WHISP

NEWSTAR-Phase Reduction Cookbook

Dolf Sijbring

May 8, 1998

Contents

1 Prologue to the NEWSTAR Reduction Phase

The objective of the WHISP project is to observe a large number of carefully selected galaxies in the 21-cm line with the WSRT, to reduce the data in a uniform way, and to store the results in a database for general use.
In this cookbook I will describe the procedures by which the WSRT data are reduced and archived using the WHISP uv-reduction C-shell scripts. I do this by following the steps in the reduction with the user's point of view in mind. I will refer to the reduction process that takes place in the NEWSTAR environment as the *uv-reduction phase* of the WHISP process.
This cookbook can be found in the HOWTO directory of the whisp account at the Kapteyn Institute in Groningen.

2 Starting up a uv-reduction session

2.1 First step

The first questions you should ask yourself is: what galaxy do I want to reduce, has it been observed for WHISP and has it not been reduced before?
You can search for all these answers on the WHISP-site (url: www.astro.rug.nl/~whisp/Database/DatabaseStatus/Reduction/reduction.html). Click on the 'List of galaxies to be done' link and search for your favorite galaxy. If it is not in this list, you can go back and click on either the 'List of reduced galaxies (only uv-plane)' or 'List of reduced galaxies' link. The first link shows all galaxies of which at least the uv-reduction has been finished and of which exist uncleaned maps. The second link shows all galaxies which have been fully reduced (i.e. also cleaned maps exist) and analyzed to first order. In the latter case you won't have to do anything, except load the data from tape.
If the observation is in none of these lists, the galaxy has not (yet) been observed for WHISP. Contact the WHISP members with your request.

2.2 Beginning

If the observation(s) of your favorite galaxy is in the 'List of galaxies to be done' list you can proceed with the uv-reduction phase. The first thing you want to do is click on the sequencenumber(s) of the observation(s). This will show you any WSRT comment on the observation(s). Sometimes the quality is too bad to be used. However, if there is more than one observation in the WHISP database, you should also read in the bad data in your SCAN-file in order to remove it from the 'List of galaxies to be done' list. After you have loaded the good and the bad data, you can flag the bad data.
When you have a clear picture of the general quality of your uv-data you can start with the uv-reduction phase.
To do this you login under the whisp account. The whisp account contains the WHISP-site (with database-administration and the WHISP Atlas), the necessary reduction environment (with scripts) and disk space for the reduction of a galaxy observation.
After you logged in you should go to the uv directory under the whisp directory, i.e. type: cd whisp/uv. You can define your own directory here e.g. u11861 and then go to that directory. To be able to use the NEWTAR programs you should first start the NEWSTAR environment with the command: innewstar.
When you have finished your uv-reduction you must copy the desired files to the xy-reduction phase directory by using the xy-reduction phase COLA-scripts (if you want to continue immediately) (also see the WHISP xy-reduction cookbook) and then empty the directory for the next observation.
A matter that needs a bit of consideration is when you have logged in via rlogin. In that case you will have to set the DISPLAY environment variable, otherwise the NGIDS display can not be started.
Now that all preliminaries are set you can start with the uv-reduction.

3 A general view of the uv-reduction process

The uv-reduction process in WHISP consists of six general steps,

1. loading all data
2. self-calibration and quality inspection of the calibrators
3. calibration and quality inspection of the observation(s)
4. making the maps and antenna-patterns at three resolutions
5. storing the SCAN-files and maps on tape
6. administrating the reduction of the observation(s) in the WHISP database

The uv-reduction phase makes use of the NEWSTAR programs. The astronomer is led through the reduction by starting up some scripts, that will present him/her with questions and graphical displays, that will enable him/her to calibrate and edit the radio observations in a manner that he/she sees fit, make maps of the uv-data and, at the same time, riddens him/her from the burden of keeping a detailed administration of all the steps that are taken. *This way the reduction process can be speeded up by a factor 20 or more.* It also enables the astronomer to reduce far more observations than was possible ever before, by lowering the psychological stress considerably. The WHISP scripts bring the position of the radio astronomer on a par with that of the optical astronomer.
It should be remembered, however, that the scripts were meant to be used within the framework of the WHISP program and not for a general usage, therefore some scripts are dealing with extracting information for the WHISP database.
As mentioned before, the astronomer starts up some scripts that will lead him/her through the reduction process. These scripts are modular C-shell scripts. Every module executes a functional task in the reduction process. A functional task is a conglomerate of tasks that, in the eye of the script author, belong together. Every script starts up the next script after it has completed it's task. There are 20 functional tasks distinguished in the uv-reduction phase and they will be described seperately in the next section.
In the middle of the reduction process you can stop, either because you made a mistake or because you want to go home. At the end of every functional task it is asked whether you want to stop now or to continue with the next task. The progress of the reduction is recorded in a file with the name: uvprocess.progress. It simply records the numbers of the tasks that have been completed and some additional information. You can restart the reduction process by running the script:

uv.continue u<ugcnumber>

You can edit the uvprocess.progress file to start at every, meaningfull, position in the reduction process by putting the number of the last task before you want to resume in the file.
Let's go to the real reduction process now.

4 Notes about the individual modular steps

After the astronomer has completed the aforementioned steps, he/she can now start the WHISP uv-reduction process.

4.1 Loading the data

Before you can start the uv-reduction process you must first initialize the NEWSTAR environment. This is done by typing: innewstar.
I will now describe the functional tasks in order.

- uv.start.reductie: to start up a uv-reduction process you start the chain of scripts with the script uv.start.reductie. This task will look in de subdirectory tapes to find all the tapes containing observations of the the galaxy that has been selected. The format of the command is:

  uv.start.reductie <galaxy-name>

  where the format of the galaxy name is the UGC number preceded by a u, so e.g. u11861. You can always type the name of the script without arguments to see the format of the arguments.

  The script will show a listing of all the tapes containing observations of the galaxy and also part of the listing of that tape. It shows e.g.

```
The galaxy u11861 has been found on tape w93003

   5: 9303672 3C48            0 0107 CC NO 930804 0250   23.70761   32.90570
   6: 9303673 UGC3826      1103 1058 NN NO 930804 0405  109.97500   61.78333
   7: 9303675 3C286           0 0029 CC NO 930804 1639  202.20689   30.76631
   8: 9303676 3C286           0 0114 CC NO 930804 1713  202.20689   30.76631
   9: 9303677 UGC11861     1103 1201 NN NO 930804 1835  328.92500   73.01667
  10: 9303678 3C147           0 0054 CC NO 930805 0643   84.68128   49.82856
  11: 9303690 3C48            0 0059 CC NO 930806 0004   23.70761   32.90570
  12: 9303691 3C48            0 0059 CC NO 930806 0105   23.70761   32.90570
  13: 9303695 3C147           0 0101 CC NO 930806 0714   84.68128   49.82856

But also...

The galaxy u11861 has been found on tape dds025

  18: 9404316 3C286           0 0021 CC NO 940810 2038  202.20689   30.76631
  19: 9404317 3C286           0 0042 CC NO 940810 2103  202.20689   30.76631
  20: 9404333 3C286           0 0004 CC NO 940811 1720  202.20689   30.76631
  21: 9404334 3C286           0 0030 CC NO 940811 1728  202.20689   30.76631
  22: 9404335 UGC11861     1103 1201 NN NO 940811 1809  328.92500   73.01667
  23: 9404336 3C147           0 0109 CC NO 940812 0616   84.68128   49.82856
  24: 9404337 3C147           0 0111 CC NO 940812 0727   84.68128   49.82856
```

```
25: 9404338 UGC7766        1103 1201 NN NO 940812 0846  188.37042   28.23972
26: 9404344 3C286             0 0121 CC NO 940813 1318  202.20689   30.76631
```

Here the name of the tape is given in the phrase above the listing. In the listing the first number gives the label on the tape, the second the sequencenumber of the observation and the third column gives the name of the observed object. The name of the object and the tape label number are important for the next step. At the end of the script it will ask whether you want to continue with the task uv.doload to load the data from tape.

- uv.doload: when you answered yes to the last question in the previous task uv.doload will be started. You can also start up uv.doload by typing

  uv.doload <galaxy-name>

  In the following we will assume that you continued from the last task by answering 'y' to the question if you wanted to continue. uv.doload now asks to put in the right tape in the tape drive, so e.g. w93003 and then you will have to give the tape labels for the observation with it's calibrators. So e.g. 8 9 10, no comma seperation. The task will start to load the data from tape in a SCAN-file with the name U11861.SCN.

  If there is more than one observation of the galaxy, you will have to stop after uv.doload has finished and type uv.start.reductie again. Now you can load the data from the second tape e.g. dds025 and give the appropriate tape labels, e.g. 21 22 23.

  You will end up with a SCAN-file containing 4 calibrators and two observations:

```
File description of node U11861:

Created: 06-May-1998 11:38  Revision(1): 06-May-1998 11:57
File contains 768 datasectors in 6 groups


File layout of SCN node U11861 (164484768 bytes):

0.0        :    1 fields *  128 channels *    1 sectors for 3C286
1.0        :    1 fields *  128 channels *    1 sectors for UGC11861
2.0        :    1 fields *  128 channels *    1 sectors for 3C147
3.0        :    1 fields *  128 channels *    1 sectors for 3C286
4.0        :    1 fields *  128 channels *    1 sectors for UGC11861
5.0        :    1 fields *  128 channels *    1 sectors for 3C147
NOTE: Values are maxima, 65 channels means highest channel is 64

     NSCAN$1 is ended at 12:11:33              STATUS=Success
```

  Now that the data are loaded on disk you can proceed to the next general phase starting with uv.1stcal.

4.2 Self-calibration and quality inspection of the calibrators

In this phase we are concerned with the quality of the calibration; we want to arrive at the best possible GAIN and PHASE corrections. That means that we want a good self-calibration solution for every channel and we want to delete any bad data points from the calibrator observation.

- uv.1stcal: you can now continue with uv.1stcal. This script makes a test self-calibration of a channel of the calibrator you selected by choosing a job-number, e.g. 0. If you're happy with the self-cal solutions you can continue with the task uv.docal. If you're not happy with the solution you can leave out some interferometers that you think may cause problems in the self-cal solutions.

- uv.docal: this task simply determines the self-cal solutions for all channels with the same settings that you decided upon in the uv.1stcal task.

- uv.checkdata: after the self-calibration has finished you can display the uv-data on screen using NGIDS (all done automatically). You should resize the size of your NGIDS window in order to be able to display all the uv-channels (the recommended sizes are given by the script). After all data has been loaded, also display a slice window so that you can view the datacube 'from all sides'.

Now you will have to check the quality of the data and flag any data that you think is bad. You first determine in NGIDS the hour-angle, the polarisation and the interferometer that contain the bad data and then you use the program NFLAG to flag the bad data pionts. Next you will be asked if you want to do a self-calibration on another calibrator or want to continue to uv.docopy.

4.3 Calibration and quality inspection of the observation(s)

In this phase we are concerned with the calibraion and quality of the observation(s).

- uv.docopy: this task will copy the GAIN and PHASE corrections, calculated for the calibrators, to the observations. You have to give the job-numbers of the calibrators to copy the corrections from, e.g. 0 2. The script will then search for the job numbers of the observations. If there is more than one observation in the SCAN-file, it will ask: do they all belong to the same calibration-group? If not, you are asked to provide the group.observation index(es), e.g. 1.0 2.0, that do belong to the same calibration group. Following this the calibration corrections will be copied.

- uv.flagshadow: this task will be started up automatically after uv.docopy, since it is a fully determined flagging operation to flag any shadowing effects. It will only be applied if the declination of the observation is below 42 degrees.

- uv.checkdata: after the calibration has finished you can display the uv-data on screen using NGIDS (all done automatically). You should resize the size of your NGIDS window in order to be able to display all the uv-channels (the recommended sizes are given by the script). After all data has been loaded, also display a slice window so that you can view the datacube 'from all sides'.

  Now you will have to check the quality of the data and flag any data that you think is bad. You first determine in NGIDS the hour-angle, the polarisation and the interferometer that contain the bad data and then you use the program NFLAG to flag the bad data pionts. After you have finished the editing of the data you can resume the uv-reduction process by either typing:

  uv.docontinuum2 <galaxy-name>

  or

  uv.continue <galaxy-name>

  This will continue the uv-reduction process and lead you to the next and last quality check, before making the maps and antenna-patterns.

- uv.docontinuum2: this task makes a map by adding (and averaging) 10 channels on the low velocity side and 10 channels on the high velocity side of the observation(s). You have to give the resolution at which you want to make the maps. A 30" resolution is in most cases ideal.

  After Fourier transforming it will show: 1) a cleaned low-velocity map; 2) a cleaned high-velocity map; 3) both the low and high-velocity raw radio continuum maps; 4) and finally the difference maps of the high and low velocity maps of the raw and of the cleaned maps and also the difference map of the antenna-patterns. This will give you a pretty good impression of the quality of the data in the xy-plane. Especially weak central features due to AC or DC offsets become clear in these maps. If you find them you'll have to go back. If not you can now continue to making the maps and antenna-patterns.

4.4 Making maps and antenna-patterns at three resolutions

Finally we get to what is the main goal of the uv-reduction: making the maps by Fourier transforming the uv-data. Most of this task is done in batch mode and can be started up at the end of the day, before going home.

- uv.map-makingback: this task will start up the making of the maps at three resolutions (full, 30" and 60" resolution maps) with their corresponding antenna-patterns. For every datacube only 5 antenna-patterns are made equally spaced in frequency. This is done to save disk space. The antenna-patterns are 4x as large as the maps to be cleaned. This task will take quite some time

- uv.checkmaps: you can resume the uv-reduction process by either typing:

  uv.checkmaps <galaxy-name> [-chans channelrange] [-ap]

  or

  uv.continue <galaxy-name>

  In both cases uv.checkmaps is started up. It displays the the datacube in the NGIDS display. You can choose the resolution of the datacube to be displayed by choosing for the galaxy-name e.g. u11861 for the full resolution map; u11861s30 for the 30" map and u11861s60 for the 60" map. If you want to display antenna-patterns you should add the option -ap.

When you're happy with the results you can proceed to store the FITS-files, needed for the GIPSY reduction phase either on disk or on tape. If you're not happy, you will have to redo either the calibration or the editing of the uv-data.

4.5 Storing the maps and SCAN-file on tapes

In this phase the results of the uv-reduction will be secured for later use. This is the actual build-up of the WHISP-database. Astronomers from all over the world should be able to request these data and the data from the next xy-reduction phase for their research. The WHISP database should serve as a limited HI version of the Palomar Sky Survey.

- uv.fits2disk: the first archiving task that can be run is uv.fits2disk. This task is only necessary if you intend to do the xy-reduction immediately after the uv-reduction. This task will write 6 FITS-files to disk with names file000001.mt, file000002.mt, etc. These files can later on be read in by the WHISP cola-script XYLOAD.

- uv.fits2tape: this task should always be run whether you store the FITS-files on disk or not. It will do the same thing as uv.fits2disk, except that it writes the 6 FITS-files to tape. The tape must have a name like WF0136, see the WHISP reduction document for the format of the tape-naming. Every galaxy has one tape for it's maps.

- uv.scn2tape: after the FITS-files are written to tape, the calibrated and edited SCAN-file is written to a tape with a name like WS0010. On one WS-tape there is more than one SCAN-file stored (do not put more than about 20 SCAN-files on one tape).

Now that the data is safely stored we can proceed to the final task of administrating the uv-reduction in the WHISP-database site.

4.6 Administrating the uv-reduction in the WHISP-database

The administration of the uv-reduction is necessary for both the WHISP-datamanager as the research-astronomer. An easy access to what has been done is important for both.

- uv.fill-in-datasheet: this task automizes most of the data extraction for the administration of the uv-reduction. It also asks some questions about the quality of the data, whether or not interferometers where left out of the self-calibration solutions and whether or not the uv-data of the calibrators or galaxy observations were edited. It will ask these questions per calibrator group. The results are stored in a file uvgal<ugcnumber>.tex that is stored in a central archiving directory defined in the environment variable $uvarchive. It will sent this file to the printer. Finally, it will start up uv.addtolist.

- uv.addtolist: this last task will search in two places defined by the environment variables $globalarchive and $alienarchive for the file uvgalaxylist.txt. It will find the newest version of these two and add information about the uv-reduction of the galaxy to this list. This list can be viewed on the WHISP-database site (url: www.astro.rug.nl/ ~whisp/ Database/ DatabaseStatus/ Reduction/ UV-plane/ make-_uv_list.cgi.

  The uvgalaxylist.txt file is also used to subtract from the list of observations. This is how the 'List of galaxies to be done' is arrived at.

After completing this last task the uv-reduction is finished. You can either continue with the xy-reduction in the GIPSY environment or start the uv-reduction of another galaxy. As a last step you should clean up your working directory by deleting all files.