Editorial

Here is the first edition of the new ASTRON/NFRA Newsletter that we plan to issue four times a year. In both contents and style it will be rather different from the "WSRT Newsletter" that was issued monthly for about 7 years (1979-1986) and the "ASTRON Nieuwsbrief" that appeared a total of 8 times (1983-1988). Both of these newsletters were discontinued because of a lack of time on the part of the editors and because there were vague feelings that they were not considered sufficiently useful to invest precious time into their preparation. The projected readership of this Newsletter is the astronomical community in the Netherlands and those foreign astronomers interested in (the use of) Dutch observing facilities. For the latter a few explanatory words may be in order to inform them about the role played by ASTRON/NFRA in the whole of Dutch astronomy. ASTRON is a Foundation recognized by and financially supported by the Netherlands Organization of Scientific Research (NWO). The (new) ASTRON/NFRA was formed on 1-1-1989 after the merger of the former NFRA (the Netherlands Foundation for Radio Astronomy), which is responsible, among other things, for running the Westerbork Synthesis Radio Telescope, and the (old) ASTRON foundation whose main function was the review, coordination and administration of Ph.D. and post-doctoral research grants. For reasons of continuity, but also to reflect our international involvement the new Foundation will continue under its hybrid name but will generally be known as ASTRON in the Netherlands and as NFRA (Netherlands Foundation for Research in Astronomy) abroad. The spectral broadening of the work of the NFRA in the last decade also led to a small change in the name, as you may have noted. The Newsletter will contain a mixture of regular news items and articles with a technical, administrative or astronomical character. It will contain news about the ASTRON "werkgemeenschappen", or working groups. It will become an important communication channel between the Dwingeloo and Westerbork staffs and users of the WSRT, and will feature articles on (new) astronomical possibilities, holographic measurements of telescopes, calibration procedures, scientific results etc. Further more it will provide you with the various telescope observing calendars and reminders of approaching deadlines. We hope you will find this Newsletter useful and informative. We are open to suggestions, from astronomers in the Netherlands and abroad, on how to improve it. You can approach your favourite editor to effect this.

WSRT

Introduction

Hans Kahlmann

This part of the newsletter is meant to keep the interested reader informed about the Westerbork Synthesis Radio Telescope (WSRT), its possibilities and developments. It is felt that circulating information describing the WSRT will serve a variety of goals. In the first place it will attempt to remove the general lack of information concerning the time application and allocation process. We also wish to inform potential users about the most recent improve-ments in the instrument and on its unique capabilities. Last but not least we would like to make it clear that it is not as difficult to obtain and reduce synthesis data as some people might think.

How to get time on the WSRT

The WSRT is open to observers from all countries and time is awarded on the merit of the scientific program. A guide line for submitting proposals to the program committee (P.C.) of the WSRT can be obtained from the secretary of the P.C. (Dr. R. Braun). The proposals are
critically evaluated by referees (two in general) who may request further information from the proposer(s) (in general the project leader will be contacted). Decisions about time allocations are taken by the P.C. at its meetings. The proposers are notified of the time allocations together with comments on their program. After the notification of the time awarded the observation is done with standard calibration performed, if requested. It than can be reduced in DRAIN or can be written in UVFITs for processing within AIPS.

The instrument

The most recent description of the WSRT is given by Bos, Raimond van and Someren Greve (1981, Astron. Astrophys. 98, 251). Since the Bos et al article, several improvements to the instrument have been realized. The development of the digital continuum backend (DCB), the re-circulating digital line backend (DXB) and the installation of 92 cm front-ends are the most noteworthy amongst these. The DCB expands the total bandwidth to 80 MHz (8 x 10 MHz) at 6 cm and 40 MHz (8 x 5 MHz) at 21 cm. The DXB allows a factor n increase in the number of channels in the correlator for bandwidths 10/n (40,000 channels for 1.25 MHz is a practical limit set by computer capacity). A few characteristics of the present system are listed in the table. The regular spacing geometry of the WSRT means that many interferometer pairs sample identical information. These so-called redundant spacings were not recorded in the early years of WSRT operations, until it was realized that this information could be used to correct for atmospheric and telescope related errors, in a way that is independent of a model of the field observed. Thus, redundancy calibration lends extra power to the well-known self-calibration techniques in use for VLA, MERLIN and VLBI data.

Examples of the kind of programs for which the WSRT is especially well suited are:

- Long wavelength observations: With the WSRT observations at both 49 and 92 cm are possible. This is important for spectral index studies (deconvolving thermal and non-thermal components), observations of steep spectral index sources and very wide field mapping.
- Polarization studies: Since the WSRT uses dipole feeds and an equatorial mount accurate measurements of circular polarization are possible. At 6 and 21 cm the instrumental polarization across the primary beam is very low.
- Line polarization: The line system can record I, Q, U and V simultaneously (for example 21 cm Zeeman observations at high precision are possible).
- Wide field mapping at 6 and 21 cm: Since the standard mode for continuum observations divided the total bandwidth into 8 channels, the effects of bandwidth smearing are reduced to levels that permit accurate work down to the 10 percent level of the primary beam.
- Very high dynamic range mapping.

WSRT scheduling

The availability of a particular observing frequency is determined by proposal pressure. Typically, 6 cm observations are made in late spring, early summer, 21 cm in summer, fall and 92 cm during wintertime. The 21 cm period usually lasts 4 to 5 months. Local WSRT synthesis observations are interrupted 4 times a year for VLBI observations. The schedule is announced in the PC Minutes.

Some WSRT characteristics.

<table>
<thead>
<tr>
<th>wavelength (cm)</th>
<th>6</th>
<th>18*1</th>
<th>21</th>
<th>49</th>
<th>92</th>
</tr>
</thead>
<tbody>
<tr>
<td>freq. range (MHz)</td>
<td>4770</td>
<td>1590</td>
<td>1365</td>
<td>607</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>5020</td>
<td>1730</td>
<td>1425</td>
<td>610</td>
<td>330</td>
</tr>
<tr>
<td>field size (HPBW degrees)</td>
<td>.17</td>
<td>.5</td>
<td>.6</td>
<td>1.4</td>
<td>2.6</td>
</tr>
<tr>
<td>max. bandwidth (MHz)</td>
<td>80</td>
<td>40</td>
<td>40</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>synthesized beam in RA (HPBW in *, 2.8 km baseline)</td>
<td>3.7</td>
<td>11</td>
<td>13</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>continuum sensitivity (r.m.s. in a 12 hour observation, mJy/beam)</td>
<td>.07</td>
<td>--</td>
<td>.06</td>
<td>.6</td>
<td>5*2</td>
</tr>
</tbody>
</table>

*1 - Only 5 (cryogenically cooled) telescope receivers are available at 18 cm.
*2 - This is a theoretical value. (see the article on 327 MHz observations in this issue).

WSRT Program Committee news

Robert Braun

We plan to record in the Newsletter the relevant parts of the minutes from the WSRT Program Committee meetings. At present these meetings are held three times per year; the meetings are known by the year and a running number. Because the PC meetings generally will not phase well with the deadlines of the Newsletter the current PC minutes distribution system will not be changed. The P.I.'s of proposals that have been discussed at the meeting will also be informed in the normal way.

Excerpts from the PC-Meeting 90-1, held at Dwingeloo, March 28, 1990.

- Reduction status.
  The current backlog of uncalibrated WSRT data is 3 months. The large number of line observations from the 21 cm period is primarily responsible for this backlog.
Ionospheric data is currently still being obtained from Hamburg with a 6 - 7 week delay. The hope is to obtain ionospheric data from the military from four stations in Northwest Europe with 15 minutes sampling and only a short time delay. An agreement to this end is being pursued.

- WSRT operations.

The 21 cm period, running from 19 December through 22 January, was used to complete the allocations from PC 89-2 and begin with those of PC 98-3. Three programs with some time pressure from PC 89-3 were completed: W850.1, W909.2 and W1050. Outstanding allocations from PC 89-3 at 21 cm are 20 x 12 hr. prior. 1 and 23 x 12 hr. prior. 2. Data quality in this period was generally quite good. A 92 cm period ran from 28 January through 2 March and from 23 March into April. The basic software to carry out and record mosaic observations with the WSRT is now in place. Various refinements are still in development to improve the move efficiency for short moves and allow robust assessment of interrupted observations. The question was raised whether the PC felt it appropriate to conduct an extended test at this time to demonstrate and debug all aspects of the technique. Approval was given for an extended test for the current 92 cm period.

- Next PC meeting and deadline.

The PC will meet again on 19 September at the WSRT to discuss proposals for observations at 6, 49 and 92 cm. Proposals should be received by noon on 3 September 1990 at the address below to receive full consideration for the upcoming period.

### The archive of WSRT observations

**Ernst Raimond - Ger de Bruyn**

**Introduction**

All observations and calibrations ever done with the Westerbork Synthesis Radio Telescope have been archived. Not only were the data, collected between 1970 and today, stored but also was the standard data processing carried out in a controlled environment. Therefore, the processing is reasonably well documented. In the early years (1970-1979) the data reduction was carried out in Leiden and the archived, calibrated, data of that period still reside at the Leiden Observatory. Since 1979 the data processing was done in Dwingeloo and the archived observations and calibration information are stored there. The storage medium is tape for the bulk of the data. Observations done since early 1990 are stored on optical disk because it is a more permanent and less bulky medium. A program to systematically copy the tape archive to optical disks will be undertaken within the next few months. With this article we wish to restate that data in this archive are available for interested astronomers. Sections below describe which data are available, their sensitivity and other parameters as well as how to explore the archive and request specific data sets.

**Archive research possibilities**

Twenty years of observing have created an enormous data reservoir. An obvious use of this data bank is in the study of variable phenomena (radio stars, active nuclei, supernova remnants etc.). A further use of the archive is in the study of objects that just happened to lie within the synthesized fields. The excellent wide-field imaging capabilities of the WSRT are a great asset in this regard. Many fields were observed with the WSRT with the aim to study a single object located near the centre of the field. In the analysis of the other sources in the field were often ignored. Many serendipitous discoveries have been made in this way and no doubt many more are still waiting to be made. Especially at the longer wavelengths (49 cm and 92 cm) but also at 21 cm the numbers of background sources are very large. Each 92 cm synthesis produces an image with information over an area almost as large as a 48-inch Schmidt plate! (see the related article in this issue) Obviously these fields lend themselves perfectly to statistical research on large numbers of sources. A further use of the archive data is the re-analysis of old data with the new (self-calibration tools developed in the last five years. There are also projects from which the results, for one reason or another, even after many years have not reached the press. And some of those data may never be published because their owners left astronomy or got sidetracked. If they were done more than 2 years ago the data are freely available!

**Availability of the archived data**

NFRA's official policy is that two years after the date of the observation WSRT data are available to anybody interested. Before that time the original proposers of the observations have exclusive access. The relatively long proprietary period (it is one year for some other observatory archives) was chosen because it often takes se-
Figure 1: The sky covered with the WSRT in (uninterrupted) observations of at least 4 hours duration at the wavelengths of 21.49 and 92 cm, since mid 1979 up till the end of 1989. Each ellipse indicates the area covered to the half-power point of the primary beam. Many fields were observed for more than 12 hours, up to 24 x 12 hours in some cases.
veral months before all data for an astronomical project have actually been observed by the WSRT. As a result a good portion of a year may elapse before proper analysis of the data can commence in earnest.

Sky coverage and sensitivity

About three-quarters of the sky is accessible from the location of Westerbork. However, the WSRT being an east-west synthesis array, the declination resolution gets progressively worse at low declinations (by a factor 1/sin $\delta$) and for declinations below the equator the obtainable UV-coverage is limited for obvious reasons. To give you an idea about what fraction of the sky has been observed, figure 1 shows a graph of all (uninterrupted) observations longer than 4 hours duration at the wavelengths of 21, 49 and 92 cm since the middle of 1979 (when the data reduction was transferred to Dwingeloo). To give a potential user of the WSRT archive some idea of the usefulness of a particular dataset, the application in mind we also give a graph showing the nominal sensitivity of the data as a function of time. This graph is shown in Figure 2 where for the four main wavelengths of the WSRT the formal thermal noise level (1-sigma) for a 1 x 12 hour continuum observation is plotted as a function of time. The graph also shows since when a given wavelength has been available. A brief explanatory guide to the improvements indicated in this graph follows:

- In 1974 the 21 cm system temperatures were improved from about 250 to 90 K.
- From 1977.5 on the 6 cm data were taken with a hybrid array with system temperatures of 150 and 220 K for 10 and 2 (4) telescopes.
- In late 1977 two more movable telescopes were added to the array and the Digital Line Backend became operational. This improved the bandwidth from 4 MHz to 10 MHz at 6 and 21 cm, and decreased the 49 cm bandwidth from 4 to 2.5 MHz. N.B. the new dishes were moved to a different location in 1980 doubling the resolution of the array.
- In 1981 the four movable telescopes were equipped with cryogenically cooled frontends creating a hybrid array with at 21 cm a 35/90 K system and at 6 cm a 65/150 K system.
- In 1982 the system temperature of the 49 cm frontends was lowered from 350 to 110 K.
- In 1984 observations at 6 and 21 cm with a considerably wider backend became possible. Normally the 6 cm bandwidth is 8 x 10 MHz and the 21 cm bandwidth 8 x 5 MHz.
- In early 1985 the recirculating buffer for the Digital Line Backend extended the number of obtainable correlation products by a factor of four for the 2.5 MHz bandwidth observations at 49 and 92 cm. This increase has in general been used to yield full polarization data, a large number of redundant baselines and a large number of frequency channels to be less vulnerable to narrow band interference. At the same time the normal mode of correlation changed from 2-bit to 1-bit, leading to a small decrease in the nominal sensitivity.
- In January 1989 the RF bandwidth for the 92 cm system was widened to 5 MHz and the system temperature lowered from about 170 to 130 K.

Exploring the archive

The WSRT archive spans twenty years of observing. Obviously, the techniques of cataloguing observations have evolved over that period. During the entire period lists of the observations and the calibrations have been maintained by the NFRA WSRT reduction group. The most basic mechanism of finding out what was observed is to consult copies of these lists. Since 1979 those lists are available in computer readable form. Recently they were converted into an Observations Catalogue in which the potential archive user can browse and from which he/she can make selections as long as he/she can log into the captive account ARQUERY on the NFRA VAX. As this is a captive account no password is required; on the other hand the account is arranged in such a way that queries are subject to the only possible activity. The interactive archive query program (ARQUERY) was designed by the NFRA for the archive of observations of the La Palma ING optical telescopes. Once you are logged in, you can obtain help on what to do next and you can review what catalogues are available. The current WSRT catalogue is called WSRTOLD. The keywords available to query this catalogue are the ones that were available, rather than a carefully selected set optimal for astronomical use. A new, better designed, observations catalogue will gradually replace the old one in the afore mentioned process of copying tapes to optical disks. Despite the drawbacks mentioned above, one can search for observations by project number, object name, coordinates, type of observation, duration of observation, observing frequency, etc. A user's manual for ARQUERY is available as NFRA Note 537 (identical to the La Palma User Manual No XIX). The NFRA will be happy to supply users with a copy. The program ARQUERY has context sensitive on-line help facility which should enable even the uninitiated user to find his/her way around. In the course of this summer a short primer to the use of the software and the catalogue will be incorporated.

Requesting data

A request to receive data out of the WSRT archive will always pass over the desk of the Head of the NFRA-WSRT reduction group (Dr. Tony Foley). How the request reaches him depends on what data you would like to receive and on the mechanism by which you made the selection out of the Observations Catalogue. For the older observations (before 1979) you may have to make your selection using a paper copy of a list of archived observations. In that case your request will probably be
made by correspondence, by e-mail or by phone to the reduction group directly. If you made your selection using ARCOQUERY you can issue a request for the observations in your final selection. You can accompany this request with comments. At the time of writing this notice you can only get the data on magnetic tape in the internal WSRT tape format. A request for data should be supplemented with information on whether you want (standard) calibrated data, or whether you prefer the raw WSRT data without baseline-based corrections applied. In the latter case you may also wish to receive one or two short calibration observations such that you can process the data with the self-calibration tools in the DWM or AIPS packages. The offered data-format can be used in the WSRT related mapmaking and analysis software, and by using the program WSLD it can, in principle, be used in AIPS. The NFRA hopes to be able to offer data in the AIPS UVFIT format within a few months.

The WSRT at 327 MHz: a status report

Ger de Bruyn

The last addition to the suite of receivers for the WSRT were those for the low frequency band at 327 MHz. The first observations were done in the winter of 1983/1984 and since then 327 MHz has been on the WSRT calendar for a few months every year. The capabilities of the WSRT at this frequency have slowly improved over the years but equally important has been the gain in knowledge about how to optimally observe and process data at this long wavelength of 92 cm. This article is intended to bring users that have data at this wavelength, and those that would like to know its astronomical capabilities, up to date with the current system and the data calibration procedures.

System overview

In the first year of operation the data taking was done with the digital line backend (DLB) with a maximum bandwidth of 2.5 MHz and a limited number of correlation products. Choices therefore had to be made between the wanted number of baselines and the number of polarization and frequency channels. The coming into operation, in March 1985, of the recirculating buffer for the DLB led to a four-fold increase of the number of correlation products. This then enabled the astronomer to acquire data for all four polarizations as well as a large number of redundant baselines while still maintaining a minimum number of 7 or 15 frequency channels. The receiver system temperature, in the coldest regions of the sky, was about 170 K. The formal noise level attainable in a single 12 hour observation - the basic observing mode for the WSRT - was then about 0.9 mJy. Because this was so close to the calculated confusion level for the WSRT 92 cm beam of about 1 arcminute there did not seem to be a strong case for further improvements to the system. However, interesting results in the area of 92 cm line and polarization work led to the decision to widen the RF bandwidth from 2.5 MHz to 5 MHz and lower the system temperature to about 130 K by installing lower-noise amplifiers. These system parameters became effective in January 1989. The available range of frequencies runs from about 320 to 330 MHz, a range that includes the frequency of the deuterium line and w- H and C recombination lines. The current default midband frequency and bandwidth are 326.4 MHz and 5 MHz, respectively. A standard observation will provide both parallel and cross-band polarizations, 15 frequency channels and a considerable number of redundant baselines usable in the self-calibration package.

Data quality

The 327 MHz band has at times been plagued by both narrow and broadband interference from a number of different sources. In order of distance from the array these are internally generated interference, nearby defective TV-antenna amplifiers, relatively nearby military communication transmissions ending with distant TV transmitters (visible during periods of "good" tropospheric propagation conditions). The amount of data that has been lost as a result has over the years settled at a modest 5-10%. For the astronomer the occasional narrow-band, sometimes drifting, interference has proved to be the most cumbersome. If it is present it requires the astronomer to reduce the data channel-by-channel, or at least requires him/her to redefine a new continuum channel during the data-reading stage. The general policy has therefore been to observe with as many frequency channels as possible; the damage due to interference can then be limited by a frequency dependent data flagging. The sun has been a more steady source of interference. But even in this year of the solar maximum the amount of data taken in the daytime that was lost due to solar flares has nevertheless been surprisingly low. Of course, the quiet and slowly variable part of the solar radio emission do result in significant interfering signals (easily a few Jy) on the shortest baselines (less or equal than 144 meters). Such data can generally be dispensed with if the largest angular structures that one wants to study are less than about 10". Projects that require reliable mapping of faint extended, polarized, objects should carefully consider the optimum time of the year to carry out their experiment. Occasionally the data are effected by very fast and erratic ionospheric phase disturbances, up to the point of complete decorrelation within a 60 second sampling interval. Under those conditions wide-field mapping has proved to be very difficult and sometimes impossible.

Map noise levels

For the astronomer one of the most important figures of merit of a synthesis array is the achieved noise level in the image. With the new system the formal r.m.s. noise in a single 12 hour observation has now been reduced to 0.5 mJy as deduced from Stokes V maps. This is equal to the thermal noise level calculated on the basis of the known system parameters. In the continuum this level can not be reached due to confusion from grating rings from the very extensive population of faint background sources. The actual noise levels that have been routinely achieved in fields outside the galactic plane and at declinations above about 30 degrees (to make the beam not too large in the declination direction), are as follows: In 1 x 12 hour one can reach 1.5-2.0 mJy noise levels in 1, 0.5 mJy in V and between
Figure 1: Image of a 2.5 x 2.5 degrees area around the sources 3C211 and 0902+34. The lowest contour is at a level of 6.0 mJy/beam area; subsequent contours increase in steps of a factor of 2 up to the maximum of 3.5 Jy.

0.7 and 1.0 mJy in Q,U (due to the omni-present structure in the galactic polarized background). In multiple 12 hour syntheses the Stokes I noise levels quickly improve to a limiting value of about 0.6 mJy which, we believe, to be the limit set for the WSRT synthesized beam by faint source confusion. This conclusion is supported by the fact that at the edges of the primary beam, where there are fewer faint sources, the map noise levels in I keep on decreasing to values as low as 0.30 mJy in some of the best fields synthesized. If one wants to go fainter in certain interesting areas, one could make use of higher resolution 21 cm and 49 cm observations that can isolate the faint confusing sources.

Data calibration

Although the instrumental gain and phase are extremely stable the images synthesized from the data are strongly effected by phase errors. These originate in the ionosphere and have to be removed via a self-calibration technique. This requires a model for the intensity distribution in the
field. The primary beam width at 92 cm measures 2.6 degrees at half-power intensity and typically a field of 6 x 6 degrees square has to be synthesised in order to locate the majority of the confusing sources. (Cass A and Cygnus A will usually also generate grating lobes in the map, especially when working with narrow frequency channels; these grating lobes can be removed by making small maps at the calculated coordinates of these ultra-bright sources and subtract their response from the data.) Typically the brightest of the background sources in the field has a map flux density of 0.7-1 Jy, there are at least several sources brighter than 0.5 Jy and the total flux density in the 100 brightest sources quickly adds up to about 10 Jy or more. These background sources provide a perfect network to self-calibrate the data. The bulk of these background sources are unresolved for the 1 arcminute beam and their response can be approximated very well by a single source flux and position. The WSRT-style self-calibration system, which involves the determination of telescope complex gain errors followed by an alignment of the successive hour-angle scans (Noordam and de Bruyn, Nature 299, 597, 1982), works very well and fast in these cases. In fact, the author has recently tested a fully automated data reduction procedure. The results are very promising. In fields that are dominated by the response of the background sources, and most fields are, the reduction can be completed blindly in about four hours of time on the NFRA Alliant FX/80. Read your data in at the end of the day and be surprised with cleaned, self-calibrated images the next morning! In the case that there are intense and extended (say 5 arcminutes) sources in the observed field the procedure must be adapted to work with clean components as well as point sources. The advantage of working with point sources is that the effects of radial bandwidth (5/327 MHz) and tangential time smearing can be completely taken out in case the data processing is (can be) done with the full bandwidth. The noise levels in the images made with this automated procedure is better than 2 mJy which means that they can hardly be improved. Figure 1 gives an impression of the inner 2.5 x 2.5 degrees of a field observed for 1x12 hours and processed in a standard way. There is only one snag, common to all internal or self-calibration procedures: the process of self-calibration loses, in an not easily controlled way, information about the absolute intensities and positions. At 92 cm the positions may easily be off by about 10'-15', one quarter of the synthesised beam, and the flux scale unknown to within 20% or 30%. With the help of a calibrator, however, the intensity scale can quickly be recovered. If also arcsecound accurate positions for the sources are required, which usually is not very meaningful with a 60' beam, the whole field can be tied to the position of one source with known position in the area. Such a source is often already known from higher resolution WSRT or VLA observations. Astronomers wishing to make use of this automated procedure, which in the future may be offered as a standard product, should contact the writer.

Flux density scale

The WSRT flux density scale at 92 cm is based on frequent observations of half a dozen objects. They have been observed in a regular sequence in every 92 cm session over the past 6 years. Their fluxes are stable, relative to one another, to about 1%. The absolute flux density scale of the WSRT is tied to the Baars et al. value of 3C286 at all frequencies available. The frequency of 326 MHz, however, is outside the range of validity of the Baars et al. spectrum for 3C286. The extrapolated value for a frequency of 326.4 MHz is 26.93 Jy. On the basis of the WSRT spectra of 3C196 and 3C295 over the frequency range from 5 to 0.6 GHz, and the flux ratios of 3C286 to both of these sources, we have concluded that this 26.93 Jy is in fact a consistent value. We therefore fixed it at 26.93 and derived the following values for the secondary calibrators on the basis of their flux density ratios to 3C286.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Flux Density (Jy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C48</td>
<td>46.11 Jy</td>
</tr>
<tr>
<td>3C147</td>
<td>56.7 Jy</td>
</tr>
<tr>
<td>3C196</td>
<td>49.4 Jy</td>
</tr>
<tr>
<td>3C286</td>
<td>26.9 Jy</td>
</tr>
<tr>
<td>3C295</td>
<td>64.5 Jy</td>
</tr>
</tbody>
</table>

(We note that the values used at the VLA are, on average, about 7% lower than the WSRT value with the exception of 3C286). More about the history of the WSRT flux density scale, including accurate data on the calibrators in use at the various frequencies will be presented in a future edition of the Newsletter.

Primary beam attenuations for the current feed is well approximated by the following formula:

\[ PBA = \cos^4 \theta \text{ where } \theta = \text{frequency in MHz, } r = \text{radial distance in degrees and } c = \text{a constant equalling 0.06290.} \]

Polarization measurements

The excellent instrumental polarization properties of the WSRT are well-known. Especially the off-axis instrumental polarization is very low and permits wide-field searches for polarized sources as well as mapping of very extended polarized sources. Functions to correct for the small amounts of off-axis polarization have been determined and will in the future be implemented in the data-reduction package.

VLBI

Richard Schilizzi

European VLBI Data Processing Facility

Two years ago, the European Consortium for VLBI submitted a proposal to the Commission for the European Communities in Brussels for augmenting the EVN by a 20-station data processing facility as well as VLBA-compatible data acquisition terminals. The review of this proposal led to the funding by Brussels of a feasibility study of tape recorders (see next section), but a decision on support for the overall proposal was deferred. Recently, the Dutch Minister of Education and Science has asked the European Science Foundation to conduct a study of VLBI in the context of other "European" proposals in ground-based astronomy. The results of such a study could lead to a recommendation to the European Community for funding of the VLBI proposal. The first meeting of a high level ESF committee to discuss this will take place in Strasbourg in early July.
The Penny and Giles MkIII A/VLBA Recording System

Penny and Giles Data Systems Ltd (UK) are presently under contract to the NFRA, acting on behalf of the European Consortium for VLBI, to construct a VLBI recorder with a VLBA-standard headstack of their own manufacture, and to interface this recorder to the MkIII A correlator at the Max-Planck-Institute for Radioastronomy using the VLBA protocol. The purpose of this project is to demonstrate whether Penny and Giles can meet the specifications for VLBA-standard recorders, and assuming they are successful, to increase the capacity of the Bonn correlator by one playback station. (A parallel project, based on a Honeywell recorder, is being undertaken by the MPIfR with Brussels support.) The first Critical Design Review of the Penny and Giles project took place in March, the second is planned for early July. The project is expected to be completed by April 1991. Penny and Giles are also prepared to manufacture complete VLBA data acquisition systems.

RADIOASTRON 5 GHz receiver

The Engineering Model of the 5 GHz receiver is nearing completion. The IF unit is being constructed in Dwingeloo and the LNA unit at the MPIfR in Bonn. Funding for this project is being provided by the member institutes of the European Consortium. Vibration and electromagnetic compatibility (EMC) tests of the Engineering Model are planned for September at ESTEC in Noordwijk, and these will be followed by almost six months of "life tests". Delivery of the Engineering Model to the Astro Space Center in Moscow is scheduled for February 1992. Two Flight Models will be constructed in 1991-2.

Dwingeloo

The best ever all-sky HI-survey

Dap Hartmann, Leiden Observatory

We are in the process of observing HI from every direction in the sky. At this moment, observing is in progress using the 25-m Dwingeloo telescope. In the beginning of 1991 we expect to start measurements of the southern celestial hemisphere. These will be made in collaboration with Esteban Bajaja from Argentina. The present measurements at Dwingeloo have suffered from tremendous delays. This was mainly due to the delays in the construction of a new autocorrelator backend. After this instrument was completed, there were still many problems to overcome.
But finally, in the beginning of 1990, the northern part of the
galactic HI survey was begun. The beam of the tele-
scope at 21 cm is 36'. Surveying is done in grid mode, whe-
re a grid of 5x5 deg is observed at a fixed point-separation
of $\Delta \ell = 0.5$ deg and $\Delta \phi = (\Delta \phi / \cos(\phi))$
Each point on the sky is observed for 3 minutes, and some
12% extra time is spent in calibrating the antenna tempera-
ture against a noise-tube of known temperature. The band-
pass is measured for each of the grids at a frequency
5 MHz above the rest-frequency (w.r.t. the LSR). The sys-
tem temperature is in the order of 38K, and the rms noise
in the spectra is better then 0.1K. With a 1024-channel
backend, the chosen 5 MHz bandwidth results in a channel
separation of about 1 km/s, and a velocity range of
[-500, +500] km/s. Due to the shape of the bandpass, the
effective velocity range is limited to [-450, +450] km/s.

In collaboration with Peter Kalberla from MPIfR Bonn,
the survey will be corrected for stray-radiation.
This is accomplished by calculating the amount of stray-ra-
diation from the antenna pattern and the HI sky. Convol-
vning these two maps for a certain position in the sky, at the
time of observing yields a 'spectrum' of the stray-radiation.
This is then subtracted from the original observation to
yield the pure HI spectrum, as if it were observed with a te-
lescope that has no sidelobes. The figure shows a spectrum
at $l=150.5, b=+53$, which is near to where Jay Lockman
(NRAO) identified the lowest column-density in the sky.
After a conversion to the right format, the data was redu-
ced with the beautiful DrawSpec package, which was deve-
loped by Harvey Liszt (NRAO). The spectrum is shown at
the full resolution. It was corrected for the bandpass, and a
3rd order baseline was fitted to the indicated regions.
No stray-radiation correction was done yet.

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Astron

Grants for research projects at universities
Wilfried Boland

ASTRON has a programme to stimulate and initiate astro-
nomical and astrophysical research at university institutes
in the Netherlands. Each year the astronomical community
in the Netherlands is invited to apply for grants that are
available in the next year. In general approx. six proposals
are granted out of the 20-25 requests. At the moment
ASTRON subsidizes 18 Ph.D. student positions and 3 post-
doc positions at university institutes. A Ph.D. student position
will be subsidized for a period of 4 years, a postdoctoral fellowship for 2 years with the option of an ex-
tension for 1 year. The new projects are chosen in a selec-
tion procedure following a peer review procedure.
ASTRON received 22 proposals for grants starting in 1990.
8 proposals were in the field of Sun and Stars, 3 concern In-
terstellar Matter and 11 deal with programmes related to
Galaxies and Cosmology. Due to financial limitations only
4 proposals were allocated, and another 6 were put pro me-
noria on a short list. Projects selected for a start in 1990.

1. De Zeeuw (Sterrewacht Leiden):
"Structure and dynamics of elliptical galaxies".
The grant is for a Ph.D. student for a period of 4 years.
Robijn started the research project on May 1st, 1990.

2. Van Paradis (University of Amsterdam):
"An optical study of X-ray sources in M31". The grant
is for a Ph.D. student for a period of 3 years.
Augusteijn will carry out the project starting fall 1990.

3. Potasch (Kapteyn Laboratory, Groningen):
"Early evolution of planetary nebulae".
The grant is for a Ph.D. student for a period of 4 years.
Oudmaijer will carry out the project starting on September 1st, 1990.

4. Van der Klis (University of Amsterdam):
"A sensitive search for millisecond pulsations in low-
mass X-ray binaries". The grant is for a Ph.D. student
for a period of 4 years. This grant will be cancelled if the
application of a NWO PIONIER grant by
Van der Klis and Verbunt is succesful.
The highest rated proposal on the pro memoria list is
that of Icke, et al. (Sterrewacht Leiden) entitled:

"Origin and physical properties of emission line gas in
active galaxies".

Joint ASTRON/SRON project

The Boards of ASTRON and SRON have decided to joint-
ly subsidize a postdoctoral fellowship for Dr. Eric Smith to
carry out a proposal submitted by Miley entitled: "Space
Telescope studies of extragalactic jets". The fellowship is
for 2 years with an option for a third year.

Invitation to apply for grants in 1991

The Board of ASTRON invites astronomers with a Ph.D.
and a permanent position at a university in the Nether-
lands, within NFRA or SRON to apply for research grants
becoming available during 1991. Applications forms are
available at the ASTRON secretariat.

- Timetable

1. September 1st 1990: Closing date to submit proposals.
The proposals are to be sent to:
ASTRON, Postbus 2, 7990 AA Dwingeloo.
2. Sept. 5 - Oct. 10: Collecting referee reports
   (in writing). Action: chairman and secretary LWG.
3. October 1: Closing date to submit reports of running
   projects and requests for continuation.
4. Applicants will receive copy of referee reports, before
   October 15.
5. Opportunity for written response on referee reports
   15 - 30.
6. November 9: The selection committee will meet to
   review the proposals and to summarize their conclusions
   by drawing up a priority list for proposals requesting a
   Ph.D. student or funds for instrumentation. The best 3
   or 4 proposals requesting a postdoc will be advertised
   to invite postdoc-candidates to apply.
7. The Board will allocate grants after receiving
   information from NWO about the subsidy in 1991.
8. Mid Feb. 1991: The selection committee or a sub-
committee will review the research proposals of the post
doc-candidates and will make up a priority list. Likely
one, possibly two postdoc projects will be granted

Selection procedures

1. A sub-committee will select 2-3 referees for each pro-
posal who will be asked to judge the request on scientific
quality, originality and feasibility. The names of the
referees will be kept anonymous.

2. The applicants are given the opportunity to comment in
writing on the referee reports.

3. In view of the expected number of proposals (ca. 20-25)
it is not possible to enable each applicant to make a
verbal statement about his/her proposal as was common
in previous years.

4. Composition of the selection committee: For the subsidy
grant 1991 the committee will consists of members of the
ASTRON Advisory Board plus three persons appointed
by the national working groups (LWG's).

5. A new element is a separate treatment of proposals
requesting for a Ph.D. student and proposals asking
for a postdoc. Proposals for a Ph.D. student should have
the same format and peer-review procedure as in previous
years.

Proposals asking for a postdoc should be more general,
they should indicate a field of research in the mainstream
of astronomical and astrophysical research in the Nether-
lands that needs additional support to develop new tools
or to start new initiatives. The selection committee will
select 3-5 proposals which will be advertised inter-
nationally to invite postdoc-candidates to submit a re-
search-plan for one of the topics advertised. The final
matching between proposals and candidates will be based
on the qualifications of the applicants, their research plans
and the original proposals.

Space

Optical interferometry in space

Jan Noordam

Space Interferometry has been identified as an area of futu-
re interest in "Horizon 2000", the long-term plan of the
European Space Agency. Recently, an ESA-sponsored
Space Interferometry Study Team (SIST) has proposed a
medium-term strategy for optical interferometry in Space" to
the ESA Astronomy Working Group. Although the full
report will be published in the near future, the conclusions
and recommendations will be briefly summarised here.
They were strongly endorsed by the AWG.

Outline of the SIST report

From the strong scientific case for high resolution imaging
that has been made by others in the past, the report derives
a set of image parameters that are implicitly required by
astronomers. It then establishes that it is unlikely that these
requirements can be met from the ground, due to the
effects of the Earth atmosphere. In space, or from the Moon,
it is possible to use bright (m = 11th) reference stars to
measure and correct instrumental pathlength differences.
Fig. 1 gives an overview of the prospects from the ground
and from space. The report discusses various practical
ways of optical pathlength stabilisation, and looks in some
detail at two possible mission concepts. The first is the so-
called "Fizeau" configuration, which is optimised for the re-
construction of extended objects, but is limited to baselines
of about 10-20m. The second is the so-called "Michelson"
configuration, which can in principle be extended to base-
lines of arbitrary length because it can tolerate quite large
(although slow) physical pathlength variations. But due to its
relatively sparse uv-coverage, it can only reconstruct im-
ages of the complexity achieved by radio VLBI. It is not
necessarily in this stage to choose a particular image recon-
struction technique or array configuration, although a cer-
tain minimum uv-coverage is necessary for the recon-
struction of even moderately complex objects. The latter
means that a long-baseline interferometer with 10-15 tele-
scopes will have to be rotated around its axis, like the
Earth rotates ground-based arrays. Typical observing times
for faint objects will be in the range of 1-5 days. Finally, the
report briefly touches on considerations like orbit (high),
deployable structures (inflatable), telemetry (wide BW),
optical fibres (perhaps), use of the Space Station (not suita-
bale), and the possibility of a balloon mission (expensive).

SIST recommendations

The ultimate object of optical aperture synthesis is micro-
arcsec resolution imaging of faint objects, with an image
quality comparable to that of radio Very Long Baseline
Interferometry (VLBI). In view of the limitations imposed
by the atmosphere, imaging of objects fainter than about
15th magnitude will require an interferometer in space or
on the moon. A 100m class instrument with milli-arcsec

![Diagram of space interferometry configurations]

Fig. 1: Overview of high resolution imaging prospects in the visible. The
limiting magnitudes are for unresolved objects, and a dynamic range of
only 1:1. The sky background limit is taken to be 21 mag per square arc-
sec on the ground, and 23 mag per square arcsec in space. It will gra-
ually flatten for unfiltered apertures. The limiting magnitude, both in
space and on the ground, is expected to decrease towards longer bas-
elines, due to practical limits imposed by realistic integration times.
resolution, and with uv-coverage comparable to that of the VLA, will be an intermediate step of great scientific importance. Therefore, the SIST recommends the following strategy for an ESA Space Interferometry Program:

1. Aim at a 100 m baseline mission around the year 2005, based on the target design parameters listed below. These parameters dictate the choice of a Michelson-type interferometer, along the lines of Mission Concept 2 discussed in the report. This concept can be readily extended to even longer baselines as soon as the efficient control of a cluster of free-flying satellites has become feasible.

2. The SIST recognises the importance of ongoing activities and proposals for space interferometers such as the European HARDI and SIMURIS, and the American OSI, POINTS, BSE and the Next Generation Space Telescope. Although the extendability of these concepts to longer baselines is limited, they have their own scientific and technical justification, such as the imaging of extended or very faint objects (HARDI, NGST), ultraviolet imaging of the Sun (SIMURIS), or astrometry (OSI, BSE, POINTS). Moreover, they include some of the critical technological developments that are required for long-baseline missions, and therefore they provide a significant complement to the preparation and the definition of these missions.

3. The SIST also notes the interest, both in the US and in Europe, to build a large optical interferometer on the Moon. ESA is establishing a study group to consider the European contribution in the scientific exploitation of the Moon, and a proposal such as LOISA could be seen within that framework. The timescales of such a project, 2015-2020 at the earliest, would make it possible for ESA to decide at a later stage whether to join the Moon effort or, if that should be delayed, to press on with a space interferometer. In either case, the preparatory studies and developed technology for the long-baseline space interferometer will be directly relevant. Similar conclusions were reached, independently from SIST, by the US Space Science Board and the so-called "Bahcall committee".

**Target design parameters**

The target design parameters for a long-baseline space interferometer around the year 2005 are the following:

- A single connected structure, as large as is compatible with a single launch, in the range 50-100 m. Ideally, the structure should not deform by more than a few cm's under space conditions, with frequencies well below 1 Hz. Pointing accuracy of the structure as a whole should be better than 1 arcmin.
- A uv-coverage approaching that of the best Earth-rotation radio synthesis arrays, the VLA (27) and the WSRT (14). This implies as many telescopes as possible (but 6 at the very least), and rotation of the array around its axis.
- A synthesised field of view of 100-1000 resolution elements, in both directions.
- A diameter of 30-80 cm for the individual telescopes (tradeoff between collecting area and field of view).
- An overall sensitivity that allows the synthesis of a point-like 20th magnitude object in a 1-3 hours, with moderate dynamic range. (The limiting magnitude depends on object complexity, dynamic range and integration time.)
- A dynamic range of at least 1:100.
- At least 1000 spectral channels, preferably more.
- Sensitivity to visible wavelengths, with a possible extension into the ultra-violet and into the near-infrared.
- Finally, the possibility of 10-100 micro-arcsec astrometry, relative to a bright nearby (Hipparcos) star should be studied.