. Click on the 'Fill' button to zoom back out. Make a note of your estimated beam-width for the 7-m telescope.

The expected HPBW (in radians) of a radio telescope is proportional to the ratio of the wavelength λ and the diameter D of the telescope (when both are measured in the same units, e.g. metres). The proportionality constant, η , typically lies between 1 and 1.4 and its exact value depends on the aperture illumination for the particular telescope in use.

Find the value of this proportionality constant from your observations, given that the frequency of observation is 1420.406 MHz and the telescope diameter is 6.4 metres. You may need to recall that frequency ν , wavelength λ and the speed of light c are related by the expression $c = \nu\lambda$, that $c = 299,792,458$ m/s and 1 degree = 0.017453 radians.

The plotting applet can also plot the theoretical beam profile for a uniformly illuminated circular aperture of diameter 6.4 metres if the appropriate checkbox is selected. Select the original data again, click this check box and refit the background. A real aperture tends not to be uniformly illuminated resulting in a slightly larger beam-width and lower 'sidelobes'. Of course, if the actual source were extended then the profile would appear even broader. Compare your scans with the theoretical profile to assess whether this expectation is correct.