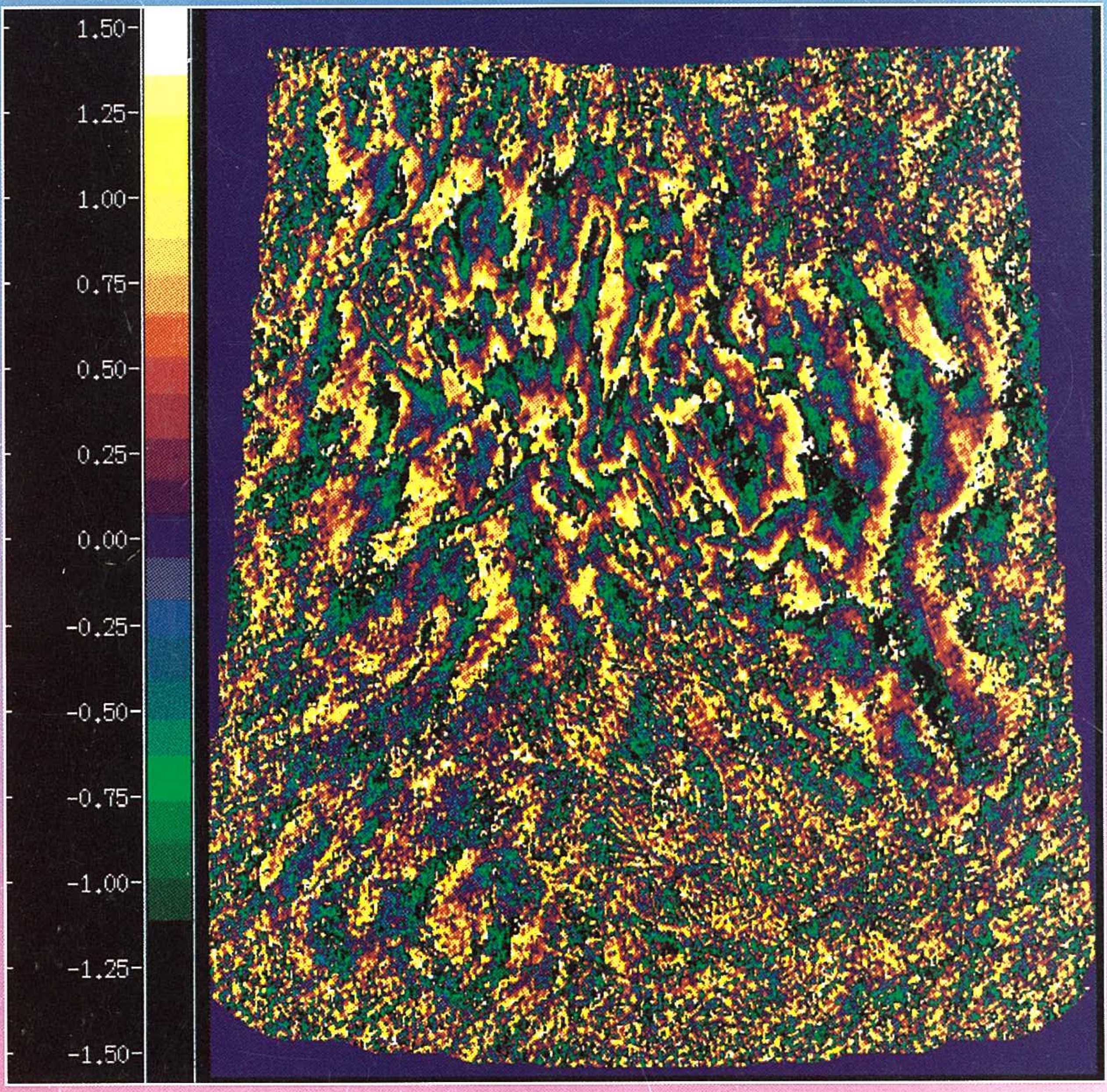
Netherlands
Foundation for Research
in Astronomy

Annual Report 1993



Westerbork Northern Sky Survey

Last year Wieringa et al. (Astron. Astrophys., 268, 215) described their discovery of diffuse polarized galactic radio emission at 325 MHz using the Westerbork Synthesis Radio Telescope (WSRT). This polarized emission shows a wealth of structure, often filamentary, on angular scales ranging from a few arcmin to more than 1 degree. The polarized radio emission has absolutely NO counterpart in total intensity. Yet, the strength and polarized nature of the emission imply that it MUST be due to synchrotron emission! The galactic synchrotron background, which has a brightness temperature of about 35-50 K in the observed directions, is not seen in the WSRT images down to levels of 1 K.
This means that the total intensity is so smoothly distributed that the WSRT (an interferometric array) is not able to detect it. On the other hand, the polarized emission, with its small-scale structure, is detectable with an interferometer and in places reaches brightness temperatures as high as 10 K. We concluded that the small-scale structure that we observe in the linearly polarized emission must arise as a result of Faraday rotation modulation of a smooth, intrinsically very highly polarized, background. This FARADAY SCREEN must therefore also have structure on that scale.

Recently, we have begun analyzing the 92 cm polarization images made from the Westerbork Northern Sky Survey (WENSS) in the region from l = 150-180° and b = 10-40° which includes one of the areas imaged by Wieringa et al. These WENSS images reveal spectacular patterns of polarized emission with brightness temperatures ranging up to 10-15 K. The cover shows the polarization angle of a mozaic which approximately covers the area from longitude 160-180° and latitude 40-50°. The data have been smoothed to a resolution of 4'.

These WENSS polarization images show that the Wieringa et al. results are quite representative and that we are about to unravel a hitherto unknown component of the magneto-ionic medium. Interferometric radio polarimetry at low frequencies is the most sensitive diagnostic of the distribution of the thermal (warm and hot) ionized interstellar medium and the magnetic field structure on scales down to a (fraction of a) parsec! The combination of very high sensitivity, high-resolution (down to 1') and panoramic view makes this a truly unique new tool.

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Contents

Report from the Board

Major issues for the Board in 1993 were (i) completion of the reorganisation of the NFRA's Institute in Dwingeloo; (ii) development of future plans for a new large project for Dutch astronomy; (iii) plans for the integration of personnel and equipment from the Kapteyn Sterrenwacht Werkgroep in Roden (a collaboration of the astronomy institutes in Groningen, Leiden and Utrecht) with NFRA's Institute; and (iv) development of a new strategic plan for the Foundation for the years 1995-1999.

Reorganisation

One of the members of the Board (Ir. C. Kramer) has made an evaluation of the reorganisation NFRA has gone through in 1991-92. This evaluation showed that much of the reorganisation has served its purpose and had the results the Board had expected beforehand. Some details still need some attention but overall the Board is pleased with the positive reactions of the people involved. The evaluation was based on several interviews and discussions with personnel of the NFRA institute and has proven to be very fruitful. In this respect it has been said that instituting a special portfolio or area of interest for each of the Board members could lead to a more closer interaction between the Board and the work done at the institute.

Future Large Project

In the fall of 1993, a decision was reached by the Board on a future large project for NFRA. It was the result of a two-year discussion in the Dutch astronomical community, which began with a request to the Landelijke Werkgemeenschappen to provide their vision of the future of Dutch astronomy in their field of interest. These committees recommended that NFRA should undertake a large instrumental project, probably as an international collaboration, that would provide the next generation of Dutch astronomers with forefront and if possible unique opportunities for research. Each committee also recommended one or more particularly interesting possibilities for such a project. In the first months of 1993, the NFRA Advisory Council narrowed the projects to be considered to three:

(1) Participation at roughly the 50% level in a northern 8-m class optical/infrared telescope. This facility would allow Dutch astronomers to work at the forefront of both optical and infrared astronomy in both hemispheres (the ESO VLT providing the southern coverage). An optimized infrared capability is seen as particularly likely to be of major importance in several fields of astronomy in the coming decades.

(2) Participation as a driving partner in an international decimeter radio telescope with a collecting area of one square kilometre (roughly 20 times the collecting area of the Arecibo or GMRT telescopes). Such a telescope would be unique. It would not only have the continuum sensitivity to make the study of all kinds of stars possible for the first time with radio techniques, but next to that would permit study of neutral hydrogen in galaxies back to the suspected epoch of galaxy formation.

(3) Strive for a uniquely strong position in the world with regard to the techniques of imaging through interferometry. Participation in several projects would then be possible, the common thread of which is application of the techniques of interferometry to provide the highest possible spatial resolution in a wide range of spectral regions. This proposal suggested that we participate at a 5%-10% level in the ESO VLTI development programme for an earth-rotation synthesis facility at optical/IR wavelengths, at the 5% level in a southern European milli-meter array instrument, and in addition extend the WSRT with a north-south arm so that southern sources could also be well observed from Westerbork. Our participation in the optical/IR and millimeter telescopes would likely include development of the necessary very high speed digital correlators as well as general infrastructure and possibly other backend instrumentation.

These three proposals were discussed at a National Discussion Day, September 20, which was attended by a major part of the Dutch astronomical community. Following this discussion, the NFRA Advisory Council was asked to consider all available input on the scientific and socio-political aspects of possible projects and to make a recommendation to the NFRA Board. It was agreed that any one of the three projects would be exciting and deliver excellent science. One or the other might provide a better basis for the training and research of future generations of Dutch astronomers, or be easier to organize locally or to obtain the political and financial support necessary. The Advisory Council felt, however, that participation in a large optical telescope, given the present construction at ESO of the VLT, should receive low priority. The NFRA Board then considered what a large project would mean for NFRA and for the community, both during the next few years and beyond the turn of the century. The Board decided that NFRA will in parallel look into the possibility of the construction of a square kilometer radiotelescope and investigate a possible participation in a large mm-array project.

Joint Institute for VLBI in Europe (JIVE)

On 9 June the Joint Institute for VLBI in Europe (JIVE) was officially inaugurated by

Ir. R.J. de Wijkerslooth on behalf of the Minister of Education & Sciences. In october the State Secretary, mr. M.J. Cohen, again showed the interest of his department with a visit to the both Dwingeloo and Westerbork.

The opening of JIVE brings new people and possibilities for NFRA. Office space and computer access had to be found for a Fellow and several support scientists as well as for visitors coming to JIVE for help and support with preparing and reducing VLBI observations. In addition, JIVE became a coördination center for many activities of the EVN. The additional load on NFRA Institute staff, especially as regards visa's, work permits, financial and personnel management and so on, increased noticeably but was carried out with characteristic enthusiasm and thoroughness. More problematical will be test and storage space for the EVN correlator hardware when it starts to arrive in Dwingeloo early in 1995.

State Secretary mr. M.J. Cohen visits NFRA

Kapteyn Sterrenwacht Werkgroep

Integration of the Kapteyn Sterrenwacht Werkgroep with NFRA will be an important topic in the coming years. This integration will serve a better coordination and more flexibility where instrumental programmes are involved. Starting in about 1997 part of

KSW non-scientific personnel will be transfered to NFRA, first on the basis of secondment and later, if financially possible, as employees of NFRA. The financial arrangements for the operation should make the integration cost neutral for all parties, and will include exchange of manpower obligations at the island observatories, La Palma and Hawaii, for KSW personnel.

Portfolios

Starting 1993 Board members each have their own field of interest to ensure an efficient flow of information to the Board. Each Board member will have a responsibility on his own topic. Next to that a second Board member can be contacted for consultation. The portfolios are as follows:

Portfolio	Primary responsible	Secondary responsible
UK/NL cooperation; relations with NOVA, SRON and KSW	Prof.dr. P. van der Kruit	Prof.dr. J.van Paradijs
Stellar astronomy, pulsars	Prof.dr. J. van Paradijs	Dr. F. Israel
(Extra)galactic astronomy	Prof.dr. R. Sancisi	Prof.dr. J. Kuijpers
Project- and programmesubsidies; schools and practica in Dwingeloo	Prof.dr J. Kuijpers	Prof.dr. R. Sancisi
Science support; Programme Commitee; Newsletter en public relations	Dr. F. Israel	Prof.dr. P. van der Kruit
Policy and long term planning; personnel and financial affairs	Ir. C. Kramer	Dr. R. Hoekstra
Projectmanagement and management-information; optical instrumentation	Dr. R. Hoekstra	Ir. C. Kramer

Forward Look Planning

Forward look planning at NFRA occurs with a two year cycle, alternate years focussing either on investment needs or on the whole programme plan for the coming five years. In the fall of 1993 the programme plan for the period 1995 - 1999 was discussed and decided. The principle lines of this programme are to complete the upgrade and maintenance of the WSRT by mid-period, and to begin preparations for participating in a next generation radio telescope in earnest in the latter half of the plan period. Financing for this programme is uncertain, as indeed is financing for completion of current NFRA projects.

Westerbork Synthesis Radio Telescope, the Netherlands

Dark matter and neutral hydrogen in spiral galaxies: the WHISP Programme

Renzo Sancisi

The observations of the 21-cm emission line of neutral hydrogen with the Westerbork Synthesis Radio Telescope have provided crucial evidence on the presence of dark matter around spiral galaxies. They have also significantly contributed to the study of the dynamics, formation and evolution of disks and of the effects of the environment. WHISP (Westerbork HI Spiral galaxy Project) is the program designed to provide the observational data base for the extension of such studies to a large sample of spiral galaxies representative for the universe at low redshifts.

Dark Halos

Spiral galaxies consist of a visible disk surrounded by a more massive and extended dark halo. This is the generally accepted picture, observationally supported by 21-cm line rotation curves. The Westerbork Synthesis Radio Telescope (WSRT) has played a central role in providing the basic radio data.

The method and the observational steps are well known. From the 21-cm line observations the density distribution of neutral hydrogen (HI) and the velocity field are obtained. From the latter, assuming that the gas moves in circular orbits, a rotation curve is derived. The standard procedure and analysis technique is illustrated in figure 1 for the spiral galaxy NGC 5204 studied by Verheijen. Generally the HI extends, as in the case of NGC 5204, much beyond the optical boundaries of a spiral galaxy and the rotation curve can be traced very far out in radius, in the best cases up to 10 or more disk scalelengths. This is the greatest advantage of radio observations as compared to optical line observations.

The measured rotation curve is compared with the rotation curve expected under the assumption that the distribution of the mass follows that of the light. In general, a large discrepancy is found between the two curves, particularly in the outer regions: the observed curve is approximately flat out to the outermost observed point whereas the curve expected from the visible disk has a, nearly keplerian, dropoff. This has led to the conclusion that the mass of a spiral galaxy is dominated by visible stars in the inner parts and by a massive dark halo in the outer parts (see review by Van Albada and Sancisi 1986).

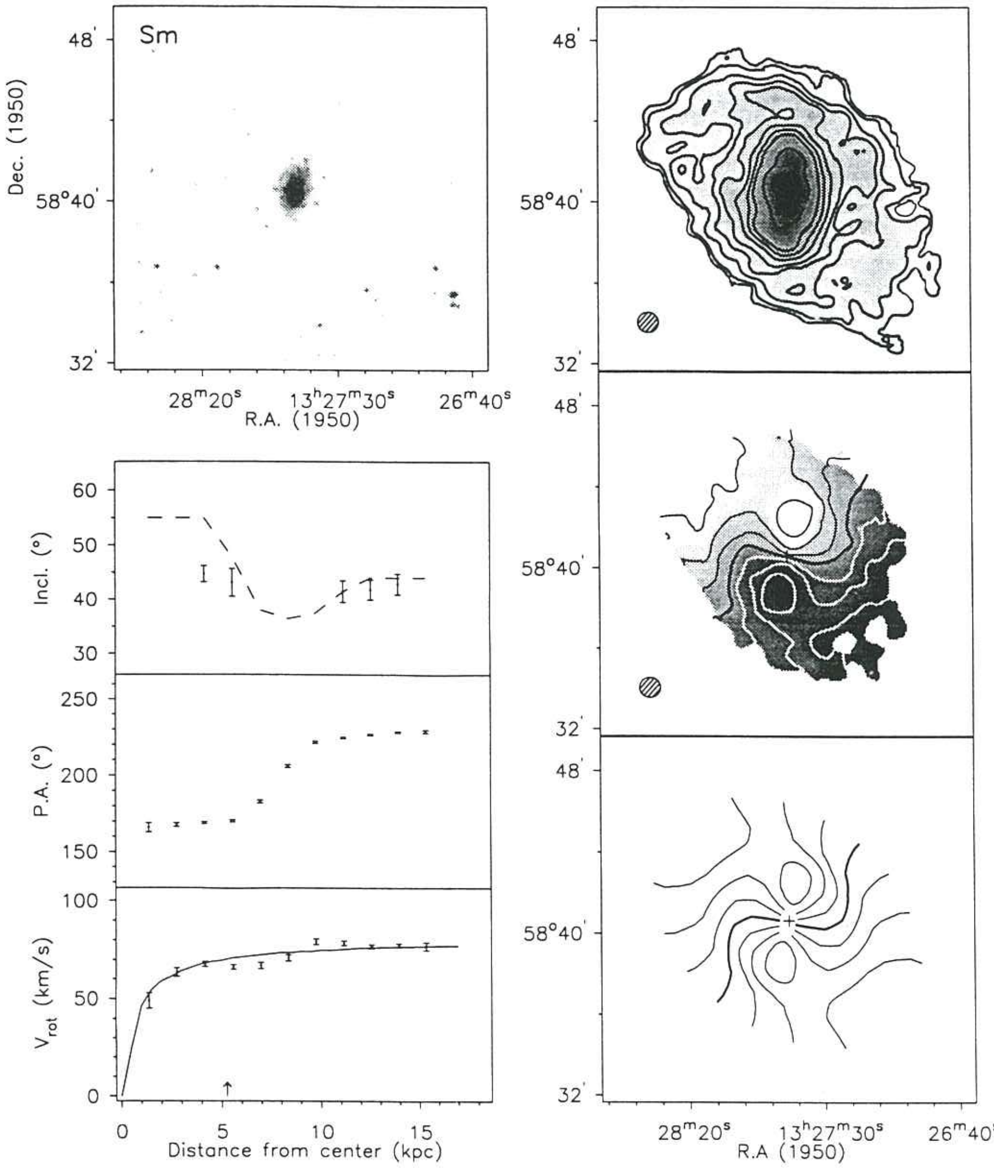

Figure 1 NGC 5204. *Upper left*: Optical image from the blue POSS plate. *Upper right:* Total HI map (same scale asthe optical image). Contour values are 0.51, 0.85, 1.7, 2.6, 3.4, 5.1, 6.8, 8.5, 13 and 17 x 10^{20} atoms cm^{-2}. The 60" beam is indicated by the shaded circle. *Middle right*: The observed velocity field. The thick contour shows the systematic velocity of 200.3 km s^{-1}. The contours are seperated by km/s. The white contours indicate the receding side. *Lower right:* The model velocity field derived by fitting tilted rings with constant circular velocity to the observed velocity field. *Lower left:* Three panels showing the variation of inclination, position angle and circular velocity as a function of distance from the center. The vertical arrow in the lower panel indicates D_{25}.

The high quality, flat HI rotation curves now available for about 25 spiral galaxies give the most secure observational evidence for the presence of dark matter in the universe. A representative sample of rotation curves for galaxies of different morphological types is shown in figure 2.

The study of dark matter in spiral galaxies is still going on at present. The difference between observed and predicted rotation curves and the derived discrepancy between the conventional dynamical mass and luminous mass of spiral galaxies is a firmly established observational fact. But various other old and new questions and issues are still open and a matter of dispute.

If one takes the conventional view that the masses of galaxies are dominated by dark halos the main questions arising are:
1) How massive and extended are such halos?
2) What is their density distribution?
3) What is the shape of dark halos? Are they spherical or flat?
4) What is the relationship between dark and luminous matter? Does it depend on luminosity, morphological type and environment?

The hope is that answers to such questions will help to understand how dark halos were formed in the first place and whether they are made of baryonic matter. Moreover, there is also the possibility that Newtonian mechanics or gravity may fail for scales of galaxies. Alternative interpretations to the dark halo hypothesis have been discussed (see review by Sanders 1990) and, indeed, the modified Newtonian dynamics (MOND) has been shown to provide in general a satisfactory phenomenological description of the observed discrepancies.

Stars, gas and dark matter

In the standard picture a flat stellar disk and a more or less spherical halo conspire to produce, as a rule, a flat rotation curve. This suggests a tight coupling between dark and luminous matter. Over the years this has remained a major puzzle although the picture has somewhat evolved. It has been noticed that rotation curves are not featurless and not always perfectly flat. Their shape, i.e. the distribution of matter, has been found to depend on luminosity and morphology. The relative contribution of dark matter is much greater in low luminosity than in high luminosity galaxies. It has also been found (Casertano and Van Gorkom 1991, Broeils 1992) that spirals with declining rotation curves outside the optical radius all have centrally condensed light distributions. The shape of the mass distribution outside the optical radius is closely

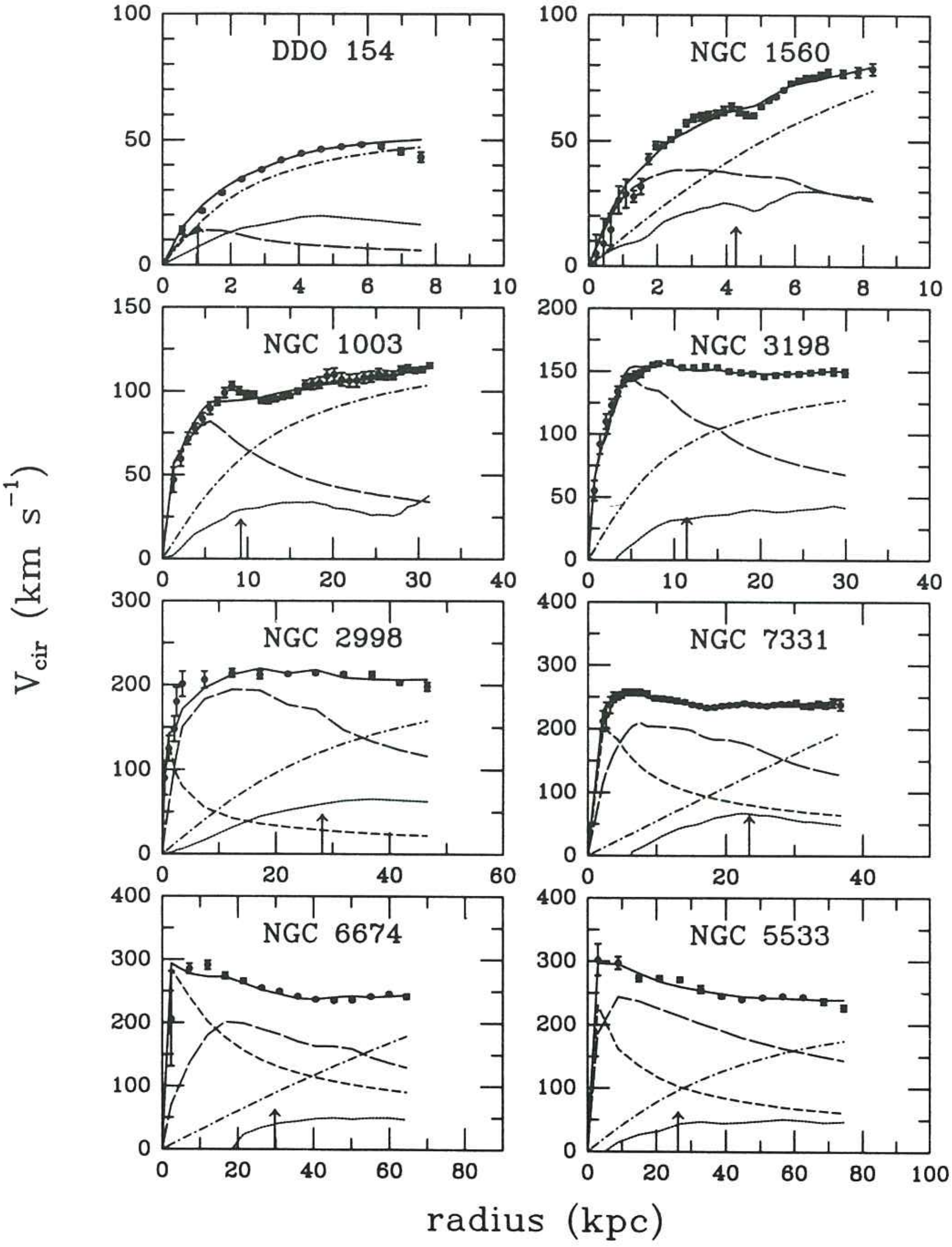

Figure 2 Maximum-disk fits (solid curves) to the observed rotation curves (dots) of eight galaxies, ordered by the amplitude of the rotation curves. The rotation curves of the individual mass components are shown: dotted line for the gas, long dash for the stellar disk, short dash for the bulge, and dash-dot line for the dark halo. The arrow indicates the optical radius R_{25}. The plots show a decreasing influence of the halo with decreasing influence of the halo with increasing V_{max}.

related to morphology and luminosity. This confirms that there exists a close link between the dark halos and the luminous parts of galaxies, as suggested originally, and seems to point to a baryonic nature of the dark halo matter.

Is there also a close coupling between dark material and neutral gas? There are two results which are suggestive in this respect. One is that in each individual galaxy the HI and dark matter components have very similar radial distributions, whereas the luminosity profile has a totally different shape. The other is that the relative total amounts of HI gas and of dark matter do not seem to depend on morphological type (cf. Broeils 1992), whereas the masses of both HI and dark matter components increase significantly from early to late type galaxies. These results seem to suggest a close connection between the neutral gas and the dark material and point, perhaps, at a baryonic nature and flat distribution of the dark component.

Current and future work with the WSRT

The study of dark matter in spiral galaxies has occupied a prominent place in the 21-cm spectral line work with the WSRT. In this a number of PhD research projects, some of which supported by NFRA, have played a crucial focusing role. After the pioneering studies of Bosma (1978) and Wevers (1984), the observational effort was pursued with increased sensitivity and more refined analysis techniques. Begeman (1987) derived high quality (Class I) rotation curves for a small sample of carefully selected spiral galaxies (e.g. NGC 3198) and established beyond any doubt the need for dark matter. Broeils (1992) extended the study to a larger sample of galaxies over a wide range of luminosities and morphological types and contributed decisive evidence showing that the relative amount of dark matter increases with decreasing luminosity and from early to late types.

At present Sicking is making a detailed investigation of a few selected spirals to determine the shape of the halos, Rhee is studying the Tully-Fisher luminosity-velocity width systematics for a large sample of galaxies and Verheijen is investigating the Tully-Fisher relation and the dark/luminous matter properties for a complete sample of spiral galaxies in the Ursa Major cluster. Parallel studies with the VLA in these recent years have brought important new information on a few late-type low-luminosity galaxies (e.g. DDO 154), on the extent of halos (NGC 3198) and on the systematics of rotation curves (e.g. declining curves).

All these various studies, based on a small number of carefully selected objects, had an exploratory character. It has become clear now that significant progress in our knowledge of dark matter in galaxies can be achieved only by a major effort with a drastic increase of the galaxy sample. A wide range in luminosities and morphological types must be covered. The construction of such a sample is the primary goal of the large Westerbork HI Spiral galaxy Project (WHISP) started by Van Albada and coworkers. The aim is to observe about 1000 of the brightest galaxies (blue diameter > 2 arcmin) at declinations higher than 20 degrees, and, so far, about 100 have been observed. For a success in this survey work the major instrumental requirement is sensitivity. It is essential that the system kinematics can be traced with high signal/noise as far out as possible in galactic radius.

For the interpretation of rotation curves good photometry is also indispensable. The comparison of observed rotation curves with the expected rotation curves for the stellar disk has been the decisive method that has led to the conclusions about the discrepancy between dynamical and luminous mass. Multicolour CCD photometry is available for a large number of galaxies or is being obtained in separate programs.

In addition to the main line of research on dark matter via the derivation of rotation curves, the WHISP data base is important for a number of other studies. Some of these are closely related, as they deal with the structure and kinematics of the HI layers. Others concern the interaction with the environment and bear on the formation and evolution of disks.

Structure and dynamics of disks: asymmetries, warps and HI halos

It has been clear from the early HI observations that large asymmetries in the HI distribution and kinematics exist in spiral galaxies, and recently it has been shown that they are not a few unusual exceptions but instead are quite common. As one of the most striking examples we show in figure 3 the lopsided HI picture of M101. Their high occurrence rate and the fact that they also seem to be present in the old stellar disks suggest that asymmetries are long lived. Furthermore, the HI density and velocity maps suggest that the lopsidedness is not a minor but a large-scale, structural distortion affecting the whole disk. It may have been imprinted at formation or result from interactions and accretion in the past. Whatever its origin and the history of the galaxy, it must now contain information on the mass distribution and dynamics of the system and in particular on mass, shape and extent of dark halos. It is, therefore, important to study the phenomenon of lopsidedness on a large sample of objects and determine its systematic behaviour. In this respect it is also necessary to construct realistic models of non symmetric disks.

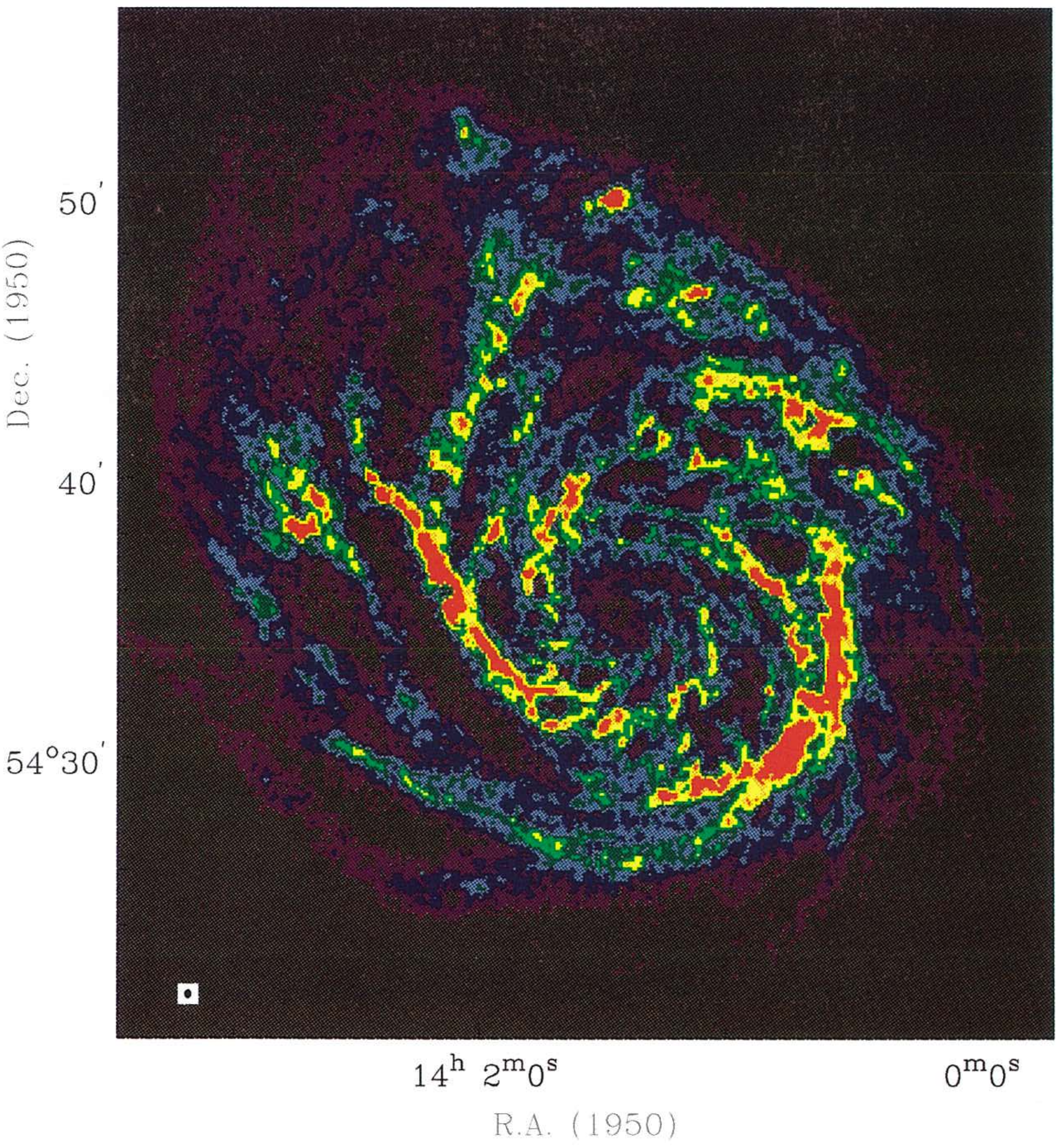

Figure 3 HI map of the nearby spiral galaxy M101.

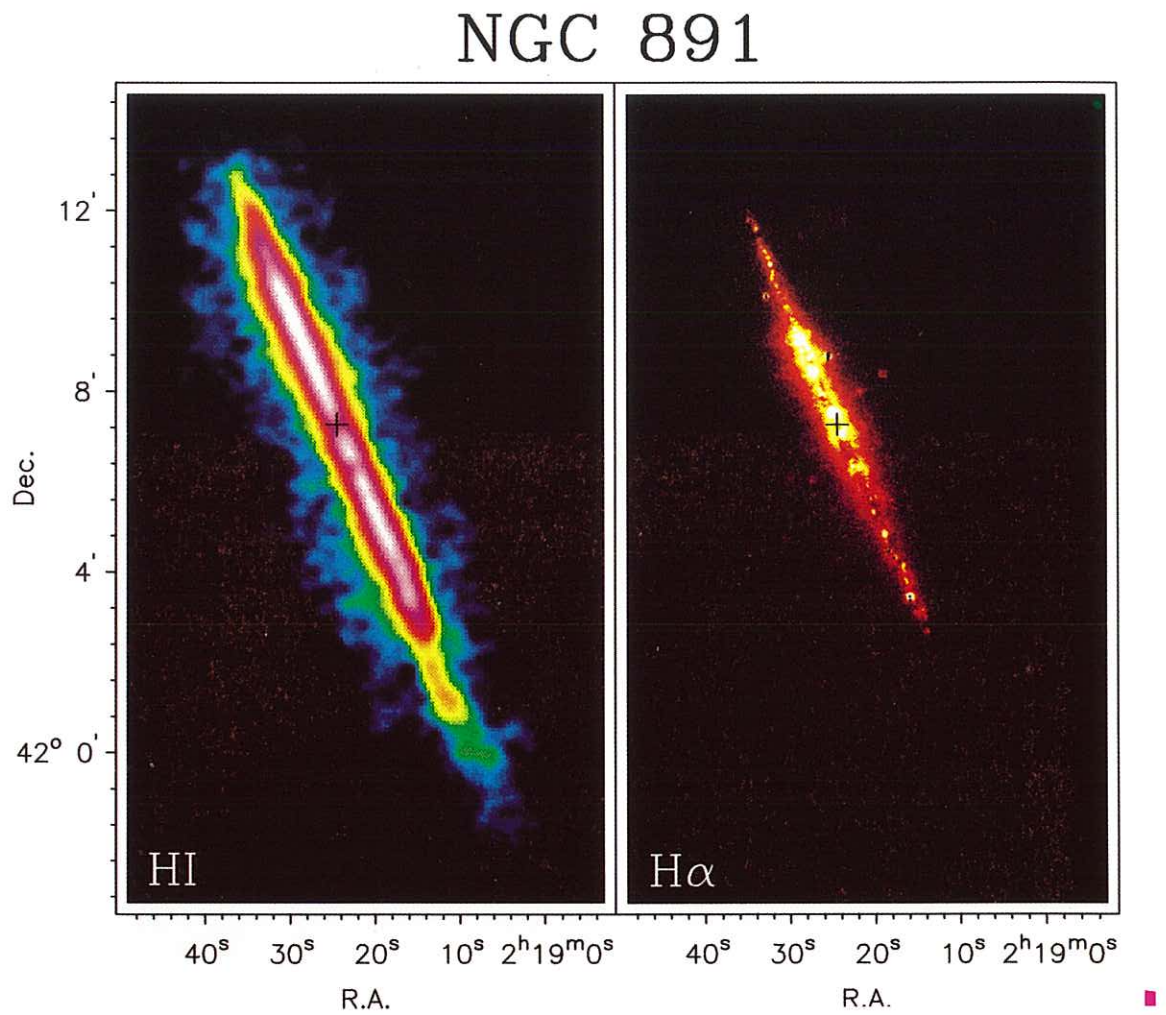

Figure 4 The edge-on galaxy NGC 891. The cross marks the centre of the galaxy. The HI map (20" beam, 1'=3 kpc) shows a thick neutral gas layer extending to about 6 kpc above and below the plane .

The detailed vertical distribution of neutral hydrogen in spiral galaxies is known only for a small number of objects. Warps in the outer parts of the HI layers seem to be the rule as they are seen in the HI density maps in most of the edge-on galaxies observed and are inferred from the velocity fields of less inclined systems. They still form an interesting puzzle.

The presence of HI gas in the halo region of galaxies has not been well studied yet, mainly because of insufficient sensitivity. The best case investigated in detail so far is that of NGC 891 which is nearby (~ 10 Mpc), is almost perfectly edge-on and is not significantly warped. The HI map of this galaxy (figure 4), obtained by R. Swaters after 12 x 12 hours integration with the WSRT, shows a gas layer with extended, faint wings on both sides. The interpretation of these high latitude features is still uncertain and it is not at all clear that they are due to an outer flare of the HI layer as was proposed in earlier studies. Such observations are not only of great interest for the study of the gas in the halo but are also crucial for the determination of the vertical distribution of dark matter.

The effect of environment: interaction and accretion

From the HI line observations collected in the past 20 years with the WSRT and 10 years with the VLA for an increasing number of objects an "HI picture" of spiral galaxies is beginning to emerge. The density and velocity structures of HI allow us to distinguish between "internal" phenomena, related to processes in the disk (e.g. star formation) and "external" effects due to the interaction with the environment. A tentative classification based on HI morphology and kinematics can already be made. It has become clear in this way that a large number of systems are heavily disturbed by strong tidal interactions. Well-known examples are the Antennae, the M81-M82-NGC3077 and the NGC4656-NGC4631 groups. But also an increasingly larger number of systems are being found which are experiencing a softer kind of interaction with small companions or show peculiar structures which may be relics of such events in the recent past. These cases are about one quarter of the number of objects mapped in HI so far. They indicate that episodic accretion of gas in galaxies is indeed taking place even at present and suggest that such infall may be playing an important role in feeding the disk with fresh material from outside. The best examples of such events are those of M 101, NGC 628 and NGC 3359 (see figure 5). Because the sample of spirals used for this study is affected by several biases and incompleteness, a better and more quantitative estimate of the frequency of infall events has so far not been possible. A large sample of spiral galaxies with HI maps, as WHISP will provide, is ideal for such a study.

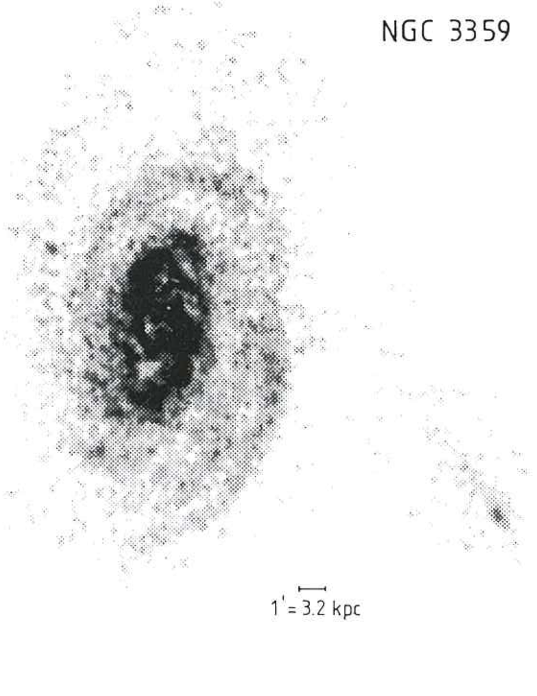

Figure 5 Grey-scale map of the total HI column density distribution of NGC 3359. The column densities range from 5×10^{19} cm^{-2} (white) to 2.5×10^{21} cm^{-2} (dark). The resolution is 30"x30" (~1.6 kpc). The small companion and the bridge are visible on the right.

Scientific outlook and cosmology

A number of spiral galaxies have been observed in the 21-cm HI line with the WSRT in the past twenty years. They have been selected for specific studies. These observations have uncovered many new facts and have significantly contributed to our knowledge and understanding of galaxies. One of the main limitations has been the necessary restriction in this pioneering stage to a small sample of nearby galaxies, mainly for reasons of sensitivity. Reasons have been given above for a substantial increase of the number of objects with HI data and for the creation of a more representative sample. This has become possible now thanks to technological developments and improvements of receiver sensitivity in recent years.

There are now exciting developments in the study of systems at large distances which also give a new perspective to the work which is going on for nearby objects. Detailed studies of the structure and dynamics of galaxies out to redshifts of 0.2 - 0.5 have become possible at optical and infrared wavelengths. The effects of evolution with time are being investigated. The presence of dark matter in such distant galaxies can be tested. These developments add interest, for an understanding of the observations of the systems at high redshift, to a substantial increase of the sample of objects nearer to us. In this view the creation of a representative "Shapley-Ames" sample of galaxies with detailed HI data, as envisaged by WHISP, is a necessary and urgent undertaking.

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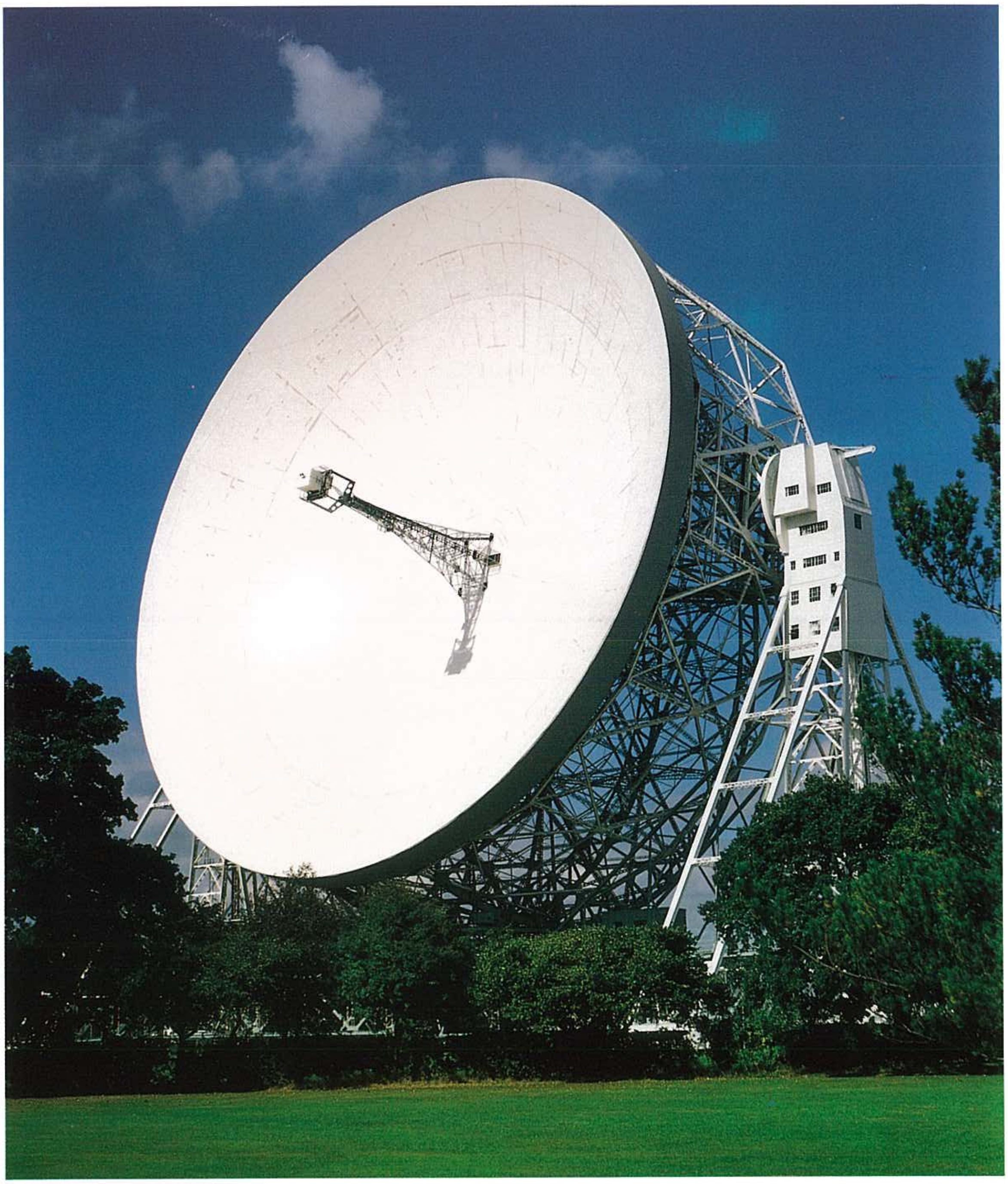


Jodrell Bank, United Kingdom

The Leiden/Dwingeloo survey of galactic HI at $\delta \geq -30°$

The Leiden/Dwingeloo survey of galactic HI, which has occupied the Dwingeloo 25-meter telescope full-time during the past several years, has been completed by Hartmann and Burton. The new material provides 21-cm coverage of the entire sky at $\delta \geq -30°$ on a 0.5° grid, over a velocity range of 1000 km/s at 1 km/s resolution. The Leiden/Dwingeloo data improve upon earlier material by about an order of magnitude in spatial and velocity coverage, and in sensitivity. The important stray-radiation correction is being applied in collaboration with Kalberla (University of Bonn).

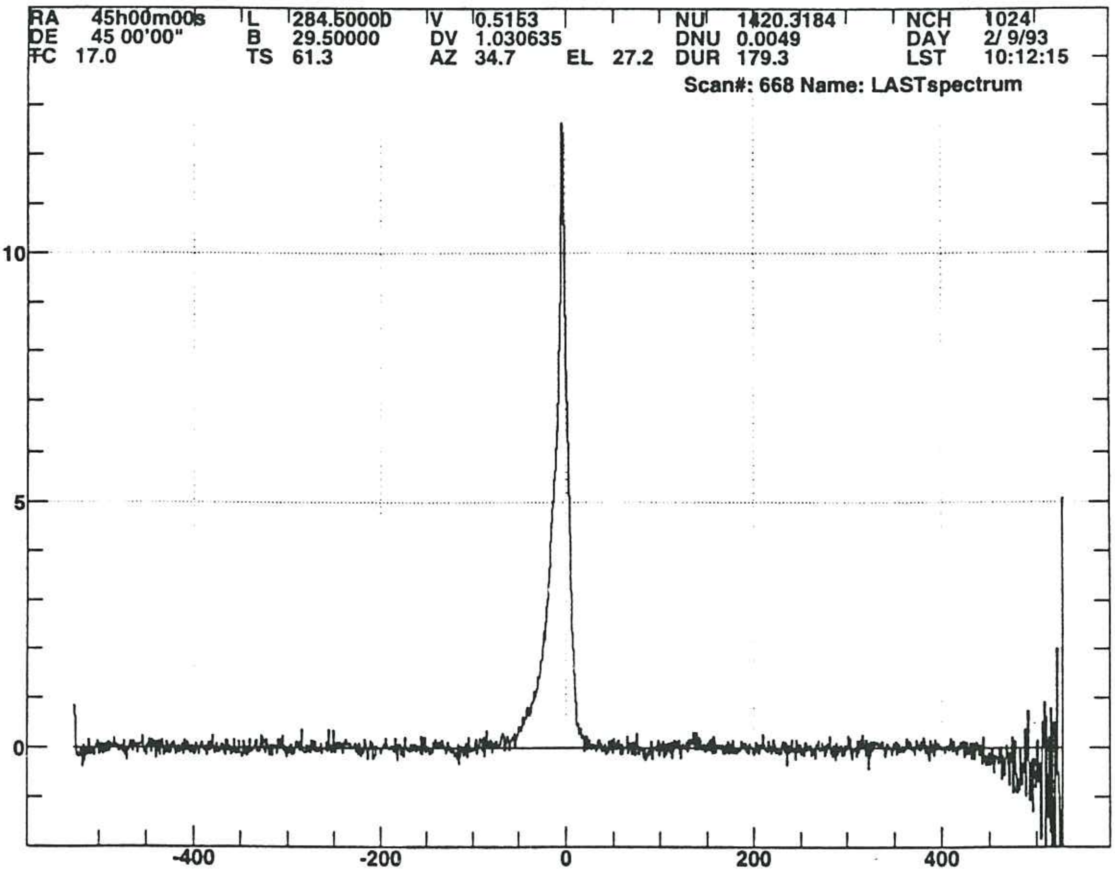


Figure 6 Last spectrum of the Leiden/Dwingeloo HI survey taken in september 1993. It is the last of a series of over 350000 spectra taken over a four year period with the Dwingeloo 25-m telescope.

The combination of the long-term availability of a small single-dish radio telescope equipped with an extremely stable frontend, and a new 1024-channel digital autocorrelator provided the ideal circumstances for undertaking the HI survey. Galactic neutral hydrogen has in the past been observed in different, rather arbitrarily defined velocity regimes. The new survey uniformly covers the local gas, near $v_{LSR} = 0$ km/s, the intermediate-velocity (IV) gas with the rather arbitrary velocity interval $15 < |v_{LSR}| < 70$ km/s, and the high-velocity (HV) material that exceeds the velocity of the IV gas ($70 < |v_{LSR}| < 140$ km/s).

The survey will be extended over the portion of the sky inaccessible from Dwingeloo by Bajaja and collaborators at the Argentine Institute for Radioastronomy using the IAR 100-foot telescope and observational parameters similar to those reported here. With the availability of the present survey in which these different (arbitrary) velocity domains are, for the first time, linked in a single data cube by a single instrument, a variety of scientific goals can be pursued:

1. Many IR cirrus features have anomalous-velocity HI counterparts which populate the realm of IVC's, i.e. with velocities differing from the simply-rotating, plane parallel case, by some 40 to 70 km/s. The topography of the IVC gas and its relation to the normal-velocity HI are being explored. The new data also reveal aspects of the HVC distribution which are evidently related to those of gas at less extreme velocities.

2. The Milky Way serves in many ways as prototype of a warped galactic system. The sensitivity, spectral resolution, and velocity coverage at high $|b|$ of the new HI data allow an improved quantitative description of the warp parameters. It is proving possible to examine gas-to-dust trends separately for the outer, local, and inner regions of the Milky Way.

3. Several regions of exceptionally low total HI column depth have been identified, in addition to the region of low N(HI) found by Lockman et al. (1984). Perhaps even more interesting is the discovery of regions in which the N(HI) at conventional velocities (within ~ 20 km/s of $v_{LSR} = 0$ km/s) is exceptionally low ($\leq 7 \times 10^{19}$ cm^{-2}), but where substantial densities do occur at anomalous velocities.

4. Measures of the HI areal as well as volume filling factors may be made. The extension of velocity information beyond the coverage and resolution available earlier shows that the new HI data may be analyzed in terms of the areal filling factor;

derivation of the volume filling factor is difficult, although important constraints may be put on this parameter.

5. The gas-to-dust interrelationships among HI column densities, galaxy counts, and reddening of galactic and extragalactic objects were analyzed by Burstein & Heiles (1978) and led to the establishment of correlations predicting galactic reddening. The gas/dust/reddening problem is being reanalyzed, exploiting the qualities of the new HI survey and of the more modern dust data. Particular attention is being paid to the breakdown of the correlation between HI and dust emissivities, which is tight in the inner Galaxy and locally, but not in the outer Galaxy.

6. Much HI gas is marshalled in the shell and supershell objects, and perhaps also in the so-called "worms". The motions of these structures reveal important aspects of the macroscopic energetics of the ISM. A few known shells have already been traced in the Leiden/Dwingeloo data to velocities well outside the range of the earlier data, suggesting an upward revision of the currently accepted energetics. Kinematic unravelling of the IRAS cirri is important in this regard as well as to understanding the nature of the IVC objects.

Effelsberg Radiotelescope, Germany

Successful commissioning of the DAS

The Dwingeloo Autocorrelation Spectrometer (DAS) is now installed on the James Clerk Maxwell Telescope (JCMT) on Mauna Kea, Hawaii, and is available to users in all modes. The first commissioning run revealed that one comparitor chip in the analogue to digital convertors was non-linear. Changes in the input total power (from varying sky, receivers, or IF) resulted in poor baselines; in particular the 'merging' of subbands produced steps and curves in the baselines. This is a difficult problem with wideband hybrid correlators such as the DAS, as good baselines require a very stable and extremely linear system throughout. We were able to manufacture an automatic gain control circuit that keeps the power into the ADC's constant. Also, we could make it small enough to fit into the current box. The July commissioning run on the telescope, and subsequent observations by users have shown that this, combined with several improvements to the software have reduced the non-linear effects by a factor of 10-20. The baselines now are as good as and sometimes better than the Acousto-Optical Spectrometer(AOS). The figures show some examples of spectra obtained from the DAS. No 'wierd' data 'reduction' techniques have been used, apart from subtracting linear baselines.

Figure 7 shows a spectrum of IRC+l0216 in 12CO J=2-1, with the line on the overlap region. The upper plot shows the same spectrum offset and scaled up by a factor of l0, in order to reveal the typical baseline offsets. These are less than 1% of the peak line intensity, even in the worst case of a bright line being in the centre of an overlap region. Therefore the 'platforming' problems noted above seem to have been reduced to a very low level.

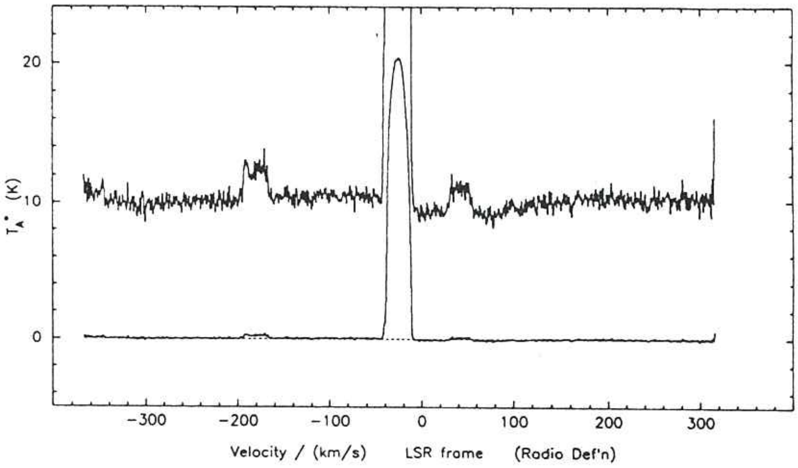


Figure 7

Figure 8 shows a beamswitched spectrum of a wide galaxy taken using RxA2 in the 750 MHz mode. The overlap between the two subbands can be seen in the centre, as can the excess noise due to the receiver 'dropoff' at the edges of the passband. In this case, no baseline has been subtracted

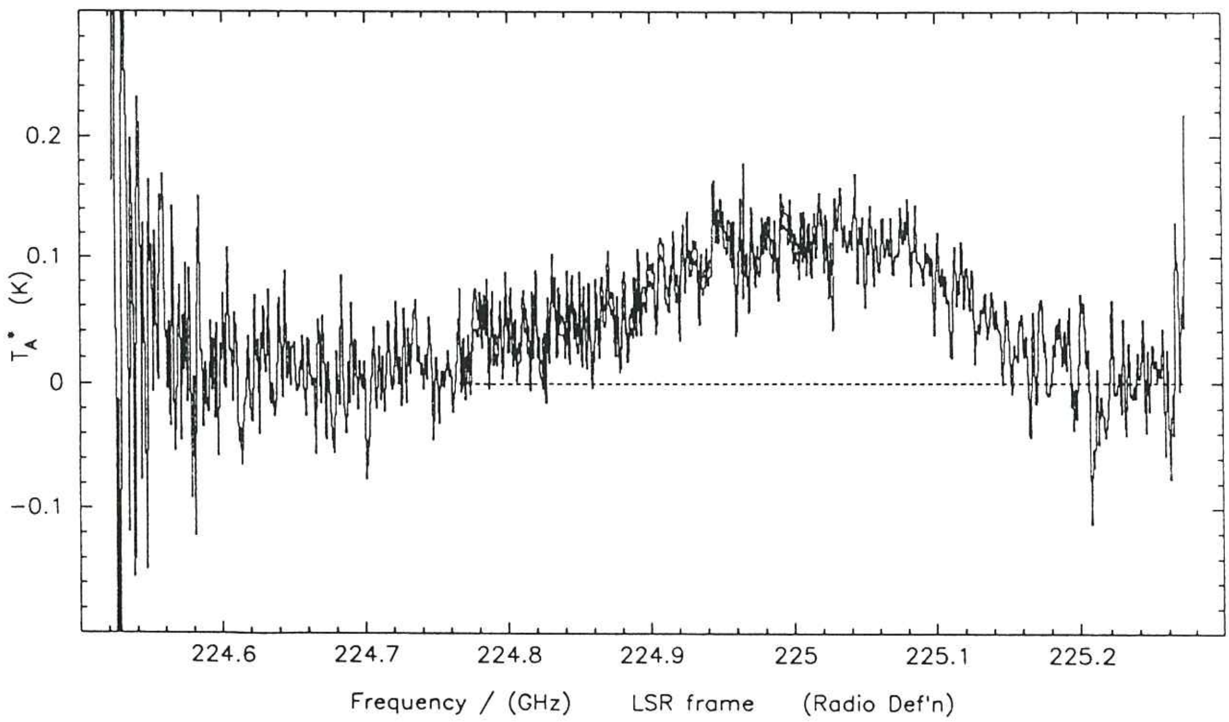


Figure 8

The next figure, figure 9 shows two raster scans taken through IRC+10216 in 12C0 2-1. An integration time of 5 seconds/point is used, and the telescope tracks continuously through the source. The efficiency of this observing method is very high (about 80% of time is spent integrating on source). In the current system the average of the two end spectra in each row is used as the reference for that row; consequently this only allows raster observations of small sources. However, it is hoped that provision for observations of large sources will be made available in the near future.

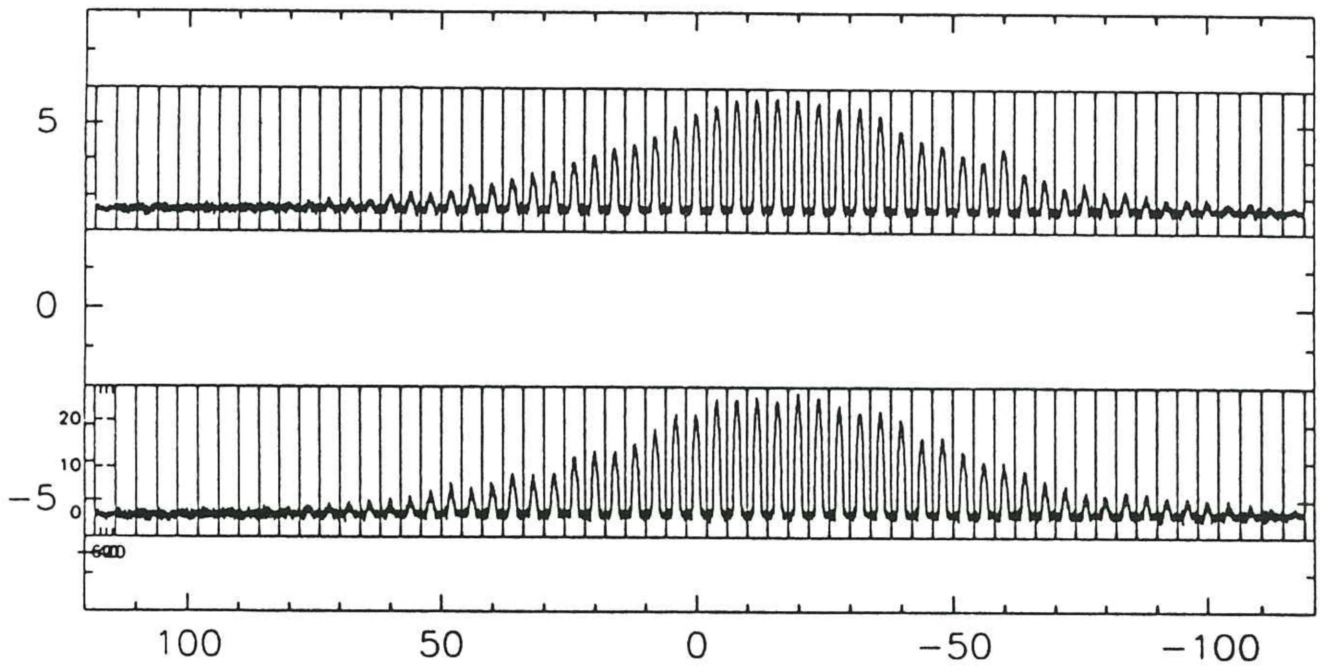


Figure 9

Overview

The DAS provides several substantial improvements over the current backend spectrometer (AOS). Among these are the capability for observing with a 920 MHz instantaneous bandwidth with RxC2, and almost 750 MHz with RxA2 and RxC2. It can give higher resolution with RxB3i (down to 0.15 MHz). The 'backend' or channel-by-channel calibration mode normally used gives more accurate calibration over the whole passband, particularly for RxB3i and RxA2. The double buffering allows the DAS to be used for raster (or 'on-the-fly') heterodyne observing. The correlator is also required for interferometry with the CSO and, in the near future, it will be needed for the new dual-polarisation wideband receivers.

The instrument is highly versatile; the electronics can be re-configured to produce spectra of different resolutions/bandwidths. In addition, the system can be split up to sample different parts of the IF passband(s) at various resolutions. However, there are rules limiting the allowed configurations. The standard bandwidth options depend on the frontend receiver; the more important configurations are listed below.

Commonly used configurations

Receiver	Bandwidth (MHz)	No./subsystems	Resolution (kHz)*
RxC2	920	1	1250
RxA2/B3i	750**	1	1250
RxA2/B3i/C2	500	1	625
RxA2/B3i/C2	250	1	312
RxA2/B3iC2	125	1	156
RxA2/B3i/C2	125	2	312

(*) This assumes Hanning smoothing of the ACF. Higher resolution (0.6 times better) can be obtained at the expense of higher sidelobes in the spectrum.
(**) This mode is obtained by overlapping two 500 MHz subsystems by 250 MHz; the bandwidth of A2 and B3i is typically about 650-700 MHz without substantial excess noise. This extra has essentially been obtained 'for free', as these two receivers were originally not designed for more than 500 MHZ bandwidth.

Simeiz Telescope, Crimea

La Palma: the Utrecht Echelle Spectograph

Peter Barthel

Since about two years the Utrecht Echelle Spectrograph (UES), permanently mounted on one of the Nasmyth platforms of the William Herschel Telescope, has been operational as the principal high dispersion spectrograph on La Palma. The UES is now a much sought common-user instrument, winning 24 % of all observing time on the WHT in 1993. After the HIRES instrument on the 10m Keck telescope, UES and its twin sister UCLES on the Anglo-Australian telescope are the most sensitive echelle spectrographs in the world. UES is indeed an all-round echelle spectrograph, with linear dispersion of just over 50,000 (5.5 km/sec) in its normal mode of operation (1 arcsec slit, EEV or Tektronix CCD detector) to 100,000 (narrow slit, IPCS detector).

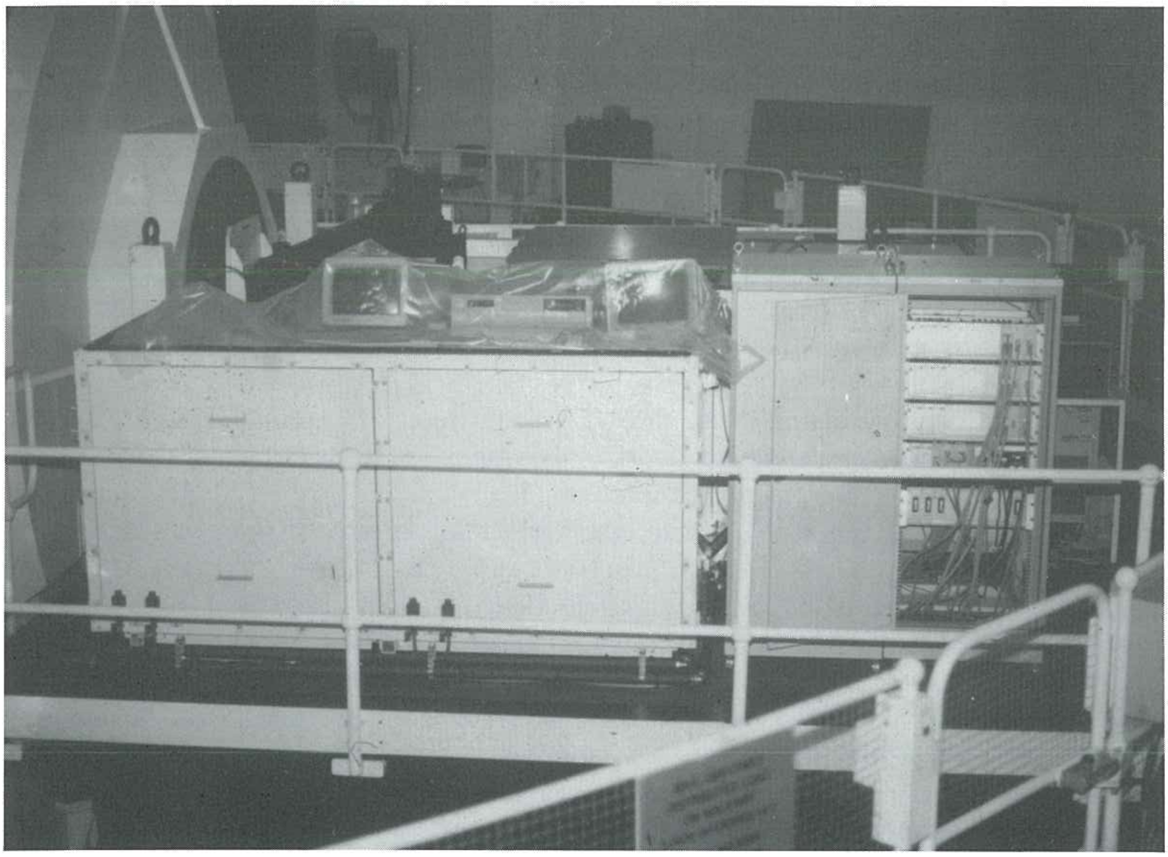


Figure 10 The Utrecht Echelle Spectrograph on one of the Nasmyth platforms of the 4.2m William Herschel Telescope on La Palma.

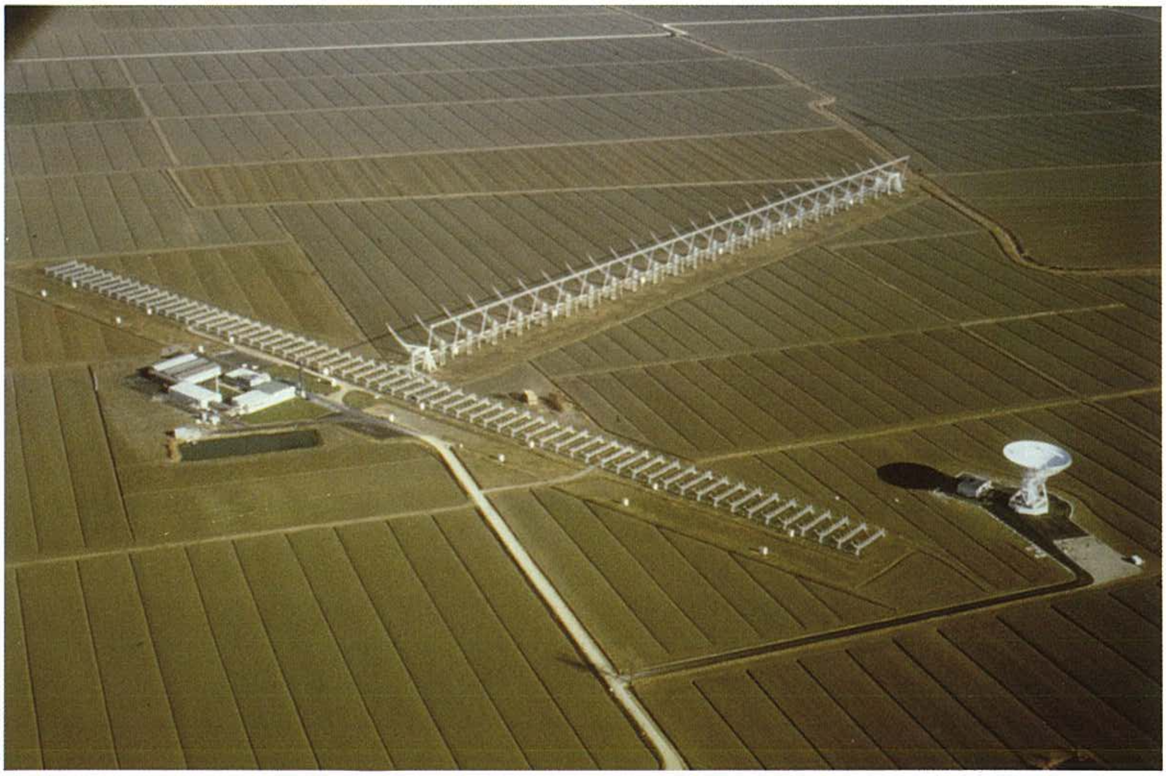
Two echelle gratings are standard available, one with 31 lines/mm and one with 79 lines/mm. Linear dispersions for both gratings are the same, but the order separation is a factor 2.5 larger for the latter grating. The 79 echelle thus allows use of an elongated slit, which in turn allows determination of the sky spectrum: in choosing the 79 vs. 31 echelle the trade-off is between accurate sky subtraction and wavelength coverage. UES was built by the astronomical instrumentation group in Utrecht, with dr. Roel Hoekstra as Principal Investigator. At a later stage, also the instrumentation group of the Kapteyn Observatory in Roden as well as NFRA in Dwingeloo became involved. Design and construction of UES was carried out in collaboration with the optical instrumentation group of University College London. This group was responsible for its twin sister UCLES, which became operational at the Coudé focus of the Anglo-Australian telescope (Siding Springs, Australia) in 1989.

UES commissioning tests in 1991/92, in which British and Dutch astronomers took part, demonstrated that the UES is an extremely stable instrument, providing slit-limited resolution over the entire detector field and over the wavelength range of 300 - 1100 nm. The excellent temperature stability of the spectrograph, due to a fine performing active temperature control system, allows integration times of many hours. The sensitivity of UES/WHT is similar to that of UCLES/AAT: although the former telescope is larger, somewhat more light is lost in the (WHT Nasmyth focus) derotation optics. Given the generally better seeing on La Palma however, UES/WHT can go deeper than UCLES/AAT. The limiting magnitude is around 17.5, for a 10:1 S/N spectrum at 5 km/sec resolution in three hours exposure time (under good conditions).

Following the commissioning runs, the UES acquisition and guiding (A&G) system has been subject to some remedial work. Fiber light losses were found to be rather severe. Although the limiting magnitude of the guiding system is now close to specification it is still somewhat ironic that while making high dispersion spectra of a 16th magnitude object, the system can only use guide stars brighter than 14.5 magnitude. Furthermore, the UES autoguide field is rather limited in size. Possible absence of suitable guide stars (from HST Guide Star Catalog), especially in high latitude fields, can result in rejection of target objects! Prospective users should be aware of these (minor) shortcomings. Fortunately, due to the installation of new slit jaws, the slit viewer fiber throughput has improved considerably. In conditions of good seeing targets as faint as 16th magnitude can be seen (on a narrow slit). An upgrade of the A&G unit is in progress.

The UES user interface software works well with only a small number of commands to be learned. Several Dutch investigators have in the meantime obtained UES observing time through the ING PATT. These investigations were mostly in the field of stellar structure (fairly bright targets). A Dutch team, consisting of R. Hoekstra, N. Douglas, E. Zuiderwijk and P. Barthel has in 1994 February/March utilised guaranteed P.I. time to attempt a range of UES observations for the Dutch community. A wide range of proposals was received, with targets spanning 16 magnitudes in brightness. Results of this moderately succesful run (weather not so obliging) will be discussed at a later stage.

It is anticipated that the WHT-UES will be an important contributor in the field of high dispersion spectroscopy for years to come. Prime subjects of interest are stellar structure (element abundances and mass loss), structure and composition of the interstellar medium in our own and in nearby galaxies, and cosmology through studies of absorption lines towards background (lensed) quasars.



Radio Astronomical Station of Medicina (Bologna), Italy

Joint Institute for VLBI in Europe

The official opening of the Joint Institute for VLBI in Europe (JIVE) took place on 9 June in Dwingeloo, attended by 80 guests including the ambassador of Sweden, representatives of the Italian, UK, French, and Spanish Embassies, an European Science Foundation representative, and the Directors of the member institutes of the European VLBI Network. The opening ceremony included speeches by prof.dr. P.C. van der Kruit (Chairman NFRA Board), mrs. M. de Boer (Commissaris van de Koningin in Drenthe), prof.dr. H.R. Butcher (Chairman, Board of Directors of the European VLBI Network), prof.dr. R.T. Schilizzi (Director-designate JIVE), and dr. J. Borgman (Chairman NWO Board). The inauguration itself was carried out by Ir. R.J. de Wijkerslooth (Director General of Science Policy, Ministry of Education and Sciences) on behalf of the Minister, dr.ir. J.J.M. Ritzen. The formal establishment of JIVE as a scientific foundation under Netherlands law took place in December. The statutes have been agreed by all the international partners.

Figure 11 Prof.dr. P.C. van der Kruit, Dr. J. Borgman, Ir. R.J. de Wijkerslooth, prof.dr. R.T. Schilizzi and prof.dr. H.R. Butcher (from left to right) at the inauguration of JIVE

During the course of 1993, a number of significant funding decisions have been taken, affecting the upgrading of the European VLBI Network.

i) The Ministry of Education and Sciences in the Netherlands approved the release of 12 Mfl (5.5 MECU) earmarked for the data reduction facilities at JIVE, and the second of four annual allocations for the years 1992 to 1995 was transferred to NWO.
ii) The Wallenberg Foundation, a Swedish Trust, has approved 4.5 MKr (480kECU) for JIVE. 3.5 MKr is reserved for the JIVE correlator construction, and 1 MKr for upgrading the data acquisition terminal (MkIV upgrade) at Onsala in Sweden.
iii) The proposal for support from the second round of "Access to Large Scale Facilities" action of the EC Human Capital and Mobility (HCM) Programme was honoured at the 600 kECU level.
iv) The proposal to support VLBI centres in Poland and Hungary under the EC Programme for Cooperation with Central and Eastern European Countries was granted 446 kECU.

The total funds now committed to the EVN Upgrade and JIVE amount to 9.876 MECU.

The results were at year's end not yet known for a number of other proposals for additional funds submitted in 1993.

i) A proposal by our Italian partners to their government for 1 MECU for JIVE, spread over 4 years, is under consideration in Rome.
ii) HCM "Fellowships grouped by laboratories" for EVN Fellows in France, Spain, Italy, Sweden, and Finland.
iii) EC Science and Technology Cooperation with Central and Eastern European Countries, for further support for Poland and Hungary.
iv) A proposal to the International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union for a scientific programme using VLBI observations with European, Russian and Ukrainian telescopes.

A contract with the University of Manchester has been signed for the employment of three programmers for the online software for the EVN correlator.

Upgrade of European VLBI Network Facilities

The upgrade consists of two parts: the construction of a state-of-the-art 16-station VLBI data processing facility (or correlator) at JIVE, and the upgrade of the data acquisition systems at the EVN telescopes (of which pictures are displayed throughout this annual report). The data processor project involves collaboration by scientists and engineers in Dwingeloo, Jodrell Bank (UK), Bologna (Italy) and the MIT Haystack Observatory in the USA. A Memorandum of Understanding to formalize this collaboration between the NFRA representing JIVE as well as itself, and NASA representing Haystack Observatory, is awaiting final approval. The seven man European project team for the data processsing facility met six times in 1993, five times in Dwingeloo and once in Jodrell Bank in England. There was one formal review meeting with Haystack held in June at Haystack. The status of the main elements of the project are summarised below.

Playback Units

An invitation to tender for the construction of 14 Playback Units was issued in September, following an announcement in the Official Journal of the European Communities. The responses are in currently undergoing evaluation. This will be the single biggest contract in the correlator project. These units will be delivered to Dwingeloo from early in 1995.

Station Units

The contract for developing the Station Unit (interface between playback units and correlator) was awarded to Penny & Giles Data Systems Ltd (UK) in July. They will deliver 4 prototype units by January 1995. The first Critical Design Review was passed successfully in October. The functional design of the rest, Synchronisation and Pulsar Gate Interface to the Station Unit has been completed.

Correlator hardware

The correlator system level design was agreed with Haystack Observatory in June (see NFRA ITR 202 by A. Bos). The specifications of interfaces in the correlator are currently under investigation in Dwingeloo and Haystack. Final versions of these specifications are to be available at the end of January 1994 at the six-monthly review meeting with Haystack to be held in Dwingeloo. The logical design of the chip has been completed by Haystack. The next phase is the circuit design and layout. The chip is expected to go to the foundry at the end of January, with 'first silicon' expected in May 1994. The detailed designs of the correlator board. input board, and backplane are in progress at Haystack. The control board design is in progress in Dwingeloo.

Online software

The design of the online software for the correlator is in progress in Jodrell Bank. It is being carried out according to object oriented design principles.

Data acquisition system upgrade

Following extensive discussion in the EVN Technical Working Group, a plan has been formulated to carry out the upgrade from the current MkIII standard to MkIV (which will allow an almost 10 times higher recording bit rate). A project team has been identified, and there was a kickoff meeting in December in Dwingeloo. The project is expected to take one year to complete.

Science Support Activities

Three Support Scientists have taken up their posts. One has been seconded to Bonn for 1 year (September 1993 - September 1994) to support EVN users of the MPIfR correlator. A second Support Scientist will spend 2 years in Socorro at the VLBA Center from June 1994 helping European users of the global VLBI array. The third will remain in Dwingeloo.

The Support Scientists carried out calibration observations for the EVN in September and November, with the aim of providing feedback to the observatories on their performance within four weeks of the end of the observing session (compared with the a feedback delay of 9 months which has been typical of recent years). These aims were achieved after the September session; the November results are in the process of analysis. Similar CAL observations are planned for each EVN observing session in the future. The astronomers will also be informed of the results. Starting in September, assistance with observing schedules was also provided to EVN PI's prior to the observing sessions.

Observatorium Torun, Poland

WSRT projects

In 1993 35 projects for WSRT observations were allocated by the program committee. These projects were given 58% of the telescope time. An additional 7% was allocated to VLBI projects. For testing and calibration 35% of the telescope time was used.

The 21 cm band is still the most popular among WSRT users with a share of 35% of the observation time (both WSRT and VLBI projects), but for 92 cm a major part (32%) of observation time was used as well. The other three bands, 50 cm, 18 cm and 6 cm, had shares of 13%, 4% and 16% respectively.

Project	Subject	Scientist
515	Variability in Radio Sources	Bruyn G.de
600	Gamma Sources	Spoelstra T.A.T./Lobel A.
880	Molecular Cloud Cores	Boland W.
936	SN in NGC891	Bruyn G. de
945	Perseus Cluster	Bruyn G. de
947	HI in Cooling Flows	Jaffe W.
1019	Structure of 0902+34	Bruyn G. de
1027	Cyg X-1	Strom R.G.
1030	HVC Distances	Schwartz U.J.
1041	WR Binaries	Hucht K.A. v.d.
1042	Monitoring HD193793	Hucht K.A. v.d.
1043	Variable Non-Thermal WRBinaries	HuchtK.A.v.d.
1102	Pulsar Polarization	Bruyn G. de
1103	A Survey of HI in Spiral Galaxies (WHISP)	Albada T.S. v.d.
1108	Low Frequency Measurements of NGC2276	Hummel K.
1109	Nova Gyg 1992	Spoelstra T.A.T.
1111	GROJ0422+32	Hanlon C.
1118	4C67.02	Junor W.
1119	Giant Radio-Galaxies	Strom R.G.
1121	Nearby (Mini)Starburst Galaxies	Braun R.
1122	Deep Polarization Images of Pulsars	Johnston
1124	Ionized Intergalactic Medium	Antonucci
1127	Darkmatter in UMa Cluster	Verheijen M.A.W.
1128	Polarized Emissions Sun	Allisandrakis
1130	Nova Shells	Strom R.G.
1131	HVC's in Front of Mk205	Woerden H.
1132	Polarization in NGC4449	Israel F.P.
1133	Yellow Hypergiant	Lobel A.
1134	SN1993J	Strom R.G.
1135	Comet-Jupiter Crash	Pater I. de

1138	HI in Galaxy Pairs	Chengalur J.N.
1139	HI near SNR G63.7+1.1	Wallace
1143	HI in low-z Lyman-Alpha Forest	Hucht K.A. v.d.
1145	Intergalactic HI	Goivanelli R.
2000	WEsterbork Northern Sky Survey (WENSS)	Bruyn G.de

Project	**92 cm**	**50 cm**	**21 cm**	**18 cm**	**6 cm**	**Total (hours)**
515	-	-	-	-	8.8	8.8
600	-	-	-	-	18.8	18.8
880	-	-	-	-	94.0	94.0
936	-	-	-	-	1.9	1.9
945	-	1.7	-	-	-	1.7
947	-	-	37.0	-	-	37.0
1019	162.7	-	-	-	-	162.7
1027	7.5	-	73.1	-	34.1	114.7
1030	-	-	111.7	-	-	111.7
1041	-	-	-	-	11.7	11.7
1042	-	5.7	-	6.1	40.0	51.8
1043	-	-	89.4	-	42.9	132.3
1102	12.0 -	-	-	-	12.0	
1103	-	-	818.4	-	-	818.4
1108	2.0	-	-	-	-	2.0
1109	-	-	16.4	-	-	16.4
1111	69.9 37.8	104.8	13.7	131.7	357.9	
1118	-	-	-	-	22.7	22.7
1119	4.1	-	-	-	-	4.1
1121	-	-	156.1	-	-	156.1
1122	79.6 -	-	-	-	79.6	
1124	131.7	-	-	-	-	131.7
1127	-	-	71.9	-	-	71.9
1128	-	-	-	-	24.0	24.0
1130	-	-	40.1	-	-	40.1
1131	-	-	23.7	-	-	23.7
1132	-	-	-	-	12.0	12.0
1133	-	-	-	-	23.9	23.9
1134	-	-	18.0	-	18.4	36.4
1135	-	-	23.2	-	-	23.2
1138	-	-	32.9	-	-	32.9
1139	-	-	12.0	-	-	12.0
1143	-	-	17.4	-	-	17.4
1145	-	-	23.2	-	-	23.2
2000	1077.6	558.1	10.4	-	-	1646.1
Tot.	**1547.1**	**603.3**	**1679.7**	**19.8**	**484.9**	**4334.8**

Project	92 cm	50 cm	21 cm	18 cm	6 cm	Total (hours)
VLBI	-	47.2	-	177.4	300.7	525.3
Cal.	434.6	95.6	686.7	4.9	434.7	1656.5
Test	234.9	50.8	122.0	119.2	450.5	977.4
Tot.	**2216.6**	**796.9**	**2488.4**	**321.3**	**1670.8**	**7494.0**

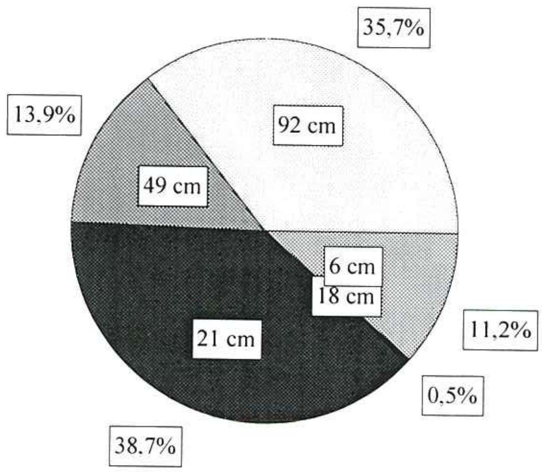


Figure 12 WSRT time for different wavelengths

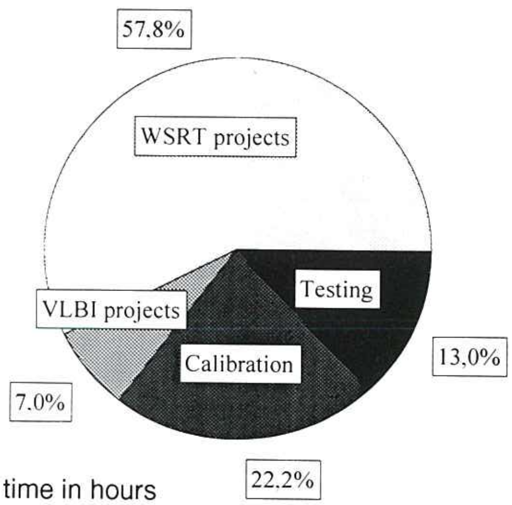


Figure 13 WSRT time in hours

WSRT user documentation

New user documentation for the WSRT has become available to all interested in observing with WSRT. It replaced the old manual and the WSRT information package.

The new user documentation consists of six parts which can be used and distributed separately. Each part is relevant for a separate stage of WSRT user preparations or for the use of the WSRT itself. Advantage of this modular approach is that the sizes of the individual parts do not become too large and that the individual parts are easy to maintain. Below a general description of the contents of the user documentation is given.

Part 1: Proposing for WSRT observing time
This part contains all the information necessary to write a proposal. Here we present a summary of the capabilities of the WSRT, explain how time is awarded and supply the necessary addresses. This part can be used individually and will be sent to people who are interested in observing with the WSRT. There is some redundancy with information in other parts of the documentation.

Part 2: Introduction to the theory of aperture synthesis
This part contains an introduction to the theory of aperture synthesis with some emphasis on the WSRT. It is probably not needed by experienced radio astronomers but it may be of use to those who are new to the field. This part contains some chapters with introductory theory with references to the standard literature. In the last chapter we included a bibliography and a 'dictionary' for quick reference to standard literature.

Part 3: Specific aspects of the WSRT
In this part we describe the different modes of operation of the WSRT, provide some technical information and explain how a set up must be specified when proposing for an observation. There is some redundancy with the first part of the documentation. During the writing of a proposal the less experienced WSRT user may find it useful to consult this part for more details about the differences between the several instrumental set ups.

Part 4: Calibration and reduction of WSRT data
In this part we describe the corrections and calibrations that are and/or need to be

performed to WSRT data. We present some tips and hints for further data reduction and present pictures with errors that may be encountered in WSRT maps.

Part 5: Various
In this part we present equations, graphs and tables that may be useful for the specification of a proposal or during the reduction phase. We also included a brief guide to ARCQUERY, the archive query software.

Part 6: NEWSTAR
The user documentation will contain the NEWSTAR program descriptions and recipes. NEWSTAR is the special software for *u,v*-data processing developed at NFRA.

A complete copy of the user documentation can be obtained in two ways. A copy of the user documentation can be requested at NFRA. This can be done by sending an e-mail request to the documentation account (wsrt@nfra.nl) or by contacting the NFRA secretary by surface mail or telephone. An alternative way to obtain a copy of the documentation is to make use of anonymous ftp to obtain the necessary PostScript files. The address of the anonymous ftp-node is rzmws10.nfra.nl (192.87.1.160)

The new WSRT user documentation will provide all scientists interested in using the WSRT with useful and up-to-date information. Regular maintenance will ensure that one is always provided with information about the latest developments in the hardware of the WSRT or in the software used to reduce its data.

Metsähovi Telescope, Finland

NFRA observing facilities

The Netherlands Foundation for Research in Astronomy operates two radio telescopes the (Westerbork Synthesis Radio Telescope and the Dwingeloo 25 m single dish radio telescope) and is, in collaboration with sister organizations in the United Kingdom and Canada, involved in the operation of three optical telescopes of the Observatorio del Roque de los Muchachos on La Palma, Canary Islands, and a sub-millimetre telescope on Mauna Kea, Hawaii. The coordinating institutes for the La Palma and Hawaii observatories are the Royal Greenwich Observatory, Cambridge and the Royal Observatory Edinburgh, respectively.

Below, the relevant parameters of the WSRT and Dwingeloo telescope are summarized, facilities for which the NFRA is fully responsible. This responsibility includes the operation, the maintenance, the instrumentation and the data processing of these telescopes.

The Westerbork Synthesis Radio Telescope

The Array

The WSRT consists of an East-West array of fourteen equatorially mounted 25-m dishes. Ten of them are on fixed mountings, 144 metres apart; the four (2 x 2) remaining dishes are movable along two railtracks, one, 300 m long, adjacent to the fixed array and another, 180 m long, 9 x 144 m more towards the East. The movable dishes can be used at any position of the rail tracks. The pointing accuracy of the dishes is 15 to 20 arcseconds, the surface accuracy is of the order of 2 mm.

Observing modes

In its 'normal', local mode of operation the WSRT is used as an aperture synthesis array with a total length of 2.8 km. It then consists of a basic set of 40 interferometers, each interferometer comprising one fixed and one movable dish, and a variable number of 'redundant' interferometers (fixed-fixed and/or movable-movable). The redundant interferometers are generally used to calibrate the short term phase and amplitude variations caused by instabilities in the atmosphere. This method, in combination with self calibration techniques, allows very high dynamic ranges to be obtained in continuum observations in particular. The redundant interferometers can, of course, also be used to contribute to aperture-synthesis maps.

A new method of using the WSRT in local mode was developed in 1990. This mosaic method allows mapping of large areas of the sky in a relatively short time. During one 12-hour period the telescopes along with the fringe-stopping and delay centres cycle through a grid of positions a number of times. The grid may contain as many as 120 positions; it can be arranged in a flexible way. If done sensibly no more than 10 seconds are required to change positions within the grid. This allows large surveys of continuum or line radiation which are not limited by the ultimate sensitivity of a full 12-hour observation per position.

Part of the time the WSRT is used for Very Long Baseline Interferometry (VLBI) along with other radiotelescopes in Europe and elsewhere (mainly the USA). The fourteen WSRT dishes are then used as a 'tied array', together yielding the equivalent of one 93-metre single dish in the VLBI network.

wavelength (cm)	6	18	21	49	92
frequency range(MHz)	4770-5020	1590-1730	1365-1425	607-610	300-380
field size HPBW (degr)	0.17	0.5	0.6	1.4	2.6
max. bandwidth (MHz)	80	40	40	2.5	80
synth. beam in RA (arcsec)	3.7	11	13	30	55
cont. sensitivity (r.m.s. in 12-hour obs. mJy/beam)	0.07	--	0.06	0.6	0.5

Table 1 Characteristics of the WSRT and its receivers

Receivers and backends

Table 1 summarizes the characteristics of the WSRT at each of the five wavelengths for which receivers are available. At 18 cm there are only five (cryogenically cooled) receivers. At this wavelength the WSRT is generally used in the VLBI tied-array mode. For the other four wavelengths a complete set of 14 receivers can be used. All receivers have two polarization channels.

Two digital correlators and two VLBI recording systems can be used to combine the signals from the array for different types of observations. A summary of their characteristics is given in table 2. Note that the Mk2 VLBI mode is from 1994 no longer a standard mode supported by the European VLBI Network. Below we give some additional information.

DXB spectral line backend								
bandwidth options (MHz):	10	5	2.5	1.25	.625	.313	.156	.078
# complex channels (2 bit)	1280	2560	5120	10240	20480	40960	40960	40960
(3 bit)	2560	5120	10240	20480	40960	40960	40960	40960
spectral resolution (kHz):								
40 interf. 2 polariz. 2 bit	625	156.3	39.1	9.8	2.4	0.6	0.3	0.15
10 interf. 1 polariz. 1-bit	39.06	9.77	2.44	0.61	0.31	0.15	0.08	0.04
DCB continuum backend								
total bandwidth (MHz):	8x10	40						
bandwidth options (MHz):	10	5						
# complex cannels:	2048							
MK2 VLBI backend								
max. total bandw. (MHz):	2							
Bandwidth options (MHz):	2	1	.5	.25	.125	.0625		
MK3 VLBI backend								
max. total bandw. (MHz):	14x4							
bandwidth options (MHz):	4	2	1	.5	.25	.125		

Table 2 Characteristics of the WSRT backends

The spectral line backend (DXB)

The basic number of independent 1-bit correlation products the DXB can produce simultaneously is 2560. In 2 bit mode the correlator produces half the number of products (1280) with a sensitivity improved by approximately 1.2. When the observed spectrum can be covered adequately with an overall bandwidth (B) narrower than its maximum value (10 MHz), the clockrate of the correlator (20 MHz) allows the number of correlation products obtained in one integration time to be increased by a factor 10/B to a maximum of 40960 (10/B is a power of 2). The number of complex channels, obtained after Fourier transform of the correlation functions, may be distributed over interferometers and polarization channels of the array. How one chooses to do this depends not only on the spectral resolution required, but also on the sensitivity needed per frequency point (=complex channel) on each interferometer.

Sensitivity may be increased by changing the correlator's bit-mode, but also by observing the same spectrum simultaneously in two independent polarization channels. The number of independent frequency channels F in each observed spectrum depends on the overall bandwidth B (MHz), the correlator bit-mode M (1 or 2), the number of interferometers I, and the number of polarization channels P by the relation:

F x M x I x P = 2560 x 10/B

As an example the spectral resolution is given for each of the eight possible overall bandwidths available and for two rather extreme choices: (i) use of 40 interferometers in two polarization channels and 2-bit correlation mode for maximum sensitivity, and (ii) use of all possible correlation products on, for instance, 10 interferometers in one polarization channel and in 1-bit correlation mode for high spectral resolution.

The Continuum Backend (DCB)
The DCB has eight independent bands, each with a width of either 10 MHz or 5 MHz. The central frequencies of the eight bands may be chosen independently within an overall range of about 90 MHz. This choice can be useful to avoid interference at a particular frequency.

Very Long Baseline Interferometry (VLBI)
Any combination of the WSRT dishes can be used as a 'tied array' to serve as one station in a VLBI network. Two types of VLBI backends are available: the narrow-band Mark2C system and the wide-band Mark3A system. In front of the recording terminals one of the normal WSRT backends is used: the DXB in combination with Mk2 and the DCB in combination with Mk3. It is possible to observe two polarization channels simultaneously with the Mk3 system. With the Mk2 system one can switch between polarization but one cannot observe them simultaneously. Again, from 1994 Mk2 observations will only be supported on an ad hoc basis.

Archiving and Data processing
The NFRA Reduction Group in Dwingeloo archives all data obtained with the WSRT on optical disks. In addition, it determines and stores standard calibration parameters. The observations catalogue of the WSRT archive can be queried by anybody at any time by running the program ARCQUERY on a captive account with userid : ARCQUERY (no password necessary) on the NFRA microVAX cluster. During the proprietary period (2 years) requests for the actual data (on regular or DAT tape) will only be granted to the original proposers. The requester of data may stipulate whether he or she wants the data with or without the standard calibrations applied. When the data will be processed the redundancy/selfcalibration programmes, it is often unnecessary or even undesirable to apply the standard corrections first.

The 25-metre Dwingeloo telescope

Unlike the WSRT the Dwingeloo telescope is available for use by astronomers who are able to schedule and to carry out their observations themselves. Although a schedule can be prepared for periods of the order of a week, the astronomer's monitoring of the progress will generally require some regular physical presence in Dwingeloo.

The characteristic parameters of the telescope are given below:

Diameter:	25 m
Mount:	alt-azimuth
Pointing accuracy:	approximately 1 arcminute
Surface accuracy:	2 - 2.5 mm
Aperture efficiency:	0.64 (λ = 18 or 21 cm)
	0.40 (λ = 6 cm)

Frontend receivers are available for 21 cm and for 18 cm wavelengths (and, upon request for 6 cm). Their parameters are:

System temperature:	36 K
Frequency range:	1375-1425 MHz (λ = 21 cm)
	1580-1725 MHz (λ = 18 cm)

Sensitivities (5 x rms noise) in 60 min integration time:

continuum, bandwidth 10 MHz	20 mJy (2 mK)
line channel, 78 kHz wide	150 mJy (17 mK)

As a backend a prototype of the Dwingeloo Autocorrelation Spectrometer (DAS), developed for the JCMT, is used. It has 1024 channels (if desired to be used with two IFs as 2*512 channels). It operates at overall bandwidths of 10, 5, 2.5 .... 0.067 MHz. If desired observations with a time resolution of 0.1 sec can be done.

Yebes Telescope, Spain

Financial report

Ontvangen subsidies	*(kf)*	*totaal*
Gewoon subsidie		13.956
NWO, gewoon subsidie	12.629	
NWO salarismaatregelen	13	
NWO beleidsruimte GB-E	715	
Versterking Hoger Onderzoek	200	
Restant GS budget/saldo 1992	399	
Investeringssubsidies		4.700
NWO investeringssubsidie	2.900	
IAS-middelgroot	900	
IIS-groot	900	
Totaal subsidies		18.656

Uitgaven	*(kf)*	*totaal*
Exploitatie instituut		11.332
Personeelskosten	8.099	
Exploitatiekosten	2.259	
Computers en meetinstrumenten	974	
Project- en programmasubsidies		1.728
Personeelskosten	1.571	
Reis- en materiele kosten	157	
WSRT infrastructuur		517
Onderhoud	516	
Vervanging electronica	1	
WSRT ontwikkelingsprojecten		2.125
Multi Frequency Front Ends	975	
R&D nieuw WSRT backend	150	
Software: AIPS++ project	100	
Pulsar search apparatuur	900	
UK/NL samenwerking		2.694
Exploitatiekosten	2.694	
Restant GS budget en saldo 1993		260
Totaal uitgaven		18.656

Shanghai Observatory, China

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Summerstudents

			begeleider
Greg Howard	University of Wisconsin	1/6 - 15/8	Robert Braun
Robert Geller	UC Santa Barbara	8/7 - 1/12	Ger de Bruyn
Sangeeta Malhotra	Princeton University	15/6 - 5/9	Wilfried Boland
Cai Zhendong	Beijing Observatory	1/6 - 1/12	Richard Schilizzi

Stagiaires

L. Beukema	HTS Emmen	23/8 -	Jaap Bregman
L. Siepel	MBO Oost-Groningen	30/8 - 26/11	Jan Idserda
A. de Vries	MBO Oost-Groningen	29/11 -	Jan Idserda
R. de Vries	Morgenland College	16/8 -	Arie Doorduin
R. Wesselink	Hogeschool Enschede	1/9 -	Bert Woestenburg

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Publications

Papers, refereed articles & conference papers by NFRA staff

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Note's & ITR's

Note 609	A.J. Boonstra, A.R. Foley, T.A.Th. Spoelstra 'The GLONASS - Radio Astronomy experiment
Note 611	J. Hofman 'S-Parameter measurement system at cryogenic temperatures'
Note 612	R.P. Millenaar 'DZB and EVN correlator data distribution study'
Note 613	J. Bregman ' Haalbaarheids demonstratie DCB waarnemingen 8*5 Mhz mode met de 87 cm breedband prototype2 front ends in het bereik 305-385 MHz.
Note 614	R. Braun, 'System temperature contributions for the WSRT'
Note 615	A. Bos 'On error sources in hybrid spectrometers'
Note 616	A. Bos 'Synchronization in the EVNFRA correlator'
Note 617	A. Bos & N. Schonewille 'On frequency response and stability of the DAS Sampler Modules

ITR 200	A. Bos 'Design considerations for the DZB: A new backend for the WSRT'
ITR 202	A. Bos 'The EVNFRA correlator: design considerations.
ITR 203	J.L. Casse 'Beheer ASTRON projecten - ASTRON regels voor het organiseren van projecten
ITR 205	B. Woestenburg & L. Nieuwenhuis 'A 230-460 MHz HEMT-amplifier with extremely low noise at room temperatures'

JIVE publications

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Groenewegen, M.A.T., de Jong, T., Baas, F., 'Near-infrared and sub-millimetre photometry of carbon stars', Astron. Astrophys. Suppl. 101, 513.

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Assendorp, R.
IRAS pointed observations of low mass star formation
Prof. dr. S.R. Pottasch, prof. dr. D.C.B. Whittet, dr. P.R. Wesselius
Rijks Universiteit Groningen

De Vries, M.
Magnetic Relaxation in Active Galactic Nuclei
Prof. dr. J. Kuijpers, prof. dr. M Kuperus
Universiteit Utrecht

De Vos, C.M.
Optical Interferometry with SCASIS
Prof. dr. H.R. Butcher
Rijks Universiteit Groningen

Groenewegen, M.A.T.
On the Evolution and Properties of AGB stars
Prof. dr. T. de Jong
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Kaper, L.
Wind variability in early type stars
Prof. dr. E.P.J. van den Heuvel, prof. dr. H.J.G.L.M. Lamers, dr. H.F. Henrichs
Universiteit van Amsterdam

Kamphuis, J.
Neutral hydrogen in nearby Spiral Galaxies Holes and High Velocity Clouds,
Prof. dr. R. Sancisi, dr. J.M. van der Hulst
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Sijbring, L.G.
A Radio Continuum and HI Line Study of the Perseus Cluster
Prof. dr. R. Sansici, prof. dr. G. de Bruyn
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Van Geffen, J.
Magnetic energy balance and period stability of the solar dynamo
Prof. dr. C. Zwaan, dr. P. Hoyng
Universiteit Utrecht

Nançay Radio Telescope, France

Projektsubsidies

These projects are being supported by NFRA.

LWG Zon en sterren

Code 782-371	Aanvrager(s)	Titel onderzoek	Onderzoeker
035	Dr. A. Achterberg	Dynamica van slanke veldbuizen, accretie-schijven en jets	Drs. G.P. Schramkowski UU (tot 30/9)
036	Prof.dr. J. Kuijpers	Electrische dubbellagen in kosmische plasma's	Drs. M. Volwerk UU (tot 31/8)
037	Dr. H.F. Henrichs Prof.dr. E.v.d. Heuvel Prof.dr. H. Lamers	Fysica van variabele windstructuur van vroeg type sterren	Drs. L Kaper UvA (tot 30/6)
038	Prof.dr. J. van Paradijs	Een optische studie van röntgen bronnen in M31	Drs. T. Augusteijn UvA
040	Prof.dr. H. Lamers Prof.dr. E. v.d. Heuvel Dr. L.B.F.M. Waters	De evolutie van lage-massa dubbel sterren van de AGB via post-AGB tot planetaire nevels	Drs. E.J. Bakker UU
041	Dr. P. Hoyng Prof.dr. M. Kuperus Prof.dr. H. v. Beijeren	Stochastische aanslag van grootschalige magneetvelden	Drs. A.J.H. Ossendrijver UU
042	Prof.dr. J.van Paradijs Dr. W. Hermsen	Produktie van gammastraling in compacte objekten in het melkwegstelsel	Drs. R.C.A. van Dijk UvA, 50% ASTRON/50% SRON
043	Dr. H.F. Henrichs	Seismologie van O sterren	Drs. J.H. Telting UvA
044	Prof.dr. J. Kuijpers	Radiopulsars en lineaire versnellingsstraling	Dr. E.T. Rowe UU
045	Dr. R.J. Rutten	Stralingshydrodynamica van de rustige chromosfeer	Drs. N.M. Hoekzema UU
046	Dr. G.J. Savonije	Niet-lineaire getijden interactie in zware-dubbelsterren	Drs. F. Alberts UvA
047	Dr. G.H.J. v d Oord Prof.dr. M. Kuperus	Het effect van retardatie op MHD-configuraties	Drs. N.A.J. Schutgens UU

048	Prof.dr. H. Lamers	Een studie van de variabiliteit van luminous blue variables	Drs. R. Noordhoek UU (vanaf 1/1/94)

LWG Interstellaire Materie

Code 782-372	Aanvrager(s)	Titel onderzoek	Onderzoeker
029	Prof. dr. V. Icke	Dynamica van niet bolvormige planetaire nevels	Drs. G. Mellema RUL (tot 30/9)
030	Prof.dr. T. de Jong	De laatste evolutiestadia van koolstofsterren	Drs. M. Groenewegen UvA (tot 30/6)
031	Prof.dr. S.R. Pottasch	Vroege evolutiestadia van plane taire nevels	Drs. R.D. Oudmaijer RUG
032	Dr. J.M. van der Hulst Dr. R. Braun	Interactie tussen stervorming en het interstellaire medium in M33 en M31	Drs. O.M. Kolkman RUG (vanaf 1/9)
033	Dr. J.M. van der Hulst	Een theoretische studie van de spectra van planetaire nevels melkwegkernen en Hll gebieden in het Infrarood	Drs. P.A.M. van Hoof RUG
034	Dr. E.F. van Dishoeck Prof.dr. H.J. Habing Dr. Th. de Graauw	Aard en evolutie van interstellair stof bestudeerd met laboratorium infra-rode spectroscopie	Dr. W. Schutte RUL, 50% ASTRON 50% SRON
035	Prof.dr. S.R. Pottasch	Early evolution of planetary nebulae	Drs. G.C.M. v.d. Steene RUG (vanaf 1/2)
036	Prof.dr. H.J. Habing	De keuze van een dynamisch model voor de binnenschijf en de bult van ons melkwegstelsel	Drs. M. Sevenster RUL (vanaf 1/3)
037	Prof.dr. W.B. Burton	Scientitic exploitation of the Leiden / Dwingeloo Hl survey; physical characteristics of galactic HI	Drs. S.R.D. West RUL (vanaf 1/11)

LWG Sterrenstelsels

Code 782-373	Aanvrager(s)	Tltel onderzoek	Naam van onderzoeker
039	Prof.dr. R. Sancisi Prof.dr. T. van Albada	De vorm van donkere halo's	Drs. F.J. Sicking RUG
046	Prof.dr. R. Sancisi Prof.dr. J. v. Gorkum Prof.dr. H. v. Woerden	Melkwegstelsels in voids en clusters	Drs. A. Szomoru RUG (tot 28/2)

047	Prof.dr. P. v. d. Kruit	Fotometrie in het nabije infrarood van schijven in spiraalstelsels	Drs. R.S. de Jong RUG (tot 31/3)
048	Prof.dr. T. de Zeeuw	Structuur en dynamica van elliptische sterrenstelsels	Drs. F. Robijn RUL
049	Prof.dr. V. Icke	Oorsprong en eigenschappen van emissielijngas in aktieve sterrenstelsels	Dr. N. Roos RUL 50% aanstelling
050	Prof.dr. G.K. Miley	Studies van extragalactische jets met de Hubble Space Telescope	Dr. N.F. Jackson RUL, 50% ASTRON 50% SRON
051	Prof.dr. G.K. Miley Prof.dr. P.T. de Zeeuw	Formatie van melkwegstelsels	Dr. M.J. West RUL
052	Prof.dr. P.T. de Zeeuw Dr. L. Braes Dr. J. Lub Drs. R. le Poole	Structuur en evolutie van OB associatles	Drs. A. Brown RUL
053	Prof.dr. T. van Albada	Standaard calibratie en fysische principes van de Tully-Fischer relatie	Drs. M.H. Rhee RUG
055	Dr. W. Jaffe	Dynamica van de kernen van elliptische stelsels	Drs. F.C. van den Bosch RUL
056	Prof.dr. G.K. Miley Prof.dr. A.G. de Bruyn	Superclustering in het vroege heelal	Drs. R.B. Rengelink RUL (vanaf 16/4)
057	Dr. P.D. Barthel	Elfs versus QSOs: leidt extreme stervorming tot QSO aktiviteit	Drs. J.P.E. Gerritsen RUG (vanaf 1/5)

UK/NL detacheringen

Code 782-374	Plaats van detachering	Funktie	Naam van de onderzoeker
001	Royal observatory Edinburgh	liaison astronoom	Dr. K. Hummel (tot 30/6)
003	ING La Palma	support astronoom	Dr. R.G.M. Rutten (vanaf 1/5)
004	JCMT Hawaii	support astronoom	Dr. R.P.J. Tilanus (vanaf 1/4)

Radio Astronomical Station of Noto (Siracusa), Italy

Dwingeloo colloquia 1993

Prof Adriaan Blaauw (Rijks Universiteit Groningen)
"De Leidse astrometrie expeditie naar Kenia rond de jaren 50"

Drs Lex Kaper (Universiteit van Amsterdam)
"Wind variability in O-type stars"

Dr Chris Carilli (NRAO)
"Low redshift quasars absorption line systems"

Dr Bikram Phookun (University of Maryland)
"NGC 4074 and NGC 4254: Two interacting spiral galaxies with m=1 modes"

Technisch Colloquium (NFRA)
"Het RadioAstron Project"
- Richard Schilizzi: Inleiding
- Lout Sondaar: Ontvanger
- Jan Buiter: Test Set
- Jean Casse: Betrouwbaarheid

Dr Harvey Liszt (NRAO Charlottesville)
"New patterns of high velocity gas flow near the galactic centre"

Dr Uwe Herbstmeier (Bonn University)
"High Velocity Clouds interacting with the galactic disk and halo gas"

Prof Vincent Icke (Rijks Universitet Leiden, Universiteit van Amsterdam)
"Jets, collimated at last!"
"Zwarte gaten: knippen en plakken met ruimte en tijd"

Dr John Heise (SRON Utrecht)
"The Dutch-Italian X-ray satellite SAX: instruments and observational possibilities"

Dr Jayaram Chengalur (Cornell University)
"A study of Wide Isolated Galaxy Pairs"

Dr Stefan Wagner (Heidelberg)
"Implications on quasar structure from rapid radio-to-Xray variability"

Prof Jacqueline van Gorkom (Columbia University)
"Evolution of the gaseous content of the Universe"

Prof Leonid Matveenko (Space Research Institute, Moscow)
"VLBI Research in the former Soviet Union"

Drs René Genee (NFRA Dwingeloo)
"Popularisering van wetenschap in Nederland"

Dr Remo Tilanus (NFRA Hawaii)
"SYBASE: Use of a commercial database package for data reduction with the Caltech mm array"

Dr Peter Hoyng (SRON Utrecht)
"PRISMA: A new ESA mission for stellar seismology and stellar activity"

Dr Sergei Pogrebenko (JIVE Dwingeloo)
"Detectability of gravity waves by means of radio scintillation"

Dr Jean-Francois Lestrade (Meudon, France)
"Latest results in VLBI astrometry"

Dr Friso Olnon (NFRA Dwingeloo)
Technisch colloquium: "Software tools in Dwingeloo"

Drs René Genee (NFRA Dwingeloo)
"Nederlandse Zonsverduistering expedities aan het begin van deze eeuw"

Stephan van Someren (HTS Enschede)
Technisch Colloquium: "Ontwerp en realisatie van een 4.5-9.0 GHz lage-ruis versterker"

Dr Maria Rioja (JIVE Dwingeloo)
"Differential astrometry on the pair of radio sources 1038+528 A and B"

Dr Daniele Dallacasa (JIVE Dwingeloo)
"Compact Steep-spectrum Sources (CSS)"

Dr Kurt Weiler (Naval Research Laboratory, Washington D.C.)
"SN1993J: Star of the 90's"

Dr Chris Taylor
"A survey of a complete sample of HII Galaxies, to detect HI companions"

Dr D.Saikia (NCRA/TIFR, Pune, India)
"Polarisation observations of extra-galactic radio sources."

Ger van Diepen (NFRA Dwingeloo)
"The AIPS++ Table System"

Dr Remo Tilanus (NFRA Hawaii)
"Molecules, dust and Blue Hawaii's: Astronomy with the JCMT"

Dr Alok Patnaik (MPI Bonn)
"Radio observations of Gravitational Lenses"

Dr Diane Wooden (NASA-Ames, USA)
"Dust in SN1987A"

Dr David Helfand (IOA, Cambridge, UK)
"The origin of the Cosmic X-ray Background"

Serie "algemene voordrachten voor ASTRON personeel"
Deel 1: Motivatie voor radio sterrekunde (Dr. T.A.Th. Spoelstra)
Deel 2: Van waarneem-voorstel tot publikatie (Ir. A.J. Boonstra)
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Deel 4: Gegevens verwerking (Dr. T.A.Th. Spoelstra)

Robert Geller (UC at Santa Barbara, USA)
"The state of the Intergalactic Medium, and a search for cosmological haloes"

Research & development projects

Principal instrumental projects under development in the Dwingeloo R&D laboratory in 1993 are the following:

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Multifrequency frontend	Ir. G.H. Tan	Dr. R.G. Strom	<tan>, <strom>
LNA	Ir. B. Woestenburg	Dr. R.G. Strom	<woestenburg>
RadioAstron	Ir. L. Sondaar	Prof.dr. R.T. Schilizzi	<rts>
EVNFRA correlator	Dr. ir. A. Bos	Prof.dr. R.T. Schilizzi	<bos>
DZB project	Dr. ir. A. Bos/Ir. A. Kokkeler	open	<kokkeler>
Pulsar backend	Ir. J. Bregman	Prof.dr. M. vd Klis	<jbregman>
DAS hardware	Dr. ir. A. Bos	Dr. D. Little	<bos>
DAS software	Drs. H. v. Someren -Gréve	Dr. W. Dent	<greve>
Newstar	Ir. J.E. Noordam	Prof.dr. A. de Bruyn	<jnoordam><ger>
AIPS++	Ir. J.E. Noordam		<jnoordam>

Secondments

These employees are stationed outside the Netherlands.

La Palma, operations Isaac Newton Group

1.	G.P.J. Benneker	ASTRON	computer technician	1 dec 91	1 dec. 95
2.	J. Haan	ASTRON	mechanical technician	1 aug 87	1 aug. 95
3.	R. Peletier	RUG	support astronomer	1 juni 93	1 juni 95
4.	R.J. Pit	ASTRON/RUL	electronics engineer	1 aug 86	-
5.	R.G.M. Rutten	ASTRON-subsidy	support astronomer	1 mei 93	1 mei 98
6.	P.H. v.d. Velde	ASTRON	programmer	1 okt. 84	1 okt. 94

Royal Greenwich Observatory

1.	E.J. Zuiderwijk	RUG	liaison astronomer	permanent

Hawaï, operations James Clerk Maxwell Telescope

1.	F. Baas	RUL/ASTRON	support physicist	1 aug. 89	1 aug. 95
2.	R.P. Millenaar	ASTRON	elektronics engineer	1 aug. 93	1 aug. 94
3.	R. Tilanus	ASTRON-subsidy	support astronomer	1 april 93	-
4.	D. Urbain	ASTRON	mm wave engineer	1 nov. 93	-

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Abbreviations

AAT	Anglo Australian Telescope
ADAM	Astronomical Data Analysis & Management system
AGB	Asymptotic Giant Branch
AGN	Active Galactic Nuclei
AIPS	Astronomical Image Processing System
AOS	Acousto Optical Spectrograph
ASTRON	Stichting Astronomisch Onderzoek in Nederland
ATNF	Australia Telescope National Facility
AU	Astronomical Unit (= afstand aarde - zon)
BHB	Blue Horizontal Branch
BLR	Broad Line Region
Caltech	California Institute of Technology
CAT	Coudé Auxiliary Telescope
CCD	Charge Coupled Device
CCI	Comité Cientifíco Internacional (La Palma/Tenerife)
CCIR	Comité Consultatif International Radio Communication
CESRA	Committee of European Solar Radio Astronomers
CIT	Calafornia Institute of Technology
CLRO	Clark Lake Radio Observatory
CRAF	Commission on Radio Astronomical Frequencies
CSIRO	Commonwealth Scientific & Industrial Research Organization
CSS	Compact Steep Spectrum source
DAS	Dwingeloo Autocorrelation Spectrometer
DCB	Digital Continuum Backend
DLB	Digital Line Backend
DMA	Direct Memory Acces
DRAO	Dominion Radio Astronomy Observatory
DWARF	Dwingeloo/Westerbork Astronomical Reduction Facility
DWOFS	Dwingeloo/Westerbork OFfline System
DXB	Extended Digital Line Backend
EFOSC	ESO Faint Object Spectrograph and Camera
ESA	European Space Agency
ESF	European Science Foundation
ESO	European Southern Observatory
EVN	European VLBI Network
FAST	Fundamental Astronomy by Space Techniques consortium
FET	Field Effect Transistor
FFT	Fast Fourier Transform
FITS	Flexible Image Transport System
FK4	Vierde Fundamentele Katalogus van sterposities
FWHM	Full Width Half Maximum
GB-E	Gebiedsbestuur Exacte wetenschappen NWO

GHRILL	Ground based High Resolution Imaging Laboratory
GIPSY	Groningen Image Processing System
GPS	Gigahertz Peaked Spectrum
HI	Ongeïoniseerde (neutrale) waterstof
HII	Geïoniseerde waterstof
HPBW	Half Power Beam Width
HVC	High Velocity Cloud
IAC	Instituto de Astrofysica de Canarias
IACG	Inter Agency Consultative Group
IAU	International Astronomical Union
IC	Integrated Circuit
IFA	Institute For Astronomy, Hawaii
IKI	Space Research Institute, Moskou
ING	Isaac Newton Group of telescopes
INT	Isaac Newton Telescope
IPCS	Image Photon Counting System
IR	InfraRood
IRAF	Image Reduction and Analysis Facility
IRAS	InfraRed Astronomical Satallite
IRS	Intermediate Resolution Spectrograph
ISM	InterStellar Matter
ITR	Internal Technical Report
IUCAF	Inter Union Commission for the Allocation of Frequencies
IUE	International Ultraviolet Explorer
IVS	International VLBI Satellite
JCMT	James Clerk Maxwell Telescope
JIVE	Joint Institute for VLBI in Europe
JKT	Jacobus Kapteyn Telescope
JPL	Jet Propulsion Laboratory
Jy	Jansky
KPNO	Kitt Peak National Observatory
LAG	Lovers of Active Galaxies
LBDS	Leiden Berkeley Deep Survey
LINER	Low Ionazation Nuclear Emission Regions
LMC	Large Magellanic Cloud
LO	Locale Oscillator
LST	Local Sidereal Time
LWG	Landelijke WerkGemeenschap
MIDAS	Munich Image Data Analysis System
MIT	Massachusetts Institute of Technology
MOST	Molonglo Synthesis Telescope
MPIfR	Max Planck Institut für Radioastronomie
MWLCO	Mount Wilson & Las Campanas Observatories
NAC	Nederlandse Astronomen Club
NASA	National Aeronautics and Space Administration

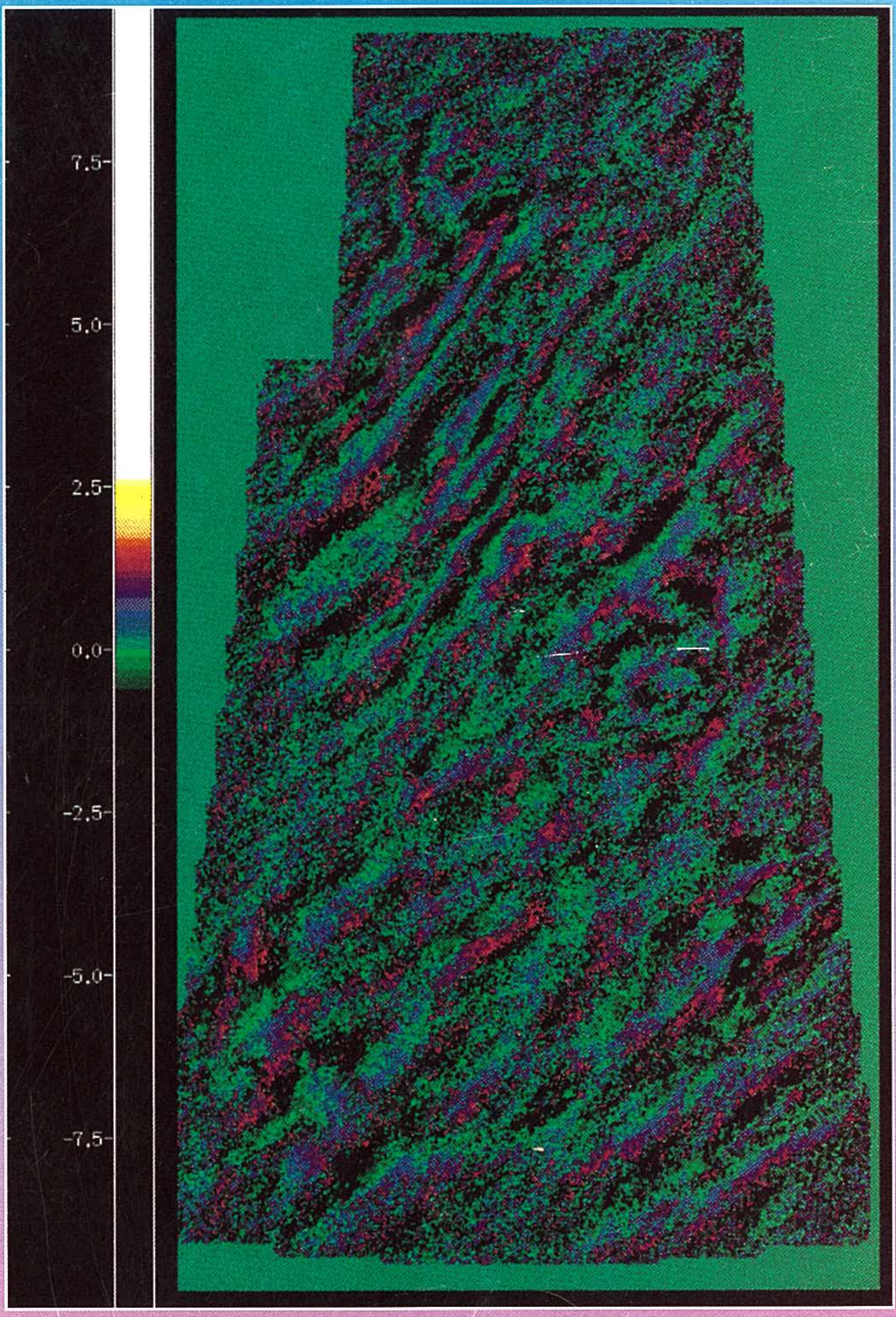
NCA	Nederlands Comité Astronomie
NFRA	Netherlands Foundation for Research in Astronomy
NGC	New General Catalog
NLR	Narrow Line Region
NOAO	National Optical Astronomy Observatories (USA)
NRAO	National Radio Astronomy Observatory (USA)
NRC	National Research Council (Canada)
NSF	National Science Foundation (USA)
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek
OVRO	Owens Valley Radio Observatory
PATT	Panell for Allocation of Telescope Time (UK/NL)
PC	Programma Commissie
pc	parsec
PSS	Palomar Observatory Sky Survey
QSO	Quasi Stellar Object
Quasar	QUAsi StellAr Radio source
RAL	Rutherford Appleton Laboratories
RAS	Royal Astronomical Society (UK)
RF	Radio Frequency
RGO	Royal Greenwich Observatory (UK)
ROG	Ruimte Onderzoek Groningen (SRON)
ROL	Ruimte Onderzoek Leiden (SRON)
ROU	Ruimte Onderzoek Utrecht (SRON)
RSN	Radio Super Nova
RUG	Rijks Universiteit Groningen
RUL	Rijks Universiteit Leiden
SATSI	Segmented Aperture Tilted Shearing Interferometer
SCASIS	Seeing Cell Aperture Synthesis Imaging Spectrometer
SERS	Science and Engineering Research Council (UK)
SEST	Swedish ESO Submillimetre Telescope
SMC	Small Magellanic Cloud
SNR	Super Nova Remnant
SRON	Stichting Ruimte Onderzoek Nederland
SRT	Synthese Radio Telescoop
ST-ECF	Space Telescope European Coordinating Facility
STScI	Space Telescope Science Institute
TAP	Technical Advisory Panel (JCMT)
TNO	Toegepast Natuurwetenschappelijk Onderzoek
TWG	Technical Working Group (VLBI)
UCB	University of California at Berkeley
UGC	Uppsala General Catalog
UKIRT	United Kingdom Infrared Telescope
URSI	Union Radio Scientifique International
UU	Universiteit Utrecht
UV	Ultra Violet

UvA	Universiteit van Amsterdam
VLBI	Very Long Baseline Interferometry
VUA	Vrije Universiteit Amsterdam
WARC	World Administrative Radio Conference
WENSS	WEsterbork Northern Sky Survey
WGAR	Working Group on Astronomical Refraction
WHT	William Herschell Telescope
WSRT	Westerbork Synthesis Radio Telescope
YERAC	Young European Radio Astronomers Conference

Courtesy

H.J. Stiepel pp. 3 & 33, Aerophoto Eelde p. 6, M. Verheijen p. 8, A. Broeils, p.10, J. Kamphuis p.13, R. Swaters & R. Rand p. 14, r. Sancisi p. 15, Nuffield Radio Astronomy Laboratories p.18, MPIfR Bonn p. 22, Space Research Institute Moscow p. 28, Argyle/RGO p.29, Instituto di Radioastronomia pp. 32 & 74, Tomasz Sobecki p. 38, Metsahovi Radio Research Station p.44, Centro Astronómico de Yebes p. 50, Shanghai Astronomical Observatory p. 52, Onsala Space Observatory p. 56, Institut für Angewandte Geodäsie p. 62, Observatoire de Paris p. 70.

On 9 June the Joint Institute for VLBI (JIVE) in Dwingeloo was officially inaugurated. The Netherlands Foundation for Research in Astronomy hosts this institute which supports VLBI observations using the European VLBI Network. Throughout this annual report pictures of participating radio telescopes are displayed.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