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Extra issue

The Westerbork Synthesis Radio Telescope, photo: Harm Jan Stiepel
Netherlands Foundation for Research in Astronomy

This General Assembly of the IAU is being hosted by the entire Dutch astronomical community: the departments of astronomy at Amsterdam, Groningen, Leiden, and Utrecht, the Netherlands Laboratory for Space Research, and the Netherlands Foundation for Research in Astronomy (NFRA; in Dutch, ASTRON).

We at NFRA are especially pleased to welcome the IAU to the Netherlands during this signal period of our history. The Dutch community is in the detailed process of defining its future, both on the short term - up until 2000 - and for the period beyond. The IAU in general, and this Newsletter in particular, provides a good opportunity for our small community to tell colleagues from around the world about our current work and about our future plans, but also to explore possible future collaborations with an eye to maximizing the scientific return from our present and planned facilities.

Of special interest in the latter regard is our program with the Westerbork Synthesis Radio Telescope (WSRT). This telescope has a 3 km east-west baseline and a total collecting area equivalent nearly to a 100 m single dish. It played a central role in the 1970's and early 1980's in defining the internal structure and kinematics of spiral galaxies, including the identification of unseen mass in many of those systems. Among a long list of other claims to fame are indicating the first msc pulsar, first discovery of a supernova at non-optical wavelengths and first formaldehyde maser. Currently, the WSRT is engaged in two large surveys, WENSS and WHISP, which are described in detail elsewhere in this Newsletter. The WENSS will provide the community with a survey to unprecedented depth of the northern sky at 92cm, with partial coverage also at 49cm; the principal motivations for this survey is to locate candidate high redshift galaxies and candidate millisecond pulsars. The WHISP will provide HI content and kinematic information for a very large sample of spiral galaxies, with a view to defining empirically the systematics of rotation curves and the distribution of unseen matter, and of HI content generally, in these systems.

NFRA's technical laboratory in Dwingeloo specializes in high performance receiver systems for meter wave to sub-mm wave applications, in very high throughput digital electronics, and in advanced software to support its other programs. Our engineers are now fully occupied outfitting the WSRT with state-of-the-art, frequency agile and wide-band, tunable receiver systems, with a new large bandwidth backend spectrograph-correlator and with pulsar observing capabilities. These new capabilities, which are conceived to complement facilities at similar telescopes elsewhere, are further described in contributions to this Newsletter. They will extend the scientifically productive life of the telescope well into the next millenium.

Of special interest is the recent foundation of a new international facility in Dwingeloo. The NFRA is now host institute for the Joint Institute for VLBI in Europe, and we are collaborating with this new Institute, with Jodrell Bank, with NASA and with MIT/Haystack to develop the next generation (Mark IV) VLBI recording and correlator standards. As a result the European VLBI Network will soon be substantially more sensitive than the VLBA and other VLBI networks.

We have also begun to wrestle with the more distant future. How best to complement our use of the ESO VLT? The next generation of mm-arrays also promises much: how can we gain access? The next step at lower frequency clearly involves a large collecting area: a square kilometer will allow study of the evolution of HI in galaxies over cosmological time, permit investigation of of normal stars other than the sun at radio frequencies, and will provide spectacular mapping capabilities via VLBI techniques. Here is a development in which we might play a pivotal role: our experience with interferometric arrays, with low noise electronics and with the design and construction of massively parallel digital correlation electronics based on custom VLSI chips, provides a sound basis for the technology development to be required.

In recent years a guiding theme for our community has been that a multi-spectral approach to research, in which a wide variety of observational facilities and techniques in the various wavelength bands are applied to specific astronomical or astrophysical problems, is the most effective way to understand the Universe. Today, the NFRA supports this approach by operating the radio observatories at Dwingeloo and Westerbork, and by collaborating with international partners in the operation of the European VLBI Network, the Isaac Newton Group of optical telescopes on La Palma in the Canary Islands, and the James Clerk Maxwell (sub)mm telescope on Hawaii. Dutch researchers also make extensive use of the optical, infrared and (sub)mm observing facilities of the European Southern Observatory (participation in ESO is organized directly through the Dutch Ministry of Education and Science) and of ESA and SRON supported space observatories, with partial support for these activities from NFRA in the form of grants for employing graduate students and postdocs.

NFRA currently employs 109 staff and carries out most of its activities at its laboratory, which is split between the villages of Dwingeloo and Westerbork in the north-central region of the country. Here operations of the 25-m Dwin-
The Westerbork Telescope: More than an image maker

Richard Strom

For nearly 25 years, the Westerbork Telescope (Synthesis Radio Telescope, or WSRT) has provided astronomers in the Netherlands and around the world with data on radio signals emitted by objects spanning the breadth and depth of the universe. Designed as an east-west array for super-synthesis mapping, the instrument has been regularly upgraded and improved to keep it at the forefront of astronomical research. At the same time, its astronomer-users have discovered novel ways of employing the telescope for new ends, which often push it beyond its intended role of "merely" imaging restricted regions of the sky. The NFRA, which operates the WSRT, has now embarked upon an ambitious plan to vastly increase the flexibility and sensitivity of the instrument, enabling it to tackle the astronomical problems of the next century.

The observing facility inaugurated by the then-Queen Juliana on a bright June day in 1970 may seem indistinguishable from the row of 25 m paraboloids still nestled in a forest clearing in the northeastern province of Drenthe. But appearance can deceive! Except for the steel of the individual dishes, almost every part of the telescope has either been replaced or undergone major revision. What began a quarter of a century ago as a single wavelength (21 cm) narrow-band (4 MHz) continuum instrument has over the years developed into a multi-band (6, 18, 21, 49 and 92 cm wavelengths) radio telescope for broad frequency coverage in both continuum (up to 80 MHz bandwidth) and line (10 MHz or less). The addition of two new movable dishes in the mid-1970s (even the steel has been augmented!) both doubled the WSRT's angular resolution and increased its sensitivity. The total sensitivity improvement at the original 21 cm wavelength means that we are now able to detect continuum sources in a half-day measurement which would have required months of observing time twenty years ago.

Among the prime discoveries which the WSRT has made or participated in, we could mention: the first maps which revealed that galaxies like M51 have spiral arms in the radio continuum. The fact that some radio galaxies attain sizes of well over 1 Mpc. The existence of a medium dense enough to distort radio galaxies in rich galaxy clusters. Radio emission from long, narrow "jets" transporting energy from galactic nuclei to distant radio components. The presence of "dark matter" in spiral galaxies from their HI rotation curves. The first millisecond pulsar. The WSRT, through its participation in the EVN, has also contributed to the study of compact objects like the galactic binary system SS433 and extragalactic AGNs. And as for the future, the two major surveys in the continuum (WENSS) and line (WHISP), described in detail elsewhere in this Newsletter, will provide fundamental data for a variety of research projects.

The major instrumental project now under way to produce multi-frequency frontends (MFFEs) will provide the telescope with a frequency agility which has been a major deficiency up to now. When fully completed in 1998, the MFFEs will enable frequency switching in seconds, and will ultimately permit true dual-frequency operation at certain wavelength combinations. This will come with improved sensitivity at all wavelengths, wider frequency bands, and an extended set of wavelengths to choose from. Observing will be possible at 3.6, 6, 13, 18, 21, 49 and 92 cm, as well as in wide bands from 25 - 43 and 65 - 120 cm. The latter are intended for studying highly redshifted HI, and will be less suitable for polarization mapping than the former, which are designed to have low instrumental polarization throughout the entire primary beam.

The two wide-band low-frequency systems (known as the UHF receivers), in combination with the 21 cm channel, will enable the 21 cm HI line to be studied at redshifts which range from 0 to 4.5, with only a few gaps where interference is expected to make observing impractical. Within the UHF systems, it will be possible to observe with...
10 and 80 MHz bandwidths (although full exploitation of the 80 MHz option with high frequency resolution will have to await the next generation digital backend, which is now beginning to take shape on the drawing board). Because the UHF systems are relatively simple, they will be implemented in the first stage of the MFFE project, and observations should be possible within two years. Indeed, we have just extended the bandwidth of our 92 cm system, so it is already possible to observe between 310 and 390 MHz.

In addition to their obvious use in cosmological studies, the low frequency systems are important to pulsar studies. We will soon acquire a high time resolution backend specifically designed for observing pulsars. Because of its large collecting area when all 14 telescopes are tied together (the equivalent of a 93 m dish) and the low frequency potential, the WSRT should be a useful instrument for pulsar research. Besides the pulsar backend, as indicated above, our two other backends (one for line, one for continuum or broadband line) will have to be replaced if we are to fully utilize all the options which the MFFE's offer.

Next year the WSRT will celebrate its silver jubilee. A radio telescope old enough to be put out to pasture? Far from it! With proper maintenance the instrument will be able to produce good science while approaching its half century. (The venerable Dwingeloo Telescope is doing so as it nears its fortieth anniversary.) By expanding the arsenal of instrumentation we feel that Westerbork will be equipped to tackle an even wider variety of astronomical problems in the future than it was in the past.

The WENSS project

Ger de Bruyn, George Miley, Yuan Tang, Martin Bremer, Wim Brouw, Roeland Rengelink, Malcolm Bremer, Huub Röttgering

The Westerbork Northern Sky Survey (WENSS) is a large-sky survey being carried out at 92 and 49 cm with the Westerbork Synthesis Radio Telescope (WSRT). Some general parameters of the survey are listed in Table 1. At 92 cm WENSS should cover the sky north of declination 30° (an area of 10,000 square degrees) to a limiting flux density (5 σ) of 15 mJy. At 49 cm about a third of this area will be covered to approximately the same limiting flux density. The resulting catalogue will contain about 300,000 sources at 92 cm and 60,000 sources at 49 cm. This summer we will have completed the observations for about 75% of the survey area at 92 cm. At the end of the year we expect to have finished the reduction of about 40 to 50% of the survey.

The most important additional information that WENSS will provide compared to previous radio surveys and future planned surveys are:

- radio spectral information on an unprecedented number of sources over a substantial fraction of the sky
- positional accuracy sufficient for optical identification purposes for a large percentage of the catalogue sources
- information on the polarization of a huge sample of discrete radio sources
- data on faint extended polarization structure over a large region of the sky (galactic diffuse emission)
- limited data on the low-frequency variability of a large number of sources over timescales from hours to years.

We hope to finish the observations for the WENSS project in 1995. The reduction should be finished by the end of 1996. We expect that the first results of the survey will become available to the astronomical community in 1995. The WENSS product will consist of a catalogue of radio sources extracted from the survey and a set of FITS images (each 1024 x 1024 pixels covering 6 x 6 degrees at 92 cm). They will become available in both digital (DAT/CD-ROM) as well as graphical form (atlas). Images will be centered at the locations for the new Palomar Observatory Sky Survey plates. A variety of low resolution images will be made as well to facilitate comparison with other radio surveys.
<table>
<thead>
<tr>
<th>Region$^1$</th>
<th>92 cm</th>
<th>49 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta &gt; 30^\circ$</td>
<td>$\delta &gt; 30^\circ$, $b &gt; 30^\circ$</td>
<td></td>
</tr>
<tr>
<td>Limiting Flux Density (5 o)</td>
<td>15 mJy</td>
<td>15 mJy</td>
</tr>
<tr>
<td>No. of Sources Expected</td>
<td>300,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Polarizations</td>
<td>$I, Q, U, V$</td>
<td>$I, Q, U, V$</td>
</tr>
<tr>
<td>Nominal Resolution</td>
<td>$55'' \times 55'' \csc(d)$</td>
<td>$30'' \times 30'' \csc(d)$</td>
</tr>
<tr>
<td>Expected Positional Accuracy (Strong Sources)</td>
<td>$2'' \times 2'' \csc(d)$</td>
<td>$1'' \times 1'' \csc(d)$</td>
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</table>

Table 1. Some of the general parameters of WENSS. $^1$ The region indicated for 49 cm is our goal in which we may not succeed in completing. There will, however, be many fields outside this area.
Scientific drivers
The unique aspects described above will make WENSS an important and fundamental database for tackling a wide range of astronomical problems. It is expected that this will lead to exciting new science in the following areas.

Radio spectra
WENSS will provide spectral information both internally (325/610 MHz) and by comparison with previous radio catalogues at other frequencies. In combination with available (6C/7C at 151 MHz, GB at 5 GHz) and planned (VLA-D at 1.4 GHz) higher frequency surveys this will permit the study of very large numbers of the following types of radio sources:

- Ultra-steep spectra sources with indices between -1.3 and -3. Such spectra are often seen in the most distant radio-galaxies, in radio sources which populate rich clusters and in pulsars. The oldest extragalactic radio sources are also believed to have ultra-steep spectra.

- Flat spectrum sources at low flux levels. Most flat spectrum sources are identified with quasars and BL Lac-type objects. One of the many uses of such a sample is the search for radio-loud gravitationally lensed objects. The selection of flat spectrum sources increases the chance of finding lenses suitable for detailed mass-modelling and determination of the Hubble constant.

- Peaked-spectrum sources with maxima in their spectra at a few 100 MHz (CSS peaker) and a few GHz (GPS peaker). This is a little-studied but important class of extragalactic radio sources which have typical sizes of ten to a few hundred parsecs and are probably undergoing vigorous interaction with the media of their parent galaxies. There is good evidence that, just as in the case of the ultra-steep spectra, peaked radiospectra may be a pointer to high-redshift objects.
Positional accuracy
Apart from reaching fainter sources the WENSS will also yield superior positional information (from 5-10" for the faintest sources to better than 2" for the brighter ones). In a large fraction of the sources this will be sufficient for obtaining optical identifications. Comparison of the positions of such an large number of radio sources with digital versions of the deep optical sky survey now being produced and with large-sky catalogues in the X-ray (ROSAT) and infrared (IRAS) regions will be important for many classes of extragalactic and galactic studies. In addition, for many years to come, WENSS will be a database for searching for radio emission from objects discovered in non-radio regions of the electromagnetic spectrum.

Giant radio galaxies
The WENSS survey has already detected many tens of radio sources with angular sizes of order 10" or more. Most of these will probably turn out to be giant radio galaxies with linear size of 1 Mpc or more.

Radio bright spiral galaxies
Cross correlation of the WENSS survey with e.g. the Nilsson catalogue of bright galaxies will produce thousands of objects with information about spiral galaxy disks and halos. The study of the nonthermal disk-halo connection can then be undertaken on large samples of edge-on objects. In addition, the selection of samples of nearby galaxies via an obscuration-free emission component will be useful in studies where extinction is a complicating factor.

Polarization
The sensitive polarization information coupled with the large number of sources give WENSS unique capabilities in searching for radio sources having (anomalously) high linear polarizations at low frequencies. These include pulsars as well as interesting variable extragalactic radio sources. The noise level achieved in linear polarization is about 2 mJy which will permit the detection of thousands of polarized sources. In addition, the sensitivity to extended structure (up to one degree) will make it possible to make a panoramic view of the diffuse polarized galactic foreground emission.

Variability
Although not primarily intended to search for variability, the mosaicing technique on which WENSS is based means that information on source variability is available on a variety of timescales ranging from hours to months. The edges of adjacent mosaics, observed in different years of the survey, will also contain information about long term source variability. The survey is thus expected to yield new information about low frequency variability of both galactic and extragalactic sources (pulsars, flare stars, SS433-likes, low-frequency variable AGN etc). In addition, WENSS could detect new classes of variable radio sources.

General statistical studies
A combination of WENSS with existing large-sky radio catalogues will produce radio colour-colour diagrams which will enable large numbers of all these sources to be selected to flux levels fainter by at least an order of magnitude than was previously possible. Using the radio spectral information these various types of sources can be separated. This should provide valuable new data about the evolution of the space density of distant galaxies. In addition, WENSS will allow for the first time studies of large-scale clustering of radio sources to be made which take into account the radio colour discriminant and optical identification information.

The mosaicing concept: observations and reductions
To image large areas of the sky with the WSRT within a reasonable amount of time we make use of the mosaicing technique whereby the array is repeatedly stepping through a fixed pattern (a mosaic) on the sky in a relatively short time. At the long wavelength of 92 cm the individual pointing centres are separated by about 1.3 degrees, which is about half the primary beam width of the individual dishes. In a time span of 40 minutes we steer the 14-element array through a mosaic with 80 fields covering a region of about 10 x 14 degrees in size. At each field we integrate for 20 seconds followed by 10 seconds to move the array to the next field. The net observing efficiency is therefore 67%. In 12 hours we thus accumulate 18 observations for each field. In order to bring down the sidelobe confusion to acceptable levels each mosaic is observed for 6 x 12 hours, with different array configurations. This typically takes six weeks. The starting field during each 12 hour observation is optimized to get uniform coverage of the UV-plane leading to very low (<1%) sidelobe levels.

The reduction of the data is done in Dwingeloo on a dedicated HP730 workstation with about 3 Gbyte of disk space. All data are selfcalibrated to remove ionospheric and instrumental phase errors. Subsequent analysis, including the production of the catalogue, is done at Leiden Observatory.

Some first results
In many of the fields referred to above some interesting results have already been obtained.

Figure 1 shows a contour image of the largest new radio source discovered thusfar. It has been identified with a Markarian galaxy whose redshift indicates that the radio source is about 2 Mpc in diameter.

Figure 2 shows a picture of the radio source identified with NGC 6048 (4C70.19), a nearby elliptical galaxy. To our knowledge this source has not been identified previously.

Figure 3 shows a picture of the polarized intensity (at 4" resolution) of part of a mosaic in the galactic anti-centre. It
Dark matter and neutral hydrogen in spiral galaxies:  
The WHISP Program

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.

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. 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 (van Albada 1986).

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.

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.
(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 featureless 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 that spirals with declining rotation curves outside the optical radius all have centrally con-densed light distributions. The shape of the mass distribution outside the optical radius is closely 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 matter 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 (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, Rheee 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. One of the most striking examples is 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.

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 2) 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 3259. 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.

**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.
WSRT off-line reduction software: NEWSTAR and AIPS++

Jan Noordam

The NFRA is changing its approach to WSRT users, in order to maximise the scientific output of the WSRT. It is hoped that a more active involvement of the users, and a widening of the userbase, will lead to innovative ways of using the telescope. An important element in this endeavour is the use of the same data reduction package in Westerbork, Dwingeloo and the User Institutes. Such unification is expected to lower the existing barriers between WSRT users and the various groups of NFRA support staff. Ultimately, the 'World Reduction Package' Aips++ will be used in this role. It will enormously increase the world-wide accessibility of the WSRT.

Some history

In the seventies, NFRA was much admired for its enlightened policy of doing the calibration and imaging of WSRT data as a service to users. There were some good reasons for this: at that time users were not able to do it properly, and it is also a lot of extra work to write, export and document user-friendly reduction software. The policy worked well as long as the Reduction Service was based at the most active user institute (Leiden), and as long as users were prepared to take great pains to get WSRT data. But in the eighties, with the move of the Reduction Group to Dwingeloo, and the rise of competing telescopes and wavelength areas, the policy backfired. Users did not like to wait for, and argue with, a distant service group. Especially as this group did not always represent the most acute experience, or use the most modern software methods available. Worse, because of their remoteness from uv-data, the new generation of WSRT users did not acquire a deep and intuitive understanding of aperture synthesis any more, and was no longer able to propose new ways to use the WSRT. Partly as a result of all this, the use of the WSRT gradually sunk to a level that did not do justice to its capabilities and its place in the world.

Newstar

In the nineties, the lesson has been learned, and the software policy has changed as part of the general upgrade of the telescope. Following the example of AIPS, the WSRT off-line data reduction package NEWSTAR (Netherlands East West Synthesis Telescope Array Reduction) is now actively exported, on various computer platforms, to any institute with at least one demonstrably active user. Moreover, NEWSTAR is used internally by the new WSRT Science Support group (the former Reduction Group, with new tasks), and by the Observing Group in Westerbork. NEWSTAR now serves as a kind of 'lingua franca' between WSRT users and the two WSRT service groups. Combined with the new user experience of calibrating and reducing their own WSRT data, and the occasional observing trip to Westerbork, this has lead to a much greater involvement with the telescope. Not unexpectedly, this trend has coincided with an increased (and more informed) demand for telescope time.

NEWSTAR contains most of the modern software techniques to reduce aperture synthesis uv-data, including various forms of Selfcal, external calibration, continuum subtraction, mappaking etc. It is designed to make the most of WSRT data, with special emphasis on strong points like polarisation, mosaicking and dynamic range. It also has some tools for image analysis, and outlets (via FITS and UVFITS) for further analysis with packages like AIPS or GIPSY. NEWSTAR will be actively supported by 2-3 full-time people, until it can be replaced by Aips++.

Aips++

Although the emphasis on NEWSTAR represents a substantial improvement for WSRT users and support staff, it cannot be the final solution to the software problem. NFRA has insufficient means to write and export the kind of reduction package that users have come to expect. Apart from excellent 'programmability' for the continuous development of complex new functionality, such a package would feature a modern Graphical User Interface (GUI) and Command Line Interface (CLI), support for parallel and distributed processing, a large increase of image analysis tools, visualisation, etc. Moreover, users do not really want to learn the idiosyncrasies of 'yet another package', and would prefer to reduce their data with a package that they already know.

Since these problems are shared by all the other major (and minor) radio observatories, they have decided to pool their resources with the aim of writing and exporting the next generation 'World Reduction Package' together. At present, the Aips++ Consortium has seven members: ATNF, BIMA, DRAO, NFRA, NRAO, NRAO and TIFR. The project management resides at the Aips++ Centre, which is hosted by NRAO in Charlottesville. The first two years have been spent in learning the new software technology of Object-Oriented Programming (including the language C++), and in building up the necessary infrastructure for the various Application Development Streams to function. At this moment, there are four semi-independent ADS's: UVCI (uv-calibration and imaging), SDCI (single dish calibration and imaging), IMAL (image analysis) and VISU (visualisation). NFRA is primarily interested in UVCI, although it makes a relatively large contribution to the Aips++ infrastructure too, and presently chairs the Steering Committee.
The first full release of Aips++ (version 1.0) is expected by the end of 1995. If this is achieved, which is not entirely certain yet, the package will have been produced in a record four years. After that, it will probably take at least another year before Aips++ is fully stable. Until then, NEWSTAR will continue to represent the 'cutting edge' of WSRT off-line data reduction.

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The Joint Institute for VLBI in Europe

A little more than one year ago, the Joint Institute for VLBI in Europe (JIVE) was officially opened in Dwingeloo by a senior official of the Netherlands Ministry of Education and Science in the presence of more than 80 distinguished guests from seven European countries. JIVE will be the home to a large (16 station) modern VLBI data processor for the European VLBI Network (EVN), and the support centre for EVN and global array users.

The construction of the data processor is the first phase of a major upgrade of the EVN which, in classic European style, has been funded from a variety of multi-national and European Union sources. The opening ceremony was a celebration of success in the somewhat long-winded process of fund raising rather than the actual opening of new premises. The second phase of the upgrade, now being planned, will improve the performance of the individual telescopes in the EVN.

The NFRA in Dwingeloo is the host institute for JIVE and will provide accommodation in the new building for the data processor and for the operations staff and visitors. JIVE is itself an independent scientific foundation with an International Board of Directors, chaired by Prof. Roy Booth of the Onsala Space Observatory in Sweden, to oversee the institute's activities. The Director of the NFRA, Prof. Harvey Butcher, is a member of the JIVE Board.

Data Processor

It will be an X-F type (multiplication followed by fourier transform) correlator designed to handle a maximum of 32 stations times 256 Mbit/sec per station or 16 stations times 1 Gbit/sec or 8 stations times 4 Gbit/sec (if we could record at that rate). Current funding will restrict the size of the correlator to a maximum of 16 stations. One of the standard continuum modes is expected to be 16 station dual polarisation, two-bit/sample recording at 128 MHz bandwidth per polarisation for a data rate per station of 1 Gbit/sec. The spectral resolution for line work can be characterised by saying that there is the capacity for 128 complex frequency points per baseline per Stokes parameter for 16 stations. Recirculation of the data through the correlator to increase the spectral resolution up to a factor of 16 will be possible. The EVN data processor project is benefiting from a collaborative agreement called the International Advanced Correlator Consortium between JIVE, the MIT Haystack Observatory, NFRA and NASA. Under this agreement, Haystack is responsible for the development of a new advanced correlator chip, the associated correlator board, and a number of auxiliary boards, and JIVE and NFRA are responsible for the interface unit between the playback units and the correlator (called the EVN/Mk1V Station Unit) and the remaining auxiliary boards. JIVE's role is to coordinate hardware and software activity at NFRA, Jodrell Bank in the UK and the Medicina and Noto observatories in Italy. The correlator board will be used in the EVN and Haystack correlators as well as in the new Westerbork DBZ backend and the Smithsonian Sub-mm Array correlator.

The main elements of the data processor are the playback units, station units, and the correlator itself:

- 16 MkIV/VLBA-compatible playback units have been ordered from Penny & Giles Data Systems Ltd (UK) for delivery between February 1995 and March 1996.
- the station units decode the track-based signal streams coming from the playback units, restoring them into channel-based sample streams as if they had never been recorded. The station units are being procured in two phases, the first a development contract in industry leading to two prototypes each for JIVE and Haystack, the second a production contract for the total number of units required. Penny and Giles Data Systems Ltd (UK) have been awarded the contract for the first phase.
- the correlator consists of the correlator proper preceded by a data distributor which allows a flexible assignment of signal streams to correlator segments and also does the recirculation to increase spectral resolution.

Other segments of the project are:

- the online software allowing communication between the correlator control computer and the hardware, as well as the interface between the correlator operators and the data processor, is being developed using the object-oriented concepts of Rumbaugh et al.
- offline software. On the longer term, we expect to make use of AIPS++ for offline data reduction at JIVE. In the meantime, visitors to JIVE will make use of the standard AIPS and the Caltech package including DIFMAP.

We expect the data processor to begin operation in 1997.
MkIII A to MkIV recording terminal upgrade

The conversion of the EVN MkIII A recording terminals to MkIV is also underway as part of phase 1 of the upgrade. Haystack have recently demonstrated the first fringes between two telescopes recording with the MkIV system at 1 Gbit/sec. The upgrade from MkIII A to MkIV is being accomplished by replacing the MkIII formatter with a MkIV formatter designed at Haystack, recording with two headstats, and carrying out some mechanical upgrades to the tape recorder to allow it to operate at high speed (330 ips) with thin (16µ) tape. Modes of operation for MkIV include all of the VLBA modes. There are two major goals for such an upgrade:

• to provide as large a measure of compatibility with the VLBA as possible on as short a timescale as possible, and
• to provide the path to wide-bandwidth recording needed for the EVN correlator.

We anticipate completing the conversion in the first quarter of 1995.

Support Scientists

Three EVN Support Scientists have been appointed. EVN users are assigned a support scientist at the time his or her proposal is scheduled for observation. The user can call on the support scientist for assistance in all aspects of the project, in particular, scheduling the observations, and post-correlation data analysis. Technical assistance with the preparation of proposals can also be provided by the JIVE support staff. We hope to see many VLBI investigators visiting Dwingeloo for their data analysis (see below).

EVN travel support

A grant from the EU allows us to support the travel of VLBI investigators to Dwingeloo for discussion of and assistance with their data reduction. We anticipate that some of this grant will also be available to (partially) support other EVN-related travel within Europe to discuss results, write papers, etc.

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The Leiden/Dwingeloo Survey of HI in our Galaxy

Dap Hartmann and Butler Burton

A survey of the HI sky north of δ > -30° has been carried out using the 25-m radio telescope of the Netherlands Foundation for Research in Astronomy, located in Dwingeloo. The spatial resolution of the new survey is determined by the HPBW of the antenna, which is 35'2 or 0.6 at 1420 MHz, and by the true-angle grid-spacing of 0.85 in both l and b. The spectral resolution of the survey is determined by the spacing of 1.03 km/s between each of the 1024 channels of the DAS Dwingeloo Autocorrelator Spectrometer, developed by Albert Bos of NFRA.

The useful kinematic range of the survey extends between velocities (measured with respect to the Local Standard of Rest) of -450 km/s and +400 km/s, and thus embraces the regime of high-velocity and intermediate-velocity clouds as well as the regime of galactic gas with conventional kinematic behaviour. The rms brightness temperature intensity sensitivity of the survey is about 0.07 K, and was achieved in 180 seconds of integration. The receiver used was similar to those used on the Westerbork Synthesis Radio Telescope. The system temperature was typically 35 K. The data have been corrected as indicated below for contaminating radiation entering the near- and far sidelobes of the antenna.

Parameters of the Survey:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sky coverage</td>
<td>all sky at δ &gt; -30°</td>
</tr>
<tr>
<td>Number of spectra</td>
<td>~ 250,000</td>
</tr>
<tr>
<td>Telescope beam size</td>
<td>36 arcminutes</td>
</tr>
<tr>
<td>Δb spacing</td>
<td>0.5</td>
</tr>
<tr>
<td>Δl spacing</td>
<td>0.85 cos (b)</td>
</tr>
<tr>
<td>Number of channels</td>
<td>1024</td>
</tr>
<tr>
<td>Δν per channel</td>
<td>1.03 km/s</td>
</tr>
<tr>
<td>Effective vel. coverage</td>
<td>-450 ≤ ν_{LSR} ≤ +400 km/s</td>
</tr>
<tr>
<td>System temperature</td>
<td>~ 38 K</td>
</tr>
<tr>
<td>Integration time</td>
<td>≥ 180 seconds</td>
</tr>
<tr>
<td>rms sensitivity</td>
<td>~ 0.07 K</td>
</tr>
</tbody>
</table>

These observational parameters of the Leiden/Dwingeloo survey represent an improvement over those of the Berkeley survey by about an order of magnitude in kinematic coverage and in sensitivity, and an improvement over those of the Bell Labs survey by about an order of magnitude in spatial and kinematic resolution. The material will be published by Cambridge University Press as an atlas of maps and as a FITS-format data cube on a CD-ROM. Figure 1 shows a representative slice through the Leiden/Dwingeloo datacube.
The 0.07 K rms limit on the measured intensities is about an order of magnitude less than the peak intensity characteristically entering the far sidelobes of the Dwingeloo antenna; at lower l/b, it is typically two orders of magnitude less than the peak intensity entering the near sidelobes of the antenna. The rms sensitivity achieved clearly can only be exploited if the data are fully corrected for contamination by stray radiation. The correction involved convolving the measured antenna pattern with the measured all-sky HI emission. Such a correction is by no means a trivial matter, as it requires extensive measurements of the antenna response to a strong source of continuum radiation as well as completion of the all-sky HI survey which then serves as input to the boot-strap correction. The algorithm used in application of the stray-radiation correction is the one developed by Peter Kalberla of the University of Bonn.

The Leiden/Dwingeloo HI survey is suited to a range of astronomical investigations. Several of the studies which motivated the survey are briefly mentioned here.

1. The warp of the outer gaseous layer of the Milky Way has been studied in some depth, but the signature of the warp extends to latitudes and velocities beyond the reach of earlier survey material. The sensitivity and kinematic coverage of the new all-sky HI survey will allow an improved description of the shape of the outer Galaxy. It is particularly important to establish the dust content in the warped outer Galaxy; the detailed kinematic coverage of the high l/b sky should allow separation of the local dust features, which are tightly correlated with the kinematic structures of local HI, from those contributed by interstellar material at large distances.

2. Several regions of exceptionally low total HI column depth have been identified, in addition to the one in Ursa Major studied by Lockman (et al.). These regions are important as low-extinction viewing ports to the extragalactic world. They are also important to discussions of turbulence and energetics of the gaseous disk and the lower halo of our Galaxy, and as regions where X-ray shadows cast by the HI gas may be studied.

3. The Leiden/Dwingeloo survey is the first to systematically encompass the kinematic range including the high- and intermediate-velocity clouds as well as the gas belonging to the conventional galactic disk. Relationships between the high-velocity and intermediate-velocity material will be investigated. The evident relationship of the IVC material with the conventional galactic disk gas will be given particular attention. Evidently dust cirrus features characterizing the IRAS survey generally have HI counterparts; it appears that many cirrus features have HI counterparts moving at velocities which are highly anomalous (compared to the kinematics which might be expected from a well-behaved galactic disk).

4. The motions and shapes of the structures characterizing the HI gas reveal important aspects of the macroscopic energetics of the interstellar medium. The extent of velocity information beyond the coverage and resolution available earlier shows that some of the structures, especially the large shell-like ones, can be traced over a larger kinematic extent than previously realized, suggesting an upward revision of the energetics involved. The topology and kinematics of the HI structures identified in the Lei-
Denn/Dwingeloo material will be investigated in terms of the areal filling factor. The kinematic resolution of the survey has revealed HI structures, isolated at high l/b, with exceptionally narrow velocity widths. There are only three molecular clouds known at high l/b which also show anomalous (l > 25 km/s) kinematics, but each of these clouds has an associated narrow HI structure. A finding chart defined by narrow (dispersion < 1 km/s) HI features might lead to additional interesting molecular features.

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The Telescopes at La Palma

Reynier Peletier and René Rutten

The Dutch astronomical community through NFRA has a share in the optical telescopes at the Observatorio del Roque de los Muchachos at La Palma, one of the major astronomical observatories in the world. La Palma is one of the western islands of the Canary archipelago part of Spain, about 1000 km South of Cadiz off the coast of Morocco.

The observatory

The observatory is situated at 2400m at the highest point of the island, and is characterised by excellent seeing conditions and a lack of light pollution from neighbouring cities. It harbours the telescopes of the Isaac Newton Group, in which the Netherlands is involved. This group consists of the 4.2m William Herschel Telescope (WHT), the 2.5m Isaac Newton Telescope (INT), and the 1m Jacobus Kapteyn Telescope (JKT). At the observatory also the 2.5 m Nordic Optical Telescope, the Swedish Solar Tower, the Carlsberg Meridian circle and a cosmic ray experiment (HEGRA) are situated. Currently under construction is the Italian 3.5m Galileo telescope. Furthermore, there are advanced plans to put the Utrecht Open Tower Telescope on this site, and in the more distant future Spain will build its 8m telescope here.

The Isaac Newton Group is a collaboration between the United Kingdom and the Netherlands. The UK generally gets 60% of the telescope time, Spain 20%, the Netherlands 15%, and 5% is international time, generally used for very large projects. The Isaac Newton Group employs about 65 people on the island.

Instrumentation and science at the ING

At the time of inauguration of the observatory, in the summer of 1984, the observatory consisted of the JKT and the INT; the latter had been moved from Herstmonceux in England to La Palma. The WHT was commissioned in 1988. It has a large number of first class instruments capable of providing spectroscopic observations with a spectral resolution ranging from 300 to 100 000, as well as imaging; usually more than one of the instruments are on-line, allowing imaging or high- and low resolution spectroscopy to be interleaved within minutes. Especially this multi-instrument versatility in combination with the excellent seeing condition makes the telescope very popular with astronomers. The JKT and INT both have common-user imaging and spectroscopic facilities as well. While the WHT is allocated in nights, the time on the two smaller telescopes is generally allocated in chunks of weeks.

The WHT has 4 focal stations, namely Cassegrain, two Nasmyth foci and Prime focus. Cassegrain focus is mainly used with the very efficient triple-beam ISIS spectrograph, used for intermediate and low-dispersion spectroscopy, spectropolarimetry, and imaging polarimetry. The Cassegrain instrument cluster also possesses an on-axis imaging port. One of the Nasmyth foci is equipped with the Utrecht Echelle Spectrograph (UES), for high-resolution spectroscopy. The other Nasmyth platform contains the GHRIL, a laboratory that currently is mainly used for experiments on high resolution imaging and adaptive optics. Other common-user instruments are a low dispersion multi object spectrograph, and a wide field Fabry-Perot imaging interferometer. Recently the Prime focus was commissioned as an imaging facility with automatic atmospheric dispersion.
correction optics. Of course all these instruments come with state-of-the-art CCD detectors and autoguiding facilities.

In the decade that the telescopes have been in use many scientific papers were written based on observations from our telescopes.

At the moment the number of refereed papers is close to 150 a year. Examples of work that has been done includes the discovery of distant quasars, the study of black holes in our galaxy and in the nuclei of nearby galaxies, the study of large scale structure in the universe, and detailed abundance studies of stars; the science done at the ING spans the range from solar system physics to the most distant objects in the universe. All data taken at the telescopes becomes public after 1 year, and can be requested from the La Palma Archive in Cambridge.

Future developments
The instrumentation on the telescopes of the ING is now in an advanced stage, but not finalized yet. In the short term a fibre spectrograph for the WHT prime focus will be available, as well as an IR imaging facility. Apart from purely instrumental developments the ING is actively pursuing the Half Arcsecond Project which aims at understanding and improving the seeing conditions at our telescopes, with the ultimate goal of fully exploiting the excellent atmospheric conditions on La Palma. In conjunction with the above mentioned seeing project an extensive Adaptive Optics program has been initiated which plans to deliver (in phases) a low-order and high-order IR/visible adaptive optics system on the WHT.

The young Observatorio de Roque de Los Muchachos with its expanding set of solar and stellar telescopes has proven to be one of the best sites in the world for astronomical observations. With the currently available equipment and future developments the observatory and the Isaac Newton Group of Telescopes will remain competitive for many years to come.

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James Clerk Maxwell Telescope

Remo Tilanus

For those who are not too familiar with this member of the Dutch astronomical facilities: the James Clerk Maxwell telescope is a 15-m high-precision radio- telescope operating at sub-mm wavelengths. In fact, it is the largest telescope in the world designed exclusively for use in that band with a frequency-range from 150 GHz (2.0 mm) up to 850 GHz (350 micron; 0.35 mm). The telescope consists of 207 panels with, in total, 800 motors enabling adjustments of the surface. The pointing accuracy currently is of the order of 1". Covering the frequency-range a continuum bolometer and a selection of line-receivers are available. Take all this and put it at the arguably best astronomical sub-mm site in the world, the 4 km high peak of Mauna Kea, an extinct volcano on the Big Island of Hawaii, and it should be clear that with the JCMT the astronomical community has access to a unique telescope. The telescope is part of the UK/NL collaboration with Canada and the University of Hawaii as additional partners.

What sort of astronomy can the JCMT be used for? In a nutshell, the physics of stellar environments, the cool interstellar medium (ISM), gas and dust in our Galaxy and external galaxies. The dust is mostly investigated by observing the spectrum of a source from 2.0 to 0.35 mm using the UKT14 bolometer system. An example is the search for true protostars, stars so immature that they are still accreting material from the cloud from which they are forming. The physical conditions of the cool (molecular) part of the ISM can be determined from observations of molecules in transitions like the CO(2-1), CO(3-2) and CO(4-3) lines, but also HCN, CS, and CI. Since each transition needs different excitation conditions (density, temperature, and chemical makeup), their relative line-strengths provide a sensitive probe of the ISM in star-forming molecular clouds or of the star-burst phenomenon in the nuclei of some galaxies. Similar, these lines can show us the conditions in outflow sources such as young and evolved stars. Cosmological applications are the variability of quasars and the sub-mm continuum of high-Z sources. Clearly this list is far from complete, but it perhaps gives some idea of projects currently being undertaken with the JCMT.

New instrumentation
Expected to be commissioned in 1994 is SCUBA, the Submm Common User Bolometer Array. This instrument represents the step from a single-photometer detector to an array detector. SCUBA will consist of two sets of bolometers: a 91 pixels-array optimized for 450 micron and a 37 pixels-array optimized for 850 micron. Both arrays can be used simultaneously. The bolometers are spaced 2 beam-widths apart, hence, for a fully sampled map 16 pointing-centres have to be observed 1/2 a beam apart. Specialized software will take care of the gridding of the observations into a regularly spaced map. The total field of view is 2 arcmins. In sensitivity each bolometer in SCUBA will be at least a factor of 10 better than UKT14, but the possibility to use flat-fielding techniques for the subtraction of the sky promises a larger overall improvement. For mapping SCUBA represents an improvement in speed by a factor of 10^5. Especially for the observations of distant and hopefully young galaxies and other high-Z objects SCUBA is going to be a major innovation. SCUBA is a facility unique to the JCMT.

Also the commissioning of the new dual-channel B-band (345 GHz) receiver B3 is expected. This state-of-the-art SIS receiver has an observing bandwidth of 1 GHz, twice that of the current B-band receiver, resulting in a velocity-range of 900 km/s. This is a very important improvement since it makes many more interesting sources, starburst galaxies, observable at this frequency. In addition to the wider band, the receiver has two channels enabling simultaneous observations of both polarisations and a possible improvement in sensitivity of a factor of 1.4.

Current instrumentation
The JCMT has now been in operation for five years and has matured into an increasingly more streamlined facility. Whereas the first years have been marred by teething problems as well as a lack of first-class receivers, the operation is now running smoothly. Even the weather can be cooperative with weeks-on-end stretches of %T(340) < 0.07. Such opacities enable routine observations with the newly commissioned 490 GHz receiver C2 e.g., of the CI and CO(J=4-3) transitions. Three state-of-the-art SIS mixer receivers form the core of the heterodyne program, A2 (230 GHz), B3i (345 GHz) and C2 (490 GHz). For the latter, the receiver temperature of about 190 K is worth a special mentioning. One other receiver, G (690/810 GHz), is available via collaboration with the MPE, Garching group.

The spectrometer backends are the digital autocorrelation spectrometer (DAS) which has 2048 delay channels having a total maximum bandwidth of 920 MHz in each of two inputs (currently in commissioning) and the AOSC which is an acousto-optical spectrometer which offers a resolution of about 330 kHz and a total bandwidth of 500 MHz for a single IF channel. Continuous observations can be made using the UKT14 bolometer system. Filters are available for 2, 1.3, 1.1, 0.85, 0.8, 0.75, 0.6, 0.45 and 0.35 mm. The aperture of the bolometer can be adjusted between 21 and
65 mm. Sensitivities range from typically 0.3 Jy/sqrt(Hz) through to 10 Jy/sqrt(Hz) or more under good photometric conditions.

The Dwingeloo Autocorrelation Spectrometer (DAS) has fully met expectations and is now the default backend for spectral line observations. The spectral line data reduction software (SPECX) has been upgraded to handle all DAS observations. Since DAS spectra can not readily be converted to FITS format owing to overlapping subbands, a subband-merging routine in SPECX has to be used prior to conversion to FITS. Some specific additions have been made to SPECX to streamline the production of FITS files.

Many of the most popular software reduction packages have been installed on the UNIX cluster at the JAC: AIPS, CLASS, GIPSY, IRAF, and MIRIAD are all currently available. Hopefully in the near future a version of SPECX for UNIX will be released. Both SPECX and CLASS are available on the VAX cluster at the Joint Astronomy Centre and at the summit.

On-line Documentation
The JCMT is slowly catching up with the distribution of current information.

- FILESERV is a file distribution service that uses electronic mail facilities to deliver files. To get more information on FILESERV, send an E-mail message to: JCMT_INFO@JACH.HAWAI.EDU with a single line of text: "HELP".
- A WorldWideWeb (WWW) server has been installed at JAC. WWW is an Internet-wide hypertext-based information service and can be accessed using e.g. Xmosaic. The JAC node is: "http://jach.hawaii.edu".

Additional details regarding the telescope, receivers, and requests for observing time can be found in The James Clerk Maxwell Telescope: A Guide for the Prospective User, which is available through me (email) or NFRA at Dwingeloo.

Further information: RPT@JACH.HAWAI.EDU
New user documentation for the WSRT is available in PostScript format at the anonymous ftp node RZMWS10.NFRA.NL

Free subscription

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