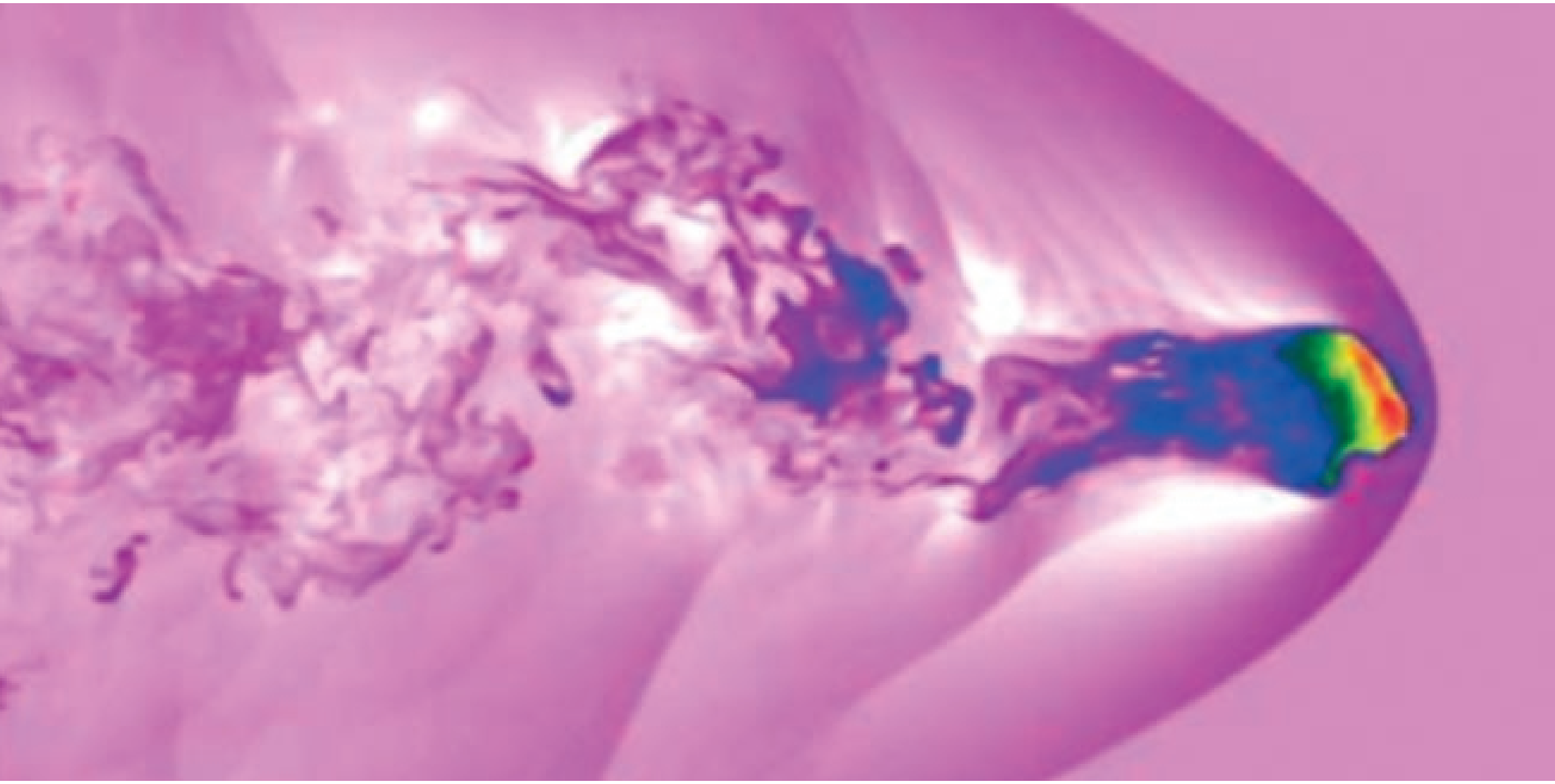
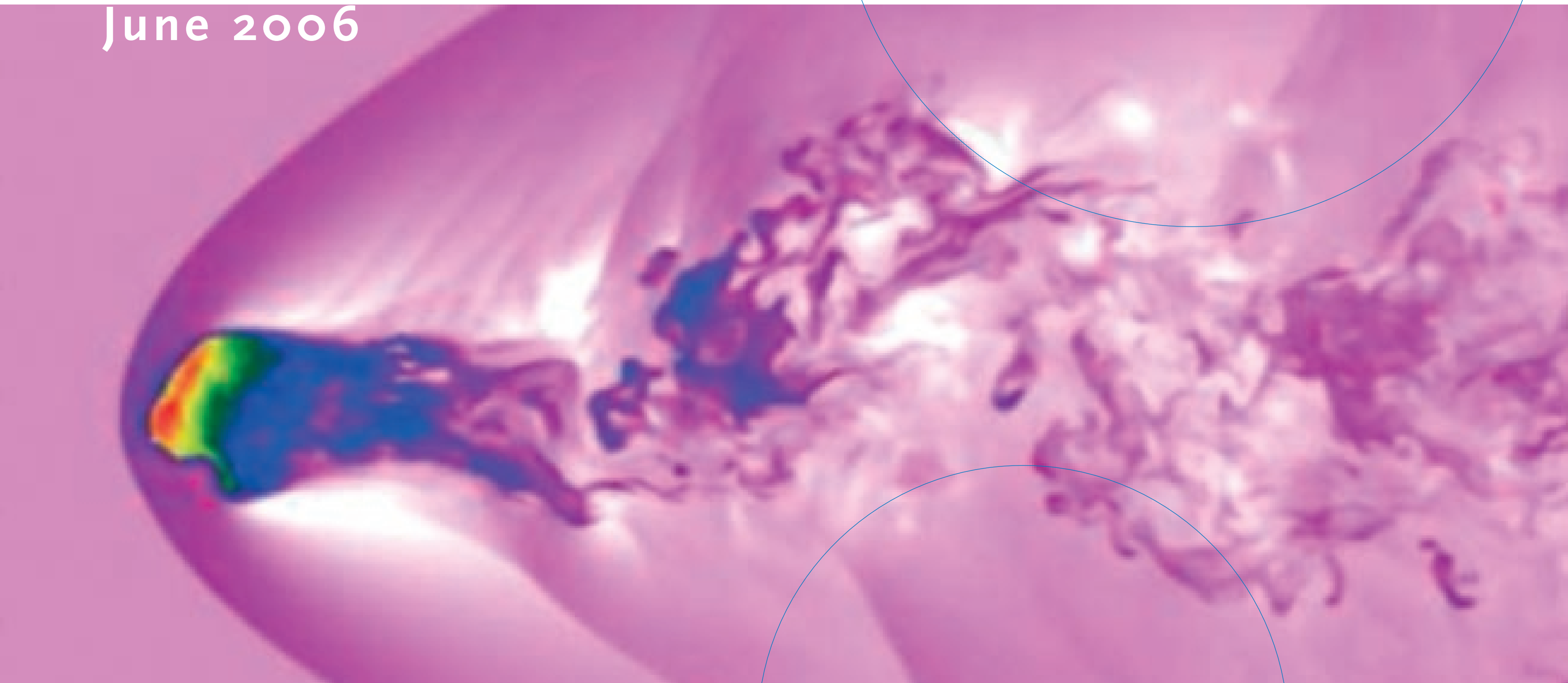


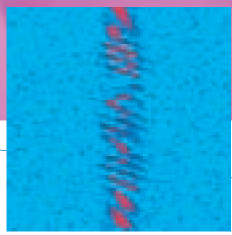
ASTRON

PO Box 2, 7990 AA Dwingeloo, The Netherlands, Tel. +31 521 59 51 00, Fax +31 521 59 51 01

Astronnews

June 2006





Featured in this issue

- *Dark matter studied in galaxies*
- *Where on Earth?*
- *Ram-pressure stripping of disk galaxies*
- *Single pulses surveyed*
- *Towards a lunar observatory*

ASTRON

Colofon

ASTRON
Netherlands Foundation for Research in Astronomy

Our goal is to enable discovery in astronomy through innovative instrumentation and facilities management

Address
PO Box 2
7990 AA Dwingeloo
The Netherlands
Tel. +31 521 59 51 00
Fax +31 521 59 51 01

ASTRON Newsletter
Editorial team | *Harvey Butcher, Raffaella Morganti, Frederiek Westra van Holthe*
Production | *Royal Van Gorcum, Assen*

Email: newsletter@astron.nl

Published
Twice a year
ISSN nr. 1871-6644

Content

Note from editors

Benvenuti to this new, full issue of the ASTRONnews where we report on the various activities and results from the last months at ASTRON.
We had a reflection of history with the Dwingeloo telescope turning 50 while the future is coming nearer with the LOFAR project entering the extremely exciting phase of having the first core station being installed over the summer.
Apart from the many technical activities related to LOFAR, you can also read about the very original experiment of testing the geophones with the help of school children from Exloo – the LOFAR-core site. More than a thousand kids had a lot of fun with it!
Dark matter studies figure prominently both at the WSRT generally and in this newsletter. Also reported are exciting new results on pulsars, and we present new results using Stella that show how galaxies loose their interstellar gas when passing through a galaxy cluster.
Finally, we should not forget that also the SKA is going through an important phase that will lead to the choice of the site. An ASTRON team has traveled to the candidate sites to make an inventory of the radio quietness: they tell us about their experiences and they have some impressive pictures of the sites to show us.
This year, we commemorate that 400 years ago, in 1606, the Dutch explorer Willem Jansz, with the yacht de Duyfken, charted and documented, for the first time, the coast of Australia. In the following years we Dutch lost interest in that continent but it has returned as we work together with our colleagues at CSIRO to chart the unknown with the next generation radio telescope: read about the trip of THEA down-under to be used in one of the SKA demonstrators.

We hope you will enjoy all this!
Raffaella Morganti & Harvey Butcher

Patrick Weltevrede (Univ. of Amsterdam) Russell Edwards (CSIRO) Ben Stappers

Single pulses surveyed

The structure of observed pulses provides information on the emission patterns and magnetic fields of radio pulsars. Using a new sensitive method, the WSRT has now surveyed 12% of the radio pulsar population for 'drifting subpulses' and discovered some delightfully weird behavior.

Seventy-five hours of data with the PuMa-I backend (at an observation wavelength of 21 cm) were analyzed using the new method. Many new drifters have been found, including a few extremely interesting sources. Much more pulsars show this phenomenon than was expected – at least half – and we found that old pulsars more often show drifting subpulses and that those drifting subpulses are more regular as well.

The single pulses of some radio pulsars consist of multiple subpulses and in some cases these subpulses 'drift' in time. If one plots a so-called 'pulse-stack' of such a pulsar, a plot in which successive pulses are displayed on top of one another, the drifting phenomenon causes the subpulses to form a regular pattern of 'drift-bands'.

In Figure 1 one can see a such a sequence for one of the new drifters. The pattern can be characterized by two numbers: the horizontal (P2) and the vertical (P3) drift-band separation. This complex, but regular intensity modulation is known in great detail for

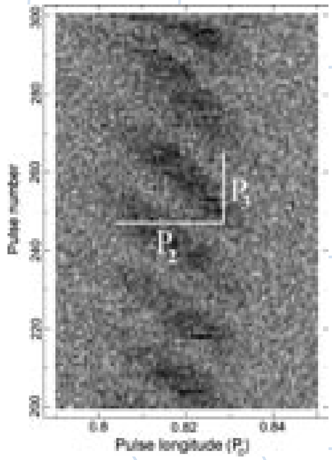


Figure 1: A pulse-stack of one hundred successive pulses of PSR B1819-22. Two successive drift bands are vertically separated by P_3 and horizontally by P_2. The pulse number is plotted vertically and the time within the pulses (i.e. the pulse longitude) horizontally, where P_0 is the pulse period.

only a small number of pulsars. Because the properties of the subpulses are determined by the emission mechanism, we can learn about the physics of the emission mechanism by studying drifting subpulses.

To find out if a pulsar has a drifting subpulse pattern, we used the Two-Dimensional Fluctuation Spectrum (2DFS). To make such a spectrum, Fourier transforms are calculated along lines with various slopes in the pulse-stack. If a pulsar has drifting subpulses, an island will appear in the spectrum centered at the corresponding values of P_2 and P_3. In figure 2 the 2DFS is plotted for three pulsars. The spectrum at the left shows a very narrow island, indicating that the drifting subpulse pattern is very stable. The middle spectrum shows a much broader island, showing that the pattern is much less regular. The spectrum at the right shows a composition of subpulses that drift to the left in the pulse-stack (negative P_2) and drifting to the right (positive P_2). The calculation of the 2DFS is an

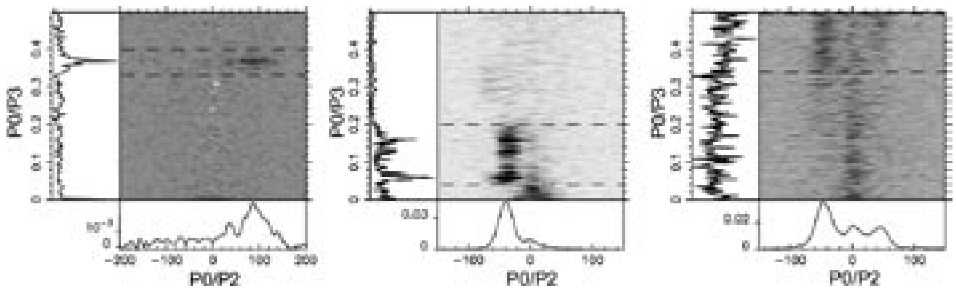


Figure 2: The 2DFS of three pulsars. The power in the spectra are horizontally integrated (producing the side-panel) and vertically integrated between the dashed lines (producing the bottom panels). The detection of an "island" means that there is a (quasi-) periodic subpulse pattern in the pulse-stack (such as in figure 1).

averaging process, making it a very powerful tool to detect drifting subulses. Even when the signal-to-noise (S/N) is too low to detect single pulses (so you cannot see them by eye), you are able to detect them using the 2DFS approach.

What fraction of the pulsars has drifting subpulses? Of the 187 analyzed pulsars, 68 show this phenomenon of which only 26 were previously known. Of the 100 pulsars with the highest S/N, 54 show drifting sub-

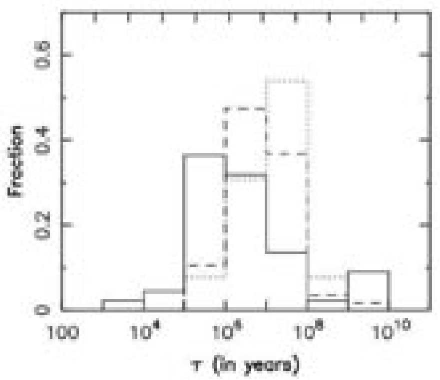


Figure 3: The distribution of characteristic ages of the pulsars which do not show drifting subpulses (solid line), do show drifting subpulses (dashed line) and do show a very regular drifting subpulses pattern (dotted line).

pulses. Therefore we conclude that at least half of the pulsars has drifting subpulses.

Because drifting subpulses are common in radio pulsars, the physical conditions required to produce them cannot be very different from the required conditions to produce the radio emission itself. It could be that drifting subpulses are always produced but are hard to detect in some cases.

With our expanded sample of pulsars with drifting subpulses, one can for the first time do some meaningful statistics. From the pulse period and its slow-down rate, the characteristic age and magnetic-field strength can be estimated.

We find that drifting is independent of the magnetic-field strength, but the population of pulsars that show drifting subpulses is on average older than those that do not show them (see figure 3). Moreover, the drifting subpulse pattern is more stable and regular for older pulsars. It is claimed that the angle between the magnetic and the rotation axis is on average smaller for older pulsars. So as the pulsar gets older, the rotation axis and the magnetic axis grow more aligned, which appears to make the mechanism that drives the drifting phenomenon more effective and stable.

Besides the interesting statistics, we have found a number of pulsars with unusual subpulse properties that deserve follow-up research. For example, we have found a pulsar that shows a very similar subpulse pattern in its main- and interpulse that stays in phase over years. Because the main- and interpulse are thought to originate from the opposite magnetic poles of the star, it means that the two poles have to communicate. Such communication is not expected from pulsar models. We also found pulsars that have discontinuous drift-bands. Some of them even show drifting in opposite directions at the left and right side of the pulse profile. Also this behavior cannot be explained by the models.

We plan to make further observations and perform more sophisticated analysis of these sources to constrain models or potentially develop new ones.

I'm Patrick Weltevrede, a PhD-student at the University of Amsterdam. After completing my masters in the end of 2002, I continued working under the supervision of Ben Stappers. Using the WSRT together with PuMa, I'll try to understand why each pulse of a radio pulsar is different. Outside work I like listening to heavy metal music, to walk in nature, cycle in the mountains and to travel. I'm very happy that my work has given me many opportunities to see very different places in the world. After my graduation I would like to continue in astronomy as a postdoc and to see the rest of the world.

Rob Millenaar

Where on Earth?

The unprecedented sensitivity of the next generation radio telescope, the Square Kilometre Array (SKA), can best be exploited at a radio-quiet site. An ASTRON team has designed instrumentation to scan the radio spectrum with great sensitivity, and has now travelled the world to inventory the radio quietness at candidate sites.

ASTRON's SKA site campaign team – Bou Schipper (left) and Rob Millenaar (right) – join Bo Peng, who leads the Chinese SKA effort, on the edge of the Dawodang depression after a strenuous hike.

The problem is clear: When astronomers and engineers rack their brains to think of a radio telescope that will outperform all current and planned instruments in sensitivity by orders of magnitude, one better make sure that it will be able to fulfil its promise by giving it a prime location on Earth. And in this case that means that the site should be extremely quiet. Man-made radio-noise is everywhere. Transmissions for FM-radio, television, communication (stationary or mobile), data transport etc don't stop at borders of countries or communities, but all combine to create a cacophony for sensitive radio-ears. Just as it is impossible to hear a whispered conversation on the other platform in a busy train station, a radio telescope is unable to detect faint cosmic murmurs amidst all that radio-noise.

Fortunately, there are still a few places on our planet that are nearly radio-quiet. Regions with a low population density, as far away from human activities as possible, can be pinpointed on the map. Adding to the requirements the wish to have a site close to the 30th parallel, either North or South, for reasons of sky coverage and avoidance of the geomagnetic equator, has led to a small list of candidate countries where the SKA might be built: the Karoo desert in South Africa, the Karst region in Southern China, the outback in Western Australia and the high plains near the Andes in western Argentina.

The challenge put to ASTRON by the international SKA steering committee was to design and construct a system that is suited for performing the measurements at the required sensitivity and frequency range, within a relatively short time, and make it robust enough to survive rough handling while travelling the world and the sometimes harsh conditions at the four sites.

Our team came up with a system that was up to the task. Ranging from the antennas at the front of the system, via low noise receiver technology, to a high quality spectrum analyzer and powerful computer system, monitoring instrumentation was created that met all the requirements set out in a protocol document. Part of the challenge was self-pollution – a system that uses digital elec-

Some of the ASTRON monitoring equipment, mounted in a 5 metre tall mast. To the right a low frequency antenna and to the left a frontend with the sensitive receiver electronics inside and an integrated high frequency antenna in a radome.

tronics usually generates radio interference that will be picked up by the receiver, thus obstructing a clear 'view' of the radio environment at the site. But when hardware and software were all tested and ready, the instrumentation was packed into two crates for shipment, altogether weighing about 1100 kilograms.

The mission of the monitoring project is to execute a predefined and well-calibrated set of measurements lasting about one month at each of the four sites in succession, while local monitoring teams are doing the same for one whole year. The independent ASTRON measurements will form the common ground on which the local monitoring data can be compared. Each session included dedicated cross-calibration measurements that allow linking the system parameters of all monitoring systems.

Thunderstorms ...

The first site visited was in early 2005, the South African Karoo desert. Upon arrival at the site it was discovered that one of the antennas had been damaged and a low noise amplifier had died. Together with some really impressive thunderstorms it took a week to get up and running. Nevertheless, this first session was very successful and the lessons learned were of great importance. The South African team leader Gerhard Petrick is thanked for his never ending efforts to make this a success. The

A tiny white dot in the distance marks the spot where the site measurements are done in the South African Karoo desert. One is humbled by the grandness of the scenery.

Looking west from the proposed site in western Argentina provides a spectacular vista of the Andes mountain range.

Karoo desert looks very 'deserted' but has a special stark beauty that was much appreciated by the ASTRON team.

... lightning

The next session on the programme was in China. South of the provincial capital Guiyang city, a monitoring site next to the Dawodang Karst depression had been prepared. Getting the equipment through customs and on site took a bit more effort here and some time was lost this way. But once the monitoring system was set up at the site, we started routine operations quickly and efficiently. The ASTRON team held many fruitful discussions on the monitoring effort with the local team members. The support by this wonderful team of people was great; problems in the mains power supply were effectively dealt with, allowing the session to proceed smoothly. There was just one mishap, when a nearby lightning strike caused damage to an amplifier. The problem could be fixed within hours, so not much time was lost by this event. The team owes many thanks to Bo Peng and his team for taking care of the support. Working amidst the local population in this area of stunning beauty has been a privilege.

... kangaroos

The third session on the list was in Western Australia, near the candidate site for the SKA core, Mileura station. This is serious outback country – red soil, low bushes and trees, and the occasional kangaroo, emu, cow or sheep. This time there were no delays in getting the equipment to the site. Furthermore, no mishaps occurred and the session was completed as scheduled. The team thanks Ron Beresford and his staff for doing an outstanding job and to ensure a successful mission.

... and high winds

Finally, the ASTRON team travelled to the fourth continent, to Argentina. The measurement site was a high valley near the CASLEO optical telescope facility. This is mountain and big sky country, and has a spectacular view of the Andes mountain range. Customs delayed transfer of our equipment, forcing

Dawodang Karst depression in Southern China, home of the RFI measurement session in the Summer of 2005. A large bowl in lush and green scenery, it is very well suited for placing large reflector type radio telescopes.

Team leader Marcelo Arnal must be thanked for providing the indispensable support; also Hugo Levato and his crew at CASLEO have been instrumental in the success of the mission.

After our travelling campaign was completed, a huge task remained in preparing the reports to finalize the project. Uncountable numbers of graphs have been produced at various levels of detail. The concept of performing site measurement around the world with one instrument and one measuring method has resulted in a valuable data set that can be mined for more information than extracted thus far in the framework of the SKA site suitability assessment.

More information on these sites is available at URL: http://www.skatelescope.org/pages/p_location_m.htm

us to split the session in two so we could spend Christmas 2005 with our families at home. The very dry and very windy conditions caused static electricity build-up on an antenna and caused two amplifiers to fail during the session. But we were well prepared this time with spares and eventually a remedy preventing this to happen again was installed. The ASTRON team was deeply impressed by the beauty of the scenery.

A panorama of the area close to the measurement site in Western Australia. Vast empty spaces; room enough to place SKA antenna elements.

G.I.G. Józsa (Argelander-Institut für Astronomie (AIfA), Bonn), T.A. Oosterloo, R. Morganti, F. Kenn (AIfA), U. Klein (AIfA)

Warped galaxies and dark matter halos

Deep WSRT observations of the neutral hydrogen in three symmetrically warped galaxies, combined with a new method of deriving the kinematics of galaxy disks, suggest that galaxy warps are due to the existence of two dynamical regimes in spiral galaxies, the inner region dominated by the visible matter and the outer region dominated by the dark matter halo.

The disk of probably every spiral galaxy is warped: inside the optical radius, where most of the visible light is emitted, the disk is flat, but beyond a certain radius it starts to bend away from this inner plane. This is best seen in observations of the neutral hydrogen because this gas can be found at radii well beyond the visible stellar disk. As warps are very common, they either have to be long lived or they are short lived but created frequently. Most disk galaxies exhibit a symmetric "S-shaped" warp (see Fig. 1),

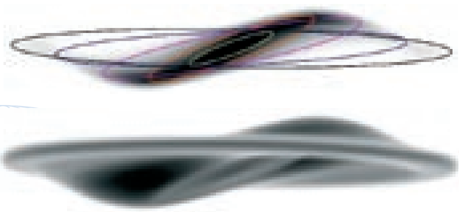


Figure 1: Models of a grand-design warp. Top: A warped disk seen nearly edge-on, translucent, overlaid with a set of tilted rings to illustrate the warp geometry. Bottom: The same warped disk, opaque.

although every warp is unique and in many cases deviates from a regular symmetric shape to some degree. Less regular warps are more common in high-density environments, so it appears that such warps are triggered by tidal interactions.

What about the more regular warps? Their regular shape suggests they may represent a dynamical equilibrium state and therefore reflect the combined (i.e. dark+visible) matter distribution. Against this background we conducted a case-study of three galaxies with very symmetric large-scale warps (NGC 2541, UGC 3580 and NGC 5204). We observed the neutral hydrogen in these galaxies with the WSRT (Fig. 2) in order to be able to study their geometry and kinematics. These datasets were analysed following a new approach. Instead of fitting kinematic models to derived properties such as 2D velocity fields, we compare models and data by generating mock observations that are compared directly with the full 3D observation. This eliminates problems that occur due to the line-of-sight intersecting the galaxy plane several times,. This is a common feature in warped galaxies and makes the interpretation of velocity fields problematic. Another major advantage is that beam smearing effects can be handled properly. This software is available from http://www.astro.uni-bonn.de/~gjozsa/tirific.html

Our analysis shows that the warp in each of the three galaxies in fact consists of two disks. There is an inner flat disk in which most of the visible stars reside, and there is an outer disk tilted with respect to the inner plane. This outer disk shows very little inter-

Figure 2: The warp in NGC 2541 illustrated by a false-colour composite of an optical image (i'-band observed with the INT, orange and pink) and the neutral hydrogen as observed with the WSRT (blue), showing the different orientation of the outer gas disk with respect to the inner optical galaxy.

nal twisting due to differential precession and is in fact almost a flat disk. This outer disk is smoothly connected to the inner disk at a transition radius, creating the overall warped structure. Another important additional result is that, apart from a change in orientation, also the rotation velocities show a change at the transition radius, indicating a feature in the gravitational potential at this location (Fig. 3).

These results suggest spiral galaxies have two dynamical regimes. A typical spiral galaxy consists of an inner region where the visible matter dominates the dynamics, with only a small contribution of dark matter, and in addition an outer inclined, flattened dark matter dominated system. The radius where the disk starts to bend away from the inner plane marks location where the dark matter starts to dominate the gravitational potential. In this sense, the warp is a halo phenomenon. The results from an earlier WSRT study by Giuseppina Battaglia and co-workers of the warped spiral NGC 5055 also indicated the existence of two such dynamical regimes.

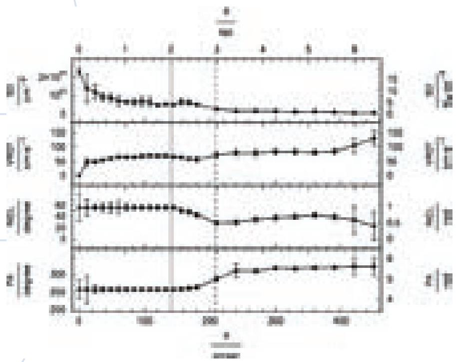
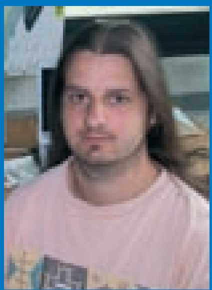


Figure 3: The best-fit kinematic model for NGC 5204. The plots of the inclination (INCL) and the position angle (PA) show that for radii between 2 and 3 kpc (140 and 200 arcsec) the disk changes orientation and warps from an inner flat disk to an outer disk. The plot of the rotation velocities (VROT) shows that at the same location the rotation of the gas disk jumps by about 30 km/s.

If the results are representative for symmetrically warped galaxies, the forces acting on the warped disk must enforce co-precession over a large range in radius in order to prevent the warp from “winding up” through differential precession. This could indicate that a warp is the result of a bending mode common to the dark halo and the inner visible disk, or that a coupling exists between the inner disk and the outer halo.



Gyula (Josh) Józsa graduated in Physics at the University of Bonn in 2002. Starting his PhD under the supervision of Uli Klein at the Radioastronomisches Institut der Universitat Bonn in the same year, he became a summer student at ASTRON, where he could persuade Tom Oosterloo to become his co-supervisor. He finished his PhD in March 2006, and is currently postdoc at AIfA. His research mainly deals with kinematical modelling and the dynamics of disk galaxies. If his daughter Dana would leave him any time, he'd enjoy to play the cello or the electronic bass.

Falcke wins Academy Prize

In Berlin on 5 May 2006, ASTRON's Heino Falcke received the prestigious Academy Prize of the Berlin-Brandenburgische Akademie der Wissenschaften (formerly the Prussian Academy of Sciences).

The award was given in recognition of Heino's contributions to the study of the black hole at the center of our Galaxy, and for his demonstration using prototype LOFAR antennas at the KASCADE particle detector array in Karlsruhe of the origin of the radio emission from Ultra-high Energy Cosmic Ray events.

An ASTRON senior astronomer, Heino is currently International Project Scientist for LOFAR and is responsible both for guiding the project's analysis software development and for organizing international groups interested in joining the LOFAR effort. He is also Adjunct Professor of High Energy Astrophysics in Nijmegen, and later this year will be visiting UC Berkeley on a Visiting Miller Research Professorship.

Heino receiving Academy Prize

Frank van Eck (Inspiro b.v.)

Inspiro: Inspired start-up!

Each LOFAR sensor station generates data at a rate of about 240 Gbits/sec. Data reduction by two orders of magnitude is performed locally before transport to the central processor, Stella. Development of the station level processing algorithms provided a launching order for the start-up company, Inspiro b.v.

Based in Arnhem, Inspiro was founded in 2002 with a mission of 'creating innovative embedded solutions'. Its founders (Maarten Angenent and myself) have a strong history in embedded systems development, both technical as well as organizational. Inspiro started with the LOFAR station processing as one it's first projects. Due to this involvement Inspiro became more aware of the possibilities of digital signal processing and programmable logic in Dutch industry.
In today's world, embedded processing systems are everywhere – homes, offices, cars, factories, hospitals, plans and consumer electronics. The application of digital techniques in domains previously considered to be analogue is an important ongoing technology trend. The availability of high-speed digital techniques opens up revolutionary new possibilities in system design, resulting in such devices as mobile phones, multimedia computers, video recorders, CD players, hard disc drive controllers and modems. Current drivers of the technology are found in the application areas, medical imaging such as brain scans, analysis and control of industrial processes, seismic data processing and of course radio astronomy.

The Inspiro team. That's me at far left; Wietse and Wessel are 2nd and 7th from left.

At an early stage of the LOFAR project, the Inspiro team became involved in the definition of the system's digital processing architecture. Subsequently Inspiro engineers developed filtering and beam forming algorithms and implemented the algorithms in FPGA chips. The art and science of this data volume reduction by filtering and beam forming makes LOFAR possible as a system.

As a design house, Inspiro aims to apply such technological competence across industrial sectors. The LOFAR station processing contract provided us with an excellent reference of proven competence, and contributed to our securing orders in applications areas as diverse as medical diagnosis, traffic management and transportation, seismic data processing and even in sports. We are confident we will be able to play an important role as independent solution provider for Dutch industry.
Key players for the LOFAR project have been Wessel Lubberhuizen and Wietse Poiesz.

Erik Zeitler (Uppsala University)

Working with Stella

The IBM BlueGene/L processor that is the heart of STELLA is able to swallow huge streams of input data and process them in real-time. In the multi-disciplinary LOFAR environment, data streams from several different sensor arrays will arrive at STELLA to be processed simultaneously. Erik Zeitler of the Uppsala University's Data-base Laboratory has been studying how to manage such data streams. Here he reports on his research.

A data stream management system (DSMS) has one important difference from a regular database: Users of a regular database query data stored in tables, whereas in a DSMS the users query on-line streams that are constantly changing. The result of a database query is a table, whereas the result of a DSMS query is a stream. At the Uppsala Database Laboratory we have implemented a DSMS for LOFAR's STELLA, called SCSQ (Super Computer Stream Query processor, pronounced *cis-queue*).

Erik Zeitler taking a break from his work on SCSQ. Erik is a PhD student in the Faculty of Information Technology in Uppsala. He may be contacted by email at: erik.zeitler@it.uu.se

SCSQ users will not have to spend much time writing programs to tell the parallel processors exactly how to perform the processing. Instead, users specify queries to SCSQ, using a non-procedural *query language* similar to SQL. This query language enables users to formulate *what* they want, rather than exactly instructing the computers *how* to process the input data streams.

Once a query is submitted to SCSQ, a program called an execution plan is automatically generated and split into pieces running on one or more SCSQ *stream processors* (SP). The SPs are running on both BlueGene/L compute nodes and on conventional Linux clusters. The SPs retrieve data streams from a sensor array, execute the query, and deliver the result of the query to the user as a data stream. SCSQ can be extended with foreign functions, that is, virtually any function written in C, Fortran, or assembler can be plugged into SCSQ. This extensibility enables users to write their own custom stream query operators.

The goal of SCSQ is to achieve scalable execution of stream queries for many incoming data streams, high input stream data rate, and computationally complex stream query operators, while maintaining the ease of use of a non-procedural query language.

As part of the LOFAR research program in ICT, we have implemented a first prototype of SCSQ. Using test queries, we have evaluated and are currently working to optimize its performance. Central to our work is investigation of how to utilize the communication subsystem of the BlueGene efficiently. When a message is sent between non-adjacent nodes, the messages must be routed through the communication co-processors of intermediate nodes. We find that this

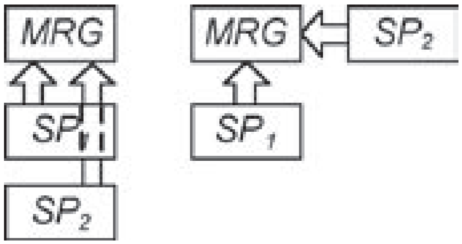


Figure 1. Alternative node placements for merging streams.

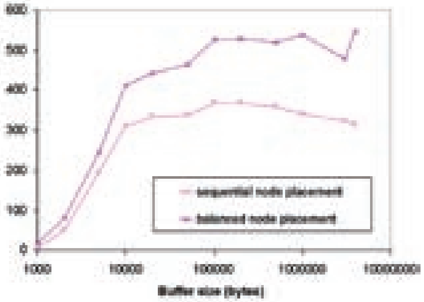


Figure 2. Communication performance of merging streams.

slows down communication if the co-processors of the intermediate nodes are busy.

To investigate the latter effect, we have tried two communication topologies, as illustrated by Figure 1. The merge operator MRG merges streams of large numerical arrays from stream processors SP_1 and SP_2. In the left *sequential topology*, the streams from SP_2 are routed through the communication co-processor of SP_1, which is also busy sending streams to MRG. With the *balanced topology* to the right, SP_1 and SP_2 both communicate directly with MRG using individual communication links.
Figure 2 shows the performance of merging streams using the two node placement strategies. The throughput per stream is shown on the y-axis. Thus, twice that data volume is received by the merge operator. Obviously, the communication topology significantly influences the performance. This knowledge will be incorporated in SCSQ's query optimizer. Moreover, we conclude that buffers smaller than 10K are not feasible for merging streams in practice.

Dwingeloo telescope turns 50!

On 18 April 2006, we celebrated the fiftieth anniversary of the opening by Queen Juliana (on 17 April 1956) of the Dwingeloo radio telescope.

Two hundred guests came from far and wide to view our archive of old photographs and newspaper clippings, and to reminisce over the early days of Dutch astronomy. Richard Strom told the gathering about the origins of radio astronomy in the Netherlands, and Hugo van Woerden related personal memories of the scientific discoveries made with the instrument during his long career. Harvey Butcher recalled the role played by the first radio astronomer, Grote Reber, who passed away in 2002, and noted that ASTRON has joined major radio observatories around the world to commemorate his work and share his ashes.

The Dwingeloo telescope is no longer used for research but the Society for Amateur Radio in the Netherlands (VERON) has a strong interest in making the facility available to amateurs, schools and the general public. At the anniversary ceremony, therefore, Thijs van der Hulst, chairman of ASTRON's Board, and Dick Harms, VERON chairman, signed a letter of intent to set up the "C.A. Muller Radio Astronomie Station" foundation, the purpose of which will be the restoration of the telescope to an operational state for use by the public.

To round off the celebrations, those present were all presented with the April 2006 issue of National Geographic magazine, which featured an extensive article by Govert Schilling on the telescope and on Dutch radio astronomy.

PuMa II set free

On 16 December 2005 the pulsar group at ASTRON and the University of Amsterdam brought a new state-of-the-art pulsar machine – PuMa II – into operation at the WSRT.

Built as part of the instrument program of our national graduate research school NOVA, PuMa II consists of four separate modules, which combine to make one of the best instruments of this type in the world. The official start of operations with the final module, the largest, of PuMa II is the crowning moment of a project led by P.I., Michiel van der Klis (UvA) and project scientist, ASTRON's own Ben Stappers. The project-lasted seven years and had a total budget of 1.3 million euros. We describe below the instrument and some of the impact it will have on pulsar research at the WSRT.

Ben Stappers and Ramesh Karuppusamy explain PuMa-II to Ed van den Heuvel, Ger de Bruyn and Jan Noordam. The demonstration used all 8 PuMa DAQs to acquire and display, in real time, single pulses from PSR B0329+54.

PuMa II's modules are designed to implement the technique of coherent de-dispersion over as large a bandwidth as possible. Coherent de-dispersion is the technique by which one can exactly correct for the deleterious effects of dispersion of radio pulses as they pass through the interstellar medium, and hence achieve the maximum possible time resolution. The dispersion causes the pulses to arrive later at lower frequencies thus resulting in a broadening of the pulse profile. Coherent de-dispersion is computationally expensive and, because it works on the raw voltages, requires the signal to be Nyquist sampled, resulting in very large data rates. Until recently, coherent de-dispersion has only been possible on small bandwidths or for short periods of time. This resulted in most pulsar machines using an incoherent method to correct for dispersion. This involved forming a filterbank to divide the wide bandwidths into smaller frequency channels and then shifting them in time with the appropriate delays. However this results in a time resolution that is limited either by the rise time of the filter or by the residual dispersion in the channels, or both.

The first module consists of the expansion of the disk space and archiving capabilities of PuMa and thus enabled us to record more base-band data (maximum of 2 times 10 MHz with 2 bit resolution) in order to investigate algorithms for data reduction and also for scientific use. In the second module we developed the software required for the coherent dedispersion of baseband data and undertook a design study for the architecture for the final module of PuMa-II.

The choices were between a real-time streaming system based on FPGAs or a recording system linked to general purpose processors. The latter was chosen as it gave the most flexibility of use and ease of development. Module 3 at the WSRT is a hardware and sophisticated software system to search for binary pulsars, and module 4, more commonly called PuMa-II, is the new pulsar machine.

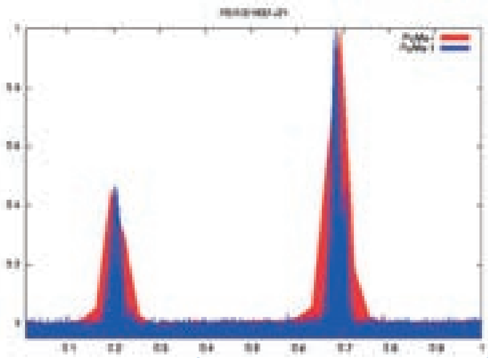
PuMa II is capable of coherently de-dispersing a frequency bandwidth of 160 MHz. This is the full bandwidth available at the WSRT and is 8 times the bandwidth which could previously be coherently de-dispersed, exceeding our initial expectations. PuMa-II is connected to the new tied-array adding system Tadu, and so receives digital input data with 8-bit resolution, which leads to further significant gains in both sensitivity and robustness to radio-frequency interference over previous analog and predominantly 2-bit PuMa data. These improvements alone resulting in about a 75% increase in sensitivity for pulsar observations, while the coherent de-dispersion further improves the fidelity of the pulse observations.

The instrument itself consists of 8 data acquisition machines (DAQs), one for each of the 20-MHz WSRT bands, and 32 dual-node Opteron processors. Each DAQ is actually a PC which contains a PuMa interface card (PiC), a direct memory access card and 4 TBytes of disk space. The PiC was developed as part of the PhD project of Ramesh Karuppusamy (very ably assisted by staff in the technical labs) and is the heart of the system. It is responsible for the acquisition, reformatting and synchronization of the incoming digital data. Each DAQ Nyquist samples 20-MHz of bandwidth in two polarizations with 8-bit resolution

PuMa-II in its new home in the HF-cabin at Westerbork next to PuMa (on the left).

resulting in a throughput of 80 MBytes/s and a total throughput for PuMa-II of 640 MBytes/s. Using the sophisticated data acquisition software these data can either be recorded directly to the local disk for later processing, distributed to the disks on the processing nodes, also for later processing, or processed in real time. This flexibility allows us to not only tailor PuMa-II to the particular observational requirements at hand, but also allows us to increase the total amount of observing time possible in any given observing session.

The massive gains offered by PuMa-II will impact on all pulsar astronomy done at the WSRT, but the biggest impact will be on the pulsar timing program. This program, in combination with the European Pulsar Timing Array, has as one of its principle goals the detection of nano-Hertz gravitational waves. Using an ensemble of pulsars distributed over the sky as the arms of a very long interferometer, it will be possible to measure the correlated variations in spin-down rates of the pulsars, a measurement that corresponds to gravitational waves with periods of the order of years. Such gravitational waves are thought to come from the very early universe, either from orbiting super massive black holes, strings or even inflation. The variations that these waves cause to the spin rate of the pulsars is so incredibly small that we need to be able to measure pulse arrival times to better than 100 nanoseconds, something which is only presently possible for a handful of sources. Observations made so far with PuMa-II show that we record pulse arrival times, for the best pulsar timing array pulsars, with an order of magnitude more precision than with



Pulse profiles from the original millisecond pulsar, obtained simultaneously with PuMa and PuMa-II showing the improved sharpness of the pulse profile achieved using the coherent de-dispersion of PuMa-II. This improvement leads directly to an order of magnitude improvement in the accuracy to which the arrival time of the pulses can be measured.

PuMa, which will allow us to carry out some of the most precise pulsar timing in the world.

The decision to go for the more flexible PuMa-II hardware has paid off already as it has enabled its use for diverse experiments including processing of a large pulsar survey, radio-frequency interference monitoring with wide bandwidths and high time resolution in the LOFAR High-Band, and most excitingly for searching for the few-nanosecond duration bright flashes of radio emission expected from the interaction between cosmic rays and the lunar regolith.

These are exciting times for pulsar astronomy with the WSRT, so if you have an interesting project you think can be done with PuMa II and the WSRT, please contact us.

Jan-Geralt bij de Vaate for the PHAROS team

PHAROS implements FPA tec

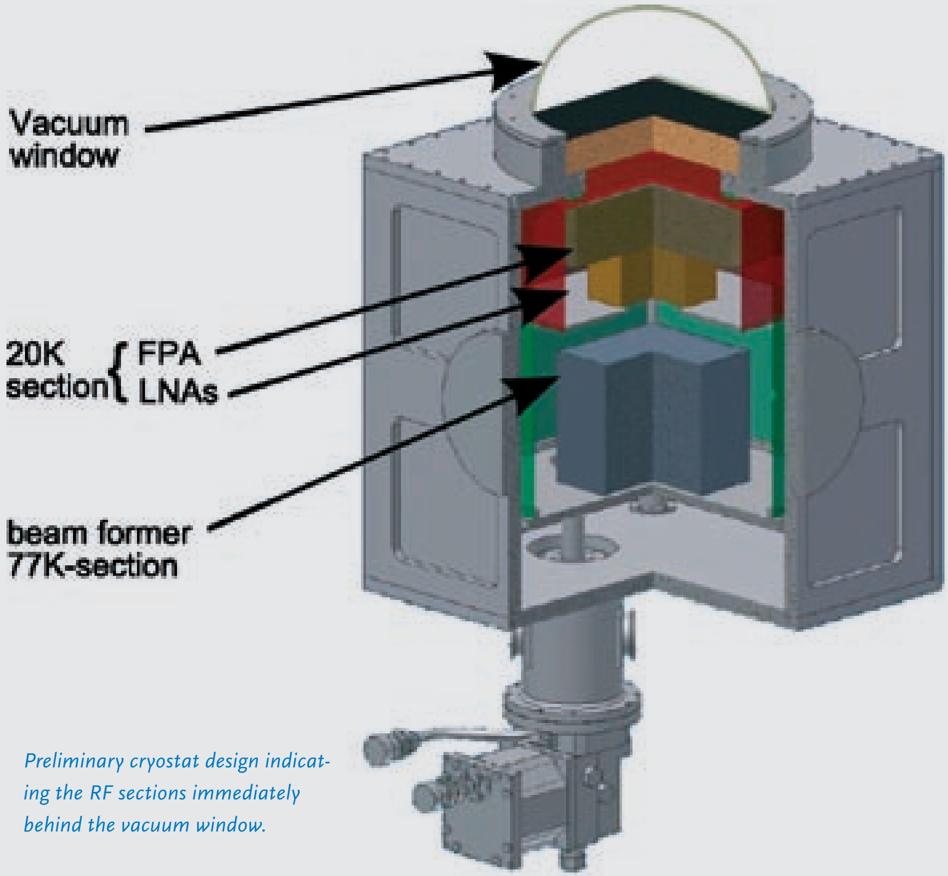
The PHAROS project (PHased Arrays for Reflector Observing Systems) aims to place an array antenna in the focal plane of a conventional dish reflector to realize a multi-beam radio telescope.

The project is part of the RadioNet FP6 program (see URL: http://www.radionet-eu.org/), which brings together institutes in Europe and Australia in a joint research effort to make focal plane array (FPA) antenna receivers with qualities similar to those of existing radio telescopes but with increased field of view.

FPAs are distinguished from traditional single-horn feeds by the fact that the antenna consists of an array of antenna elements. This research uses dense arrays with elements smaller than $\lambda/2$. Multiple beams are formed by electronically summing the signals from different groups of elements. The beam properties can be optimized over a wide range of frequencies by electronically controlling element phases and amplitudes leading to high aperture efficiencies and low spillover losses. The flexibility of the FPA also enables correction of surface errors of the dish and RFI mitigation. The multi beam capabilities of the FPA enable an increased Field Of View leading to a higher survey speed of the telescope.

The project teams met in February to discuss the preliminary design of a four beam demonstrator of the FPA technology. The system will be optimized for a frequency range of 4 to 8 GHz and will have a cryogenically cooled antenna array with Low Noise Amplifiers (LNAs) at a temperature around 20 K. The FPA is foreseen to consist of 316 Vivaldi antenna elements of which 24 will be fitted with LNAs. These received signals of these elements are condensed using an RF beam former section performing functions such as phase control, amplitude control and intermediate amplification. Using passive power combiners the adjusted element signals are assembled into the four RF output beams. This beam former section will be held at an intermediate 70 K.

The PHAROS demonstrator system is foreseen to be mounted in the different radio telescopes of the project partners so that all can evaluate this new technology. The RF beam signals will be fed into the existing RF back-ends of the specific radio telescopes for evaluation. The project further comprises



Preliminary cryostat design indicating the RF sections immediately behind the vacuum window.

hnologies

several supporting activities such as GaAs IC design for LNAs and for specific beam former circuits, mechanical and cryostat design. Finally, control software will be developed to adjust all individual element signals for each of the beams and to interface to the existing radio telescope system.

In order to reach the 20K temperature specified for the FPA antenna a vacuum cryostat is being designed with an RF entry window which will provide IR shielding so that unwanted influx of radiation does not heat the antenna too much. The dome shaped window with a diameter of about 380 mm sets a new challenge for vacuum system design. It is under development in a cooperation between ASTRON and INAF, our Italian partner in the project.

The cryostat will consist of a large vacuum casing in which the antenna and beam former circuits are isolated from their room temperature surroundings. For receiving the RF signals a semi-spherical window is being designed. Besides being transparent to radio waves, the window is fitted with filters to block unwanted infrared radiation. The ASTRON antenna engineers are closely cooperating with INAF colleagues to ensure that the FPA receiver function is maintained at the highest level of performance.

PostDoc at ASTRON Subhashis Roy

I started as a Post Doctoral Fellow at ASTRON in February 2005. I came from India at a time when winter was at its peak and watched the first snowfall in my life with amazement. It took quite a long time to adjust to a very different climate and cultural environment than what I was accustomed to in India.
I carried out my Ph.D. at the National Centre for Radio Astrophysics (NCRA), Pune, India and I have used the Giant Metrewave Radio Telescope (GMRT) extensively along with the Very Large Array (VLA) and the Australia Telescope Compact Array (ATCA).

The central region of our Galaxy is one of my main research interests. This region is complex as well as rich in various unique objects. One particular aspect of my thesis was to determine line of sight relative locations of some of these objects which would make possible to model different physical phenomena at the heart of our Galaxy. I worked on free-free absorption at low radio frequencies and on atomic Hydrogen absorption towards filamentary structures in the central region of the Galaxy. I also worked on confirming candidate supernova remnants in that region. Through Faraday rotation studies of background compact sources I have probed the magnetic field in this region, which was found to be far weaker than believed earlier.
Presently my interest is more on studies of the interstellar medium near the Galactic Centre at wavelengths greater than 1 metre. I am also involved in other projects. This includes finding the extent of the ionised medium beyond the HI disk in galaxies and study of polar ring galaxies.

ASTRON named top innovator

ASTRON has been named one of the world's top public sector innovators in a recent study by IBM. Our LOFAR project is cited as one of only four projects world-wide in the area of academic research that feature "challenges met – and transcended – through fresh thinking and the creative application of state-of-the-art information technology".
The project also features prominently in the May 2006 issue of IBM's 'Inspired' magazine (on-line at http://www.ibm.com/innovation/publicsector/inspired).

Descartes Prize for pulsar research

ASTRON staff astronomer Ben Stappers and his European colleagues have been awarded the European Union's prestigious Descartes Prize.

The award celebrates outstanding scientific and technological results through collaborative research. In this case the collaboration – The Pulsar Science in Europe, or PULSE, collaboration – included researchers at ASTRON, Jodrell Bank Observatory, the Max Planck Institute for Radio Astronomy, INAF's Astronomical Observatory of Cagliari and the University of Thessalonika, and was led by Andrew Lyne of the University of Manchester. The research involved the use of pulsars to study some of the most extreme physical conditions in the universe and test its most fundamental laws.

PULSE was initiated in 1995 with a grant from the European Union with the aim of creating a team who could undertake large scale research projects that were otherwise too big for the individual groups on their own. This coincided with the start of radio pulsar research at the Universities of Amsterdam and Utrecht and at ASTRON. Ten years on, the PULSE team are world leaders and their research achievements cover not only the extreme physics of the pulsars themselves, but also their use as probes of the galaxy through which their signals pass.

Access to three of the world's largest radio telescopes has enabled the collaboration to design and perform unique experiments to understand pulsars. In particular, the ability to carry out simultaneous observations of pulsars at multiple frequencies has revolutionised the understanding of how pulsars shine. A highlight has been simultaneous multi-frequency observations of single pulses from pulsars. These observations, involving up to 7 observatories and 9 frequencies simultaneously could only be coordinated successfully through a group like PULSE. Moreover the existence of a common data format made the transfer and analysis of data much more efficient. The data so obtained are vital to expanding our understanding of how the pulsar emission mechanism and the pulsar magnetosphere work and interact.

PULSE collaboration members at the award ceremony in London showing off their prize. From left they are: Andrea Possenti, Michael Kramer, Axel Jessner, Ben Stappers, Andrew Lyne, John Seridakis and Nichi D'Amico.

Further information and images can be found at:
http://www.jb.man.ac.uk/descartes/
http://europa.eu.int/comm/research/descartes/index_en.htm

Läslo Evers (KNMI)

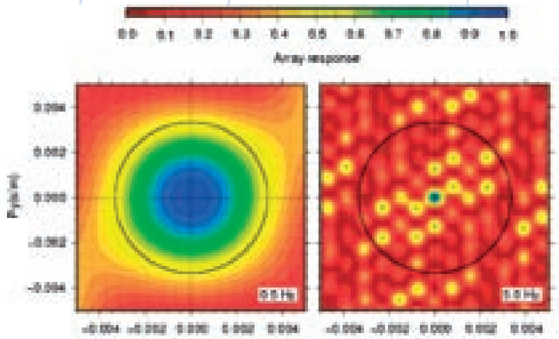
UK Explosion heard in Exloo

On 11 December 2005, the LOFAR prototype infrasound array detected a gas depot explosion near London, over 500 km away.

The Royal Netherlands Meteorological Institute (KNMI) has developed a microbarometer capable of measuring infrasound between 0,002 and 40 Hz, and has deployed these sensors at several sites including the LOFAR test site in Exloo.

Infrasound is inaudible sound; its lower frequency cut-off is limited by the thickness of the atmosphere. Infrasound can travel over large distances with minimal damping due to its low frequency content. Typical sources of infrasound are explosions, severe weather, meteors, sonic booms, sea waves, volcanoes, mountain associated waves, aurora, nuclear tests, and so on. Coherent infrasound of unknown origin is also regularly detected at the arrays.

Wind noise reduction is of major concern in infrasound measurements. Arrays are deployed to increase the signal-to-noise ratio by averaging out the incoherent wind signals. Wind noise is also reduced at each array element, the microbarometer, by applying porous hoses or pipe arrays. Doing so, the wind noise is further reduced at each element by sampling the atmosphere over an area rather than at one point. To characterize the signals further, the direction of arrival and apparent sound speed can also be determined by the array.

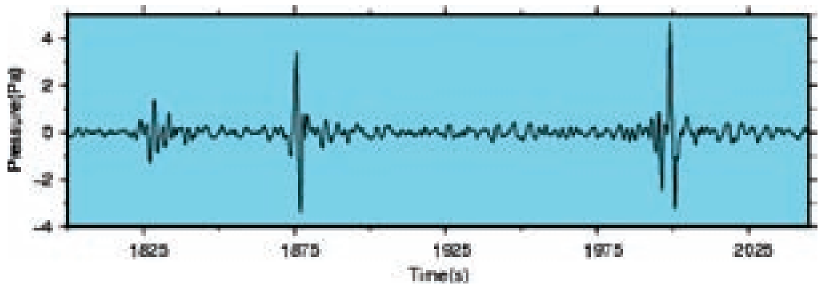


Response of Exloo test array at two frequencies.

Multiple arrays are used for localization of detected sources. KNMI currently operates four infrasound arrays varying in aperture between 35 and 1500 meters and using between 6 and 16 individual sensors. Research interests include the development of techniques to discriminate between infrasound from earthquakes and from atmospheric phenomena, to study the physical phenomena affecting the propagation of low frequency acoustic waves in the atmosphere, and ultimately to provide acoustic imaging of atmospheric phenomena above the LOFAR array.

The test array at the LOFAR Initial Test Site in Exloo consists of six microbarometer sensors. Figure 1 shows its response to infrasound signals. The circular shape of the main lobe means the array is equally sensitive to all infrasonic energy independent of its incoming angle. Side lobes are of low amplitude and located at considerable distance of the main lobe, making unique identification of sources straightforward. The main lobe has a sharp and peaked form, providing high resolution both spatially and in velocity. These characteristics were optimized through a genetic algorithm leading to a unique array configuration.

On 22 December 2005, the Exloo array recorded at least three strong signals (see Figure 2). Combining these signals with those from a sister array in Deelen and applying corrections for known wind speeds and directions, the source was identified as the Bruncefield oil dept in Hemel Hampstead, some 40 km northwest of London. The 'event' subsequently developed into one of the largest oil fires since the Second World War.



Signals from initial explosions at Bruncefield oil depot near London. Total time series is 300sec.

Dark matter in early-

The WSRT played a key role in the discovery that rotation curves of spiral galaxies remain flat to the outermost measured radii, indicating the presence of large amounts of unseen matter. Now, the improved sensitivity of the upgraded WSRT has allowed for the first time to measure HI rotation curves of a large sample of early-type disk galaxies. The results are remarkable: massive SØ and Sa galaxies have rotation curves which rise extremely fast in the central regions, but decline at larger radii, rather than staying flat. This peculiar shape has important consequences for the distribution of dark matter in these systems.

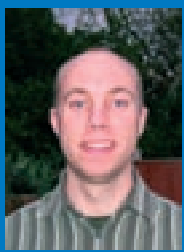
Early-type disk galaxies are among the most luminous and highest surface brightness galaxies in optical wavelengths, yet they contain relatively little gas. HI observations of these systems are therefore much more difficult than in later-type, more gas-rich galaxies. With the improved sensitivity of the upgraded Westerbork receivers and correlator, however, it became possible for the first time to observe a large sample of So and Sa galaxies in reasonable integration times. In the larger framework of the WHISP survey (the Westerbork HI survey of spiral and irregular galaxies), we have observed 68 of such galaxies, thereby greatly increasing the number of early-type disks with spatially resolved HI kinematics (see Noordermeer et al. 2005).

Many of the 68 galaxies were found to have distorted gas morphologies and kinematics, due to e.g. the presence of bars, interactions with companions or recent merger activity. But for 19 galaxies, the gas disks were regularly rotating, and the data were of sufficient quality to derive rotation curves. As a complement to the HI observations, we obtained for these systems additional long-slit optical spectra to better resolve the velocity gradients in the central regions. Figure 1 shows the resulting rotation curves, which probe the gravitational potential in early-type disk galaxies on scales ranging from about 100 pc to 100 kpc.

The rotation curves share a number of characteristic properties. Foremost, many rotation curves show a remarkable decline at intermediate radii, especially those with V_{max} > 200 km/s. There had already been hints for such behaviour in a handful of galaxies from older data (Casertano & Van Gorkom 1991), but our data show unambiguously that *all* massive early-type disk galaxies have declining rotation curves. Thus, the 'conspiracy' between dark and luminous matter to produce a flat rotation curve is not perfect over the entire Hubble sequence. Note, however, that all rotation curves flatten out in the outer regions. No galaxies were found where the rotation curves keep declining till the outer point. This implies that, as in later-type spiral galaxies, large amounts of dark matter must be present in these galaxies too.

Another common feature of the rotation curves of our galaxies is the extremely steep rise in the center. In many cases, the rise is unresolved, even in the optical spectra, and the rotation velocities rise from 0 to more than 200 km/s in less than a few hundred parsecs. Clearly, this implies very high mass concentrations in the inner regions of these galaxies.

A long-standing question in galaxy dynamics is whether the gravitational field in the inner regions of galaxies is dominated by the lumi-



Edo Noordermeer obtained his master's degree in Astronomy from Utrecht University, having spent the last year of his program as an exchange student at the University of Wisconsin, Madison. Afterwards, he went to the Kapteyn Institute at the Rijksuniversiteit Groningen to do his PhD under supervision of Thijs van der Hulst, Renzo Sancisi and Tjeerd van Albada. Since December 2005, he lives in the UK with Joanna, and works as a research fellow at the University of Nottingham. When Edo gets fed up with astronomy, he likes to wear himself out in a rowing boat or on a bicycle.

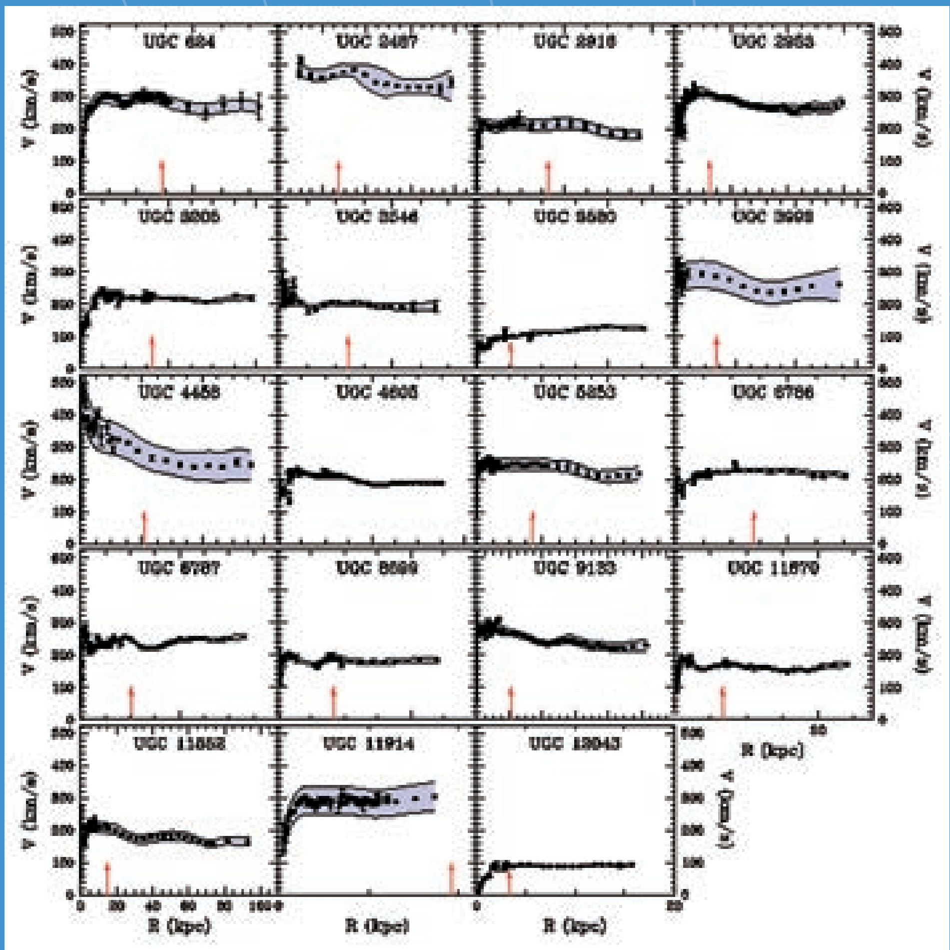
Edo Nordermeer (Univ. of Nottingham)

-type galaxies

nous matter, or whether dark matter dominates everywhere with the stars and gas simply responding. To study this issue in the early-type disk galaxies in our sample, we carefully compared the shape of the rotation curves with the distribution of the stellar light. We found that the two are correlated, in the sense that galaxies with a more compact light distribution have more steeply rising rotation curves, whereas the rotation curves of more diffuse galaxies reach the maximum at relatively larger radii. This finding provides important evidence that the dynamics in the inner regions of massive, high surface brightness galaxies are dominated by the luminous matter, and that dark matter becomes important at larger radii only.

Our study has yielded important insights in the relation between dark and luminous matter in the most massive and high surface brightness disk galaxies in the universe and has again shown the power of the WSRT for dark matter studies. The main challenge for the future lies in a more accurate determination of the contribution of the stars to the rotation curves.

Although we now know that they dominate the gravitational potential in the inner regions, the transition radius where dark matter takes over is still poorly constrained. Without independent information on the mass-to-light ratios of the stars in especially the disks of spiral galaxies, the details of the dark matter content and distribution still remain elusive.



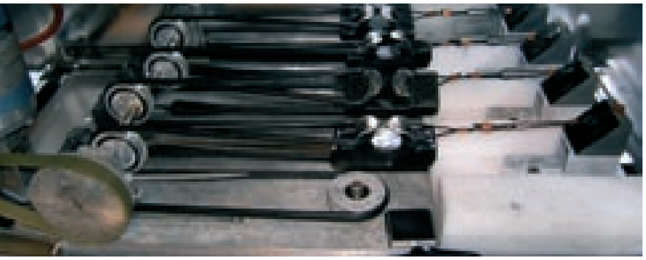
Rotation curves for a sample of 19 early-type disk galaxies, based on HI observations with the WSRT and complementary optical spectra. Errorbars show uncertainties due to measurement errors and kinematical asymmetries, the blue shaded regions show the uncertainties from inclination errors. Radii are in kpc, small and large tickmarks indicating 5 and 20 kpc intervals respectively. Red arrows show the radius of the 25th magnitude isophote (B-band, except for UGC 6786, where R-band was used). The labels in the top right hand corner of each panel indicate the morphological classification and the B-band absolute magnitude for each galaxy.

... but how long will they last?

LOFAR antennas have to be low cost, have high performance and last a long time in the open field. Just the kind of challenge on which ASTRON engineers thrive.

The requirements of the LOFAR Low Band Antenna (30 – 80MHz) provided the ASTRON team with major challenges. On the one hand, for cost-effectiveness, inexpensive materials, production techniques and installation procedures had to be used. But on the other hand, the reliability of the antennas was not allowed to be compromised and the lifetime should easily exceed 15 years. The final design and material selection was performed in 2005 and early in 2006 extreme environmental tests have confirmed the required lifetime of the antennas.

The LOFAR Low Band Antenna (LBA) consists of a central pole that is kept upright by four arms. Each arm consists of an electrically conducting wire, which is the actual antenna, and an EPDM spring to put the arm under a constant pre-tension. The other end of the EPDM spring is attached to a tent peg in the ground. A Low Noise Amplifier (LNA) cast in epoxy (resembling an ice hockey puck) is located on the top of the pole. Since the antennas are scattered over a very large area, it would be very expensive to have to replace them in significant numbers. All materials were selected to have the required lifetime, but no industrial supplier will give a hard guarantee that the actual design will withstand the Dutch climate for 15 years.

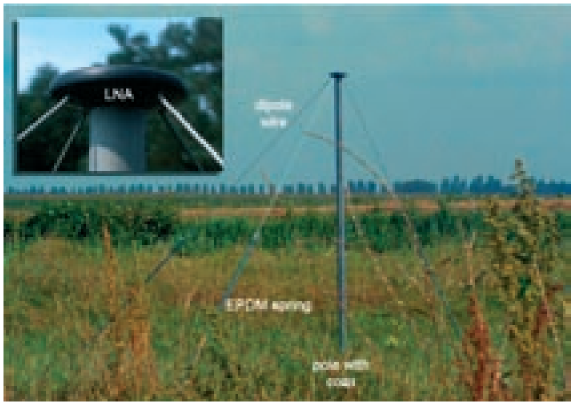


The test setup in the solar radiation chamber. The antenna arms are folded to reduce the size of the setup. On the left side is the motor to induce vibrations.

To confirm the performance, reliability and lifetime of the antennas, a test program has been executed. First, several 'basic' tests were performed. For example, pulling tests to ensure that the arms do not come loose from the LNA, liquid penetration tests have shown that the LNA is well sealed against moisture and a long term test has been performed to make sure that the tent pegs that secure the elastic arms don't come loose from the ground.

Next, the construction has been tested under extreme conditions in a series of environmental tests, which were accelerated by scaling the test conditions following international standard protocols so they needn't last the full 15 years!

The tests focused on the corrosion and wear of the individual parts and their connections. Most of the tests were conducted on a representative test setup in which the antenna arms have been folded (to reduce the size of the setup). The arms are constantly vibrated to simulate the wind load of the antennas. After each test the samples were inspected and the elasticity of the rubber bands was measured.

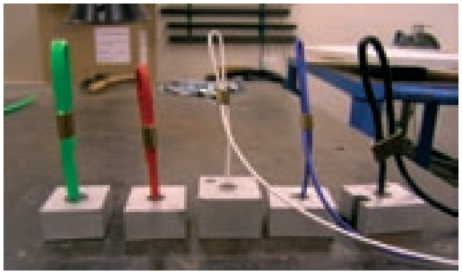


LOFAR Low Band Antenna

The samples were exposed to 200 hours of salt-spray, 96 hours of concentrated SO_2 and 96 hours of concentrated ozone all at a temperature between 35°C and 40°C. These tests were performed by Thales Nederland B.V. In addition, a solar radiation test has been performed by ASTRON in which the samples were exposed 1000 hours (almost 6 weeks!) to continuous intensive 'solar' radiation (mainly infrared and UV, 65 W/m^2).

The environmental test results are very satisfying: all tests showed no or negligible degradation of the antenna and a lifetime

exceeding 15 years is very plausible.
In addition to the environmental tests, the temperature of the LNA (molded in epoxy) has been studied under varying conditions. The analysis takes into account the worst case outdoor temperatures, heating by the sun and the dissipation of the LNA itself. The temperature dependency of the LNA was characterized separately in ASTRON's climate chamber. The complex gain of the LNA was measured over a temperature range from -30°C to +80°C. The initial tests led to a modified design resulting in a very stable (< 0.005 dB per degree between -20°C to +50°C). The inputs and outputs of the LNA are protected against voltage peaks caused by lightning and/or static electricity. The effectiveness of these protective measures has been tested with an Electrostatic Discharge (ESD) gun and showed that the LNA is protected up to a certain level of peak shock.
This test program has convinced us that the LOFAR Low Band Antenna will perform as expected over a broad range of environmental conditions and that it will continue to do so over the full lifetime of LOFAR. It also gives us confidence we can design large array antennas for outdoor applications, such as will be required for SKA.



A number of dipole wires molded in epoxy just before the pulling test to check their bonding with the epoxy.

Lex Kaper (Univ. of Amsterdam)

X-Shooter moves to construction

ASTRON is helping design and build the world's most efficient, medium resolution, wide-band spectrograph for the ESO VLT.

X-Shooter is a single target spectrograph for the Cassegrain focus of one of the Unit Telescopes of the ESO Very Large Telescope. It is designed to cover in a single exposure the whole spectral range from 300 to 2500 nm (from the UV to the K band) at resolutions in the range R = 4000 – 14000). It aims to maximize sensitivity by directing the light to three wavelength-optimized spectrograph arms simultaneously.

The capability to observe faint sources with an unknown flux distribution in a single integration inspired the name of the instrument. The science drivers for X-Shooter range from the study of brown-dwarf atmospheres, star formation, compact objects and close binary systems to research on supernovae, lensed high-redshift galaxies to gamma-ray bursts. With such capability it will be able to serve a very large user community.

A consortium of partner institutes in the Netherlands, Denmark, Italy, France and involving ESO was selected by ESO Council in 2003 to design and build the instrument, based on a feasibility study financially supported with NOVA seed funding. X-Shooter will be the first of the second generation of VLT instruments, and will be offered to the community from 2008.

The Dutch contribution to X-Shooter is one of the three spectrographs: the near-infrared arm, designed, constructed and tested at ASTRON and its cryogenic enclosure, being developed at the Radboud University (RU) in Nijmegen. Funding is provided by the NOVA Phase-2 instrumentation program, by NWO, by a grant from the University of Amsterdam (UvA) and in-kind contributions from ASTRON and RU.

Lex Kaper (UvA) is the Dutch PI and member of the Project Board, Paul Groot (RU) is co-PI and chairman of the X-Shooter Science Team, and Ramon Navarro (ASTRON) is the Project Manager.

The project's Final Design Review was held at ESO Garching on February 6-7, 2006, and the remaining action items are to be finished before the summer. Then the construction phase will start with final delivery of the instrument to ESO foreseen in 2007. Commissioning at ESO Paranal is planned for 2008.

Ronald Nijboer, Kjeld van der Schaaf, Michael Wise

First LOFAR station

Over the summer, the first LOFAR antenna station, named Core Station 1 (CS1), will be installed near the Exloo test site.

CS1 will consist of 96 production quality, dual polarization, Low Band Antennas optimized for 30 to 80 MHz. In a later phase, 96 High Band Antennas optimized for 120 to 240 MHz will be added. The antennas will actually be distributed over four locations: one cluster having 48 dipoles and three clusters each having 16 dipoles. These clusters can also be grouped dynamically to form sub-groups of 4, 6, 16, or 24 micro-stations. In this sense, CS1 will function as a small-scale version of the full LOFAR array and will be used to demonstrate all elements of the operational chain – from observation configuration, station-level processing and transport over the Wide Area Network (WAN) to the central processing facility, to the standard pipeline processing which produces LOFAR data products.
The CS1 data chain begins at the micro-station level when a radio signal is received, digitized, and filtered. The weights that are needed to follow sources while the Earth rotates are calculated in the Local Control Unit (LCU) and the signals are combined to form beams on the sky. The resulting data stream is then sent over the WAN to the CEntral Processor (CEP), located 70 km away in Groningen. Additional useful metadata such as information about the health of the instrument or weather conditions at the station are collected by the Monitoring And Control (MAC) subsystem and also sent to CEP.

At CEP the data from the micro-stations are further processed. First the data are received, validated, synchronized, and an additional delay is applied to correct for the Earth's rotation. Then the data are put through a polyphase filterbank and correlated on Stella, the IBM Blue Gene/L supercomputer. This concludes for CS1 the real time, on-line data pipeline.

For CS1 the correlated output from Stella is stored and after the observation is completed the remaining processing steps are performed. In general these steps will include the flagging of bad data (to remove RFI for example), calibration, and finally the construction of images. This processing will be done using a dedicated cluster and will generate the data products for CS1, which will include visibility data sets and images. The "users" of CS1 will be the LOFAR Key Science Projects.

There are currently four Key Science Projects (KSPs) accepted for execution with LOFAR. They are currently going by the shorthand names: the Epoch of Reionization, Surveys, High-Energy Cosmic Rays, and Transients. These key projects span a wide range of unique scientific topics and involve scientists from all over the Netherlands as well as international partners.

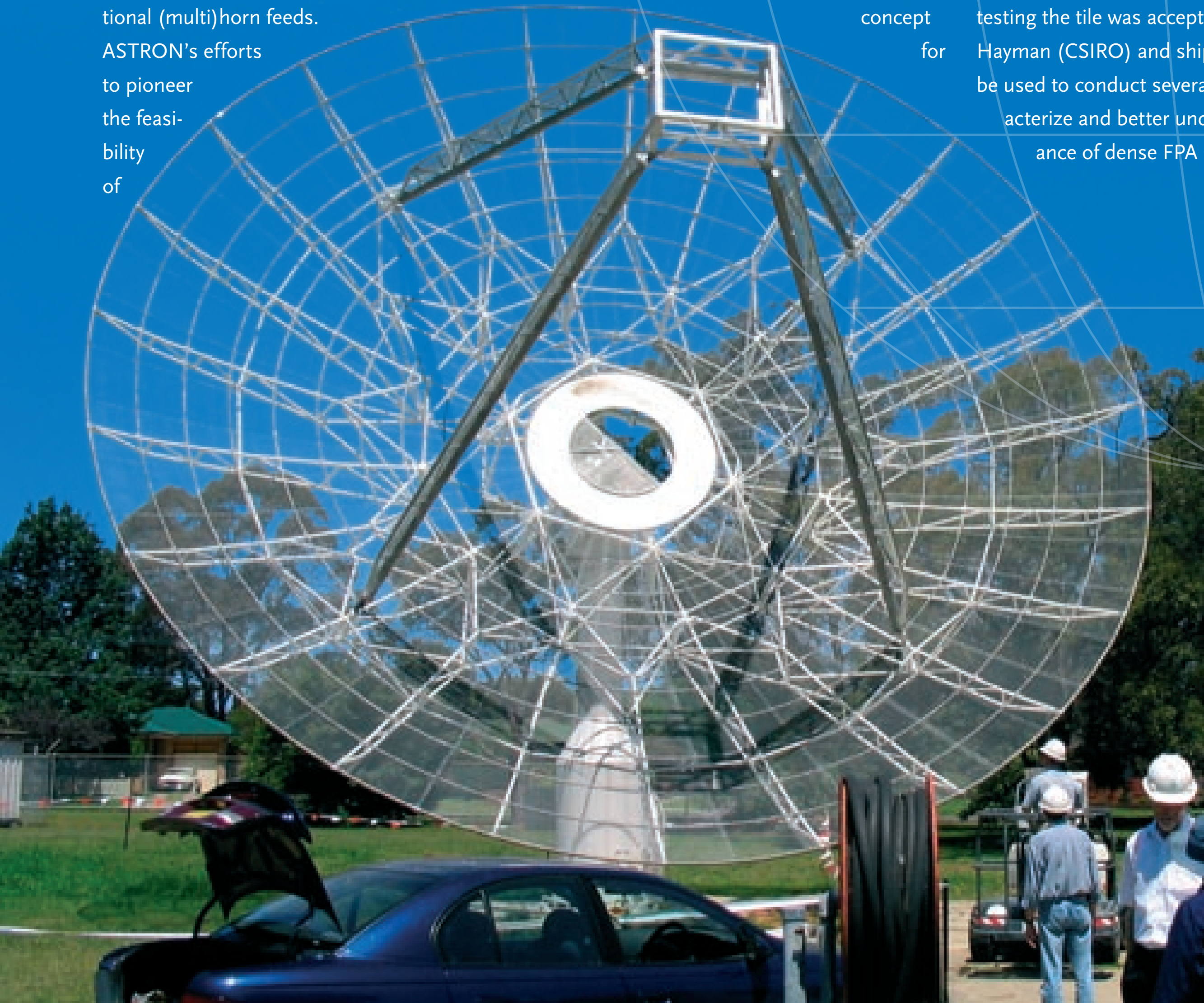
In partnership with the LOFAR project, the KSP teams are developing a variety of software tools to extract meaningful scientific results from the standard LOFAR data products. These tools include software to plan observations, achieve improved calibration, assess data quality, detect and extract sources, construct flexible databases of source properties, and visualize datasets. After testing and improvement using CS1 data, some of these tools may eventually become part of the standard LOFAR processing pipelines while others may be made available to the general LOFAR user for their own scientific analysis.
Although the scientific capabilities of CS1 will be limited compared to those of the full LOFAR array, it represents an excellent opportunity to begin testing the operation of the entire data chain. The lessons learned once CS1 becomes operational will be an important step in commissioning both the hardware and the software components necessary to make the LOFAR observatory a success. Following our initial experience with CS1, the remaining LOFAR system will be procured and installed.

THEA goes Down Under

One of the aperture array antenna tiles developed by ASTRON has been modified and delivered to CSIRO in Australia to be used in their NTD focal plane array demonstrator project.

A smart array antenna in the focal plane greatly enhances the capabilities of conventional reflector antennas by expanding their Field of View when compared to conventional (multi)horn feeds. ASTRON's efforts to pioneer the feasibility of dense focal plane arrays in radio astronomy have resulted in wide spread adoption of the concept in new instruments.

One such new instrument is being developed at CSIRO in Sydney, the xNTD, which is one of the SKA pathfinders based on dense focal plane array technology. The array antenna technology used is very similar to that used in the aperture array concept for future radio telescopes, except of course with the array deployed in the focal plane rather than the aperture plane.
Late summer 2005 it was recognized that it would be beneficial to use one of ASTRON's aperture array tiles as the feed of the CSIRO New Technology Demonstrator (NTD) project. The required electrical and mechanical modifications to the tile were performed at ASTRON and in December 2005 after a short period of testing the tile was accepted by Douglas Hayman (CSIRO) and shipped to Sydney. It will be used to conduct several experiments to characterize and better understand the performance of dense FPA systems.



CSIRO representative Douglas Hayman accepts the modified THEA tile.

Elke Rödiger, Marcus Brüggen (International University Bremen)

Ram-pressure stripping

New computer simulations performed with STELLA reveal how galaxies lose their interstellar gas when passing through a galaxy cluster.

They explain, for example, the observations of neutral hydrogen trailing a spiral galaxy in the Virgo cluster, as reported by Oosterloo and van Gorkom in the July 2005 edition of this newsletter.

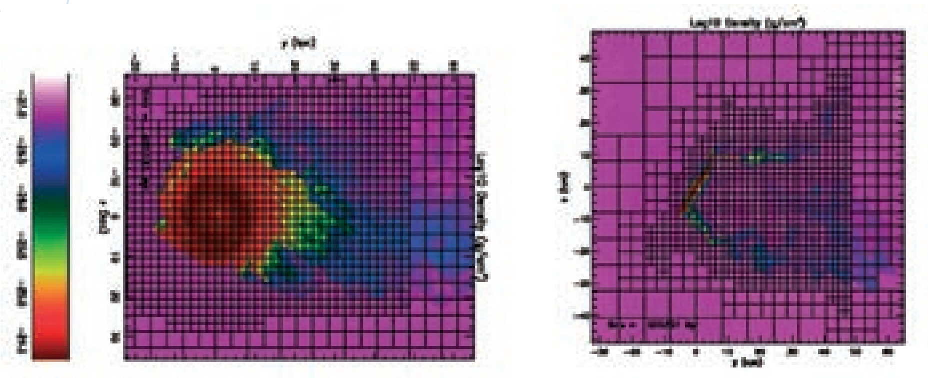


Figure 1. Cut through the simulation box, showing the colour-coded gas density in the x-z-plane. For two different inclinations of the galactic disk: i = 90ﬄ (left, the disk is seen face-on), i = 30° (right). The ICM wind is flowing along the y-axis (from left to right) in both cases. The outer parts of the gas disk are stripped by the ICM wind. In the 90° case, the stripping proceeds asymmetrically. The squares demonstrate the adaptive refinement of the resolution: One square corresponds to one block with 83 grid cells.

Galaxies populate different environments in the universe, ranging from isolated field regions to dense galaxy clusters. Depending on environment, the properties of galaxies differ: In denser regions the galaxies tend to contain less neutral gas, show a weaker star formation activity and redder colours than galaxies in sparse regions. Several processes have been proposed to explain these observations. The most important process is thought to be ram-pressure stripping which works as follows: Besides galaxies, clusters also contain a large amount of rarefied gas - the intra-cluster medium (ICM). In fact, there is more mass in this dilute intra-cluster gas than in all the stars of the cluster galaxies. As galaxies move through a cluster, they also move through the ICM. The ram pressure caused by these motions can push out (parts of) their gas disks. To verify and understand this process we have carried out exciting new calculations with STELLA.

Our simulations use the hydro-dynamical adaptive mesh refinement code FLASH. The simulations were performed in 3D and required a large spatial resolution in order to resolve the interaction between the external wind and the galactic gas. These types of simulations are only possible on the largest computers of the world and our simulation is the first suite of 3D hydro-dynamical simulations of ram-pressure stripping. They were performed on 512 processors of STELLA and took more than a month to complete.

We have studied two aspects of ram pressure stripping: How much gas is lost from the galaxy and what happens to the stripped gas?

To study the galactic gas disk, we have focused on the question how the mass loss depends on the inclination angle between the galaxy's rotation axis and the ICM wind direction. We found that the inclination angle does not play a major role for the amount of gas loss from the galaxy as long as it is not moving close to edge-on. Figure 1 shows the gas density in slices through the simulation box for two different cases. In both cases, the ICM wind can strip the outer part of the galactic gas disk.

The stripped gas plays an important role in the chemical evolution of the ICM. Practically all metals (in astrophysics this means all elements heavier than hydrogen and helium) are produced in stars inside galaxies. Hence, the metals found in the ICM

# of disk galaxies

must originate from the cluster galaxies. Obviously, galactic gas lost by ram pressure stripping is a source of metals for the ICM. In order to understand how the metals are distributed within the ICM, we have studied the evolution of the galactic wakes of stripped gas. Moreover, the galactic gas is much colder than the ICM, and such low-density wakes of cooler material now become observable. Figure 2 shows slices of the gas density through the simulation box for a galaxy that moves supersonically.
The structure of the galactic tails depends on the strength of the ram pressure and the galaxy's Mach number. A particularly interesting case is shown in Figure 3. Here we see a projection of the galactic gas at different stages of the stripping. In this case, the ram pressure is strong enough to strip the entire gas from the galaxy. As the galaxy moves on, the gas is left behind as a huge gas cloud. Such cases are a real challenge for observers, because it is extremely difficult to reveal the original connection between this gas cloud and its source galaxy. To our knowledge, the first such observations are those by Oosterloo and van Gorkom of NCC 4388, reported in the July 2005 issue of Astronnews.
The results of this study are now published in two papers: E. Roediger and M. Brüggen, Ram pressure stripping of disc galaxies. The role of the inclination angle and E. Roediger, M. Brüggen and M. Hoeft, Wakes of ram pressure stripped galaxies, both in press in MNRAS, (astro-ph/0512365 and astro-ph/0603565)
The author would like to thank Heino Falcke for his support.

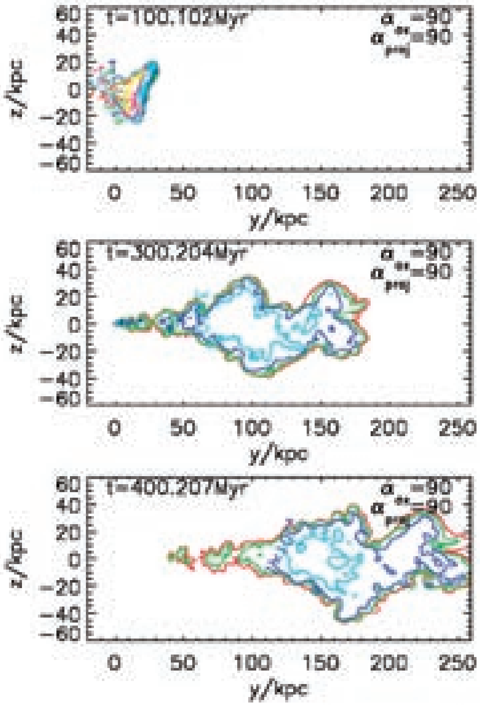


Figure 3: Projected gas density in the galactic tail at different stages of the stripping process. The galaxy is located at (x; z) = (0; 0). Some time between 300Myr and 400Myr the galaxy's gas disk is stripped completely, and the galactic gas lags behind the galaxy as one huge cloud.

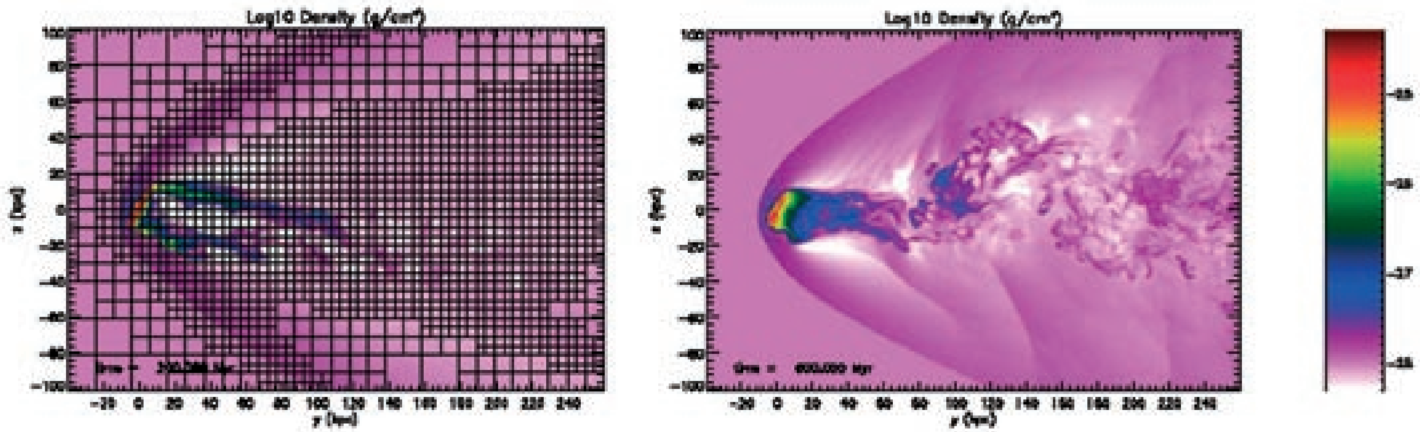


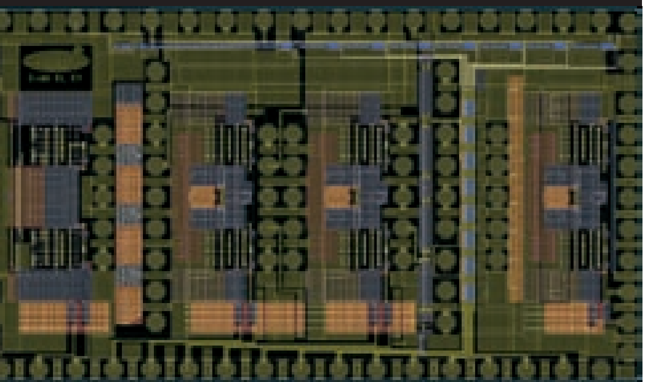
Figure 2: Cut through the simulation box, showing the colour-coded gas density in the x-z-plane for two different times. The rich shock structure requires massive refinement. As we want to follow the tail for a large distance behind the galaxy, these simulations are computationally expensive.

Beam-forming MMIC

The SKA Design Study demonstrator antenna, EMBRACE, has a goal of dramatically reducing cost. One strategy is to integrate many functions onto a small number of MMICs. The first of these has been successfully designed.

A fully integrated beam-former MMIC (Monolithic Microwave Integrated Circuit) has been designed for EMBRACE. The chip includes an input Low Noise Amplifier, output buffer amplifiers and digital control around a core of the actual beam circuits. Beam control is by means of phase-shifting and if required also amplitude control. Two independent beams are generated.

A new, patented beam-forming technique has been used in the design. Previously implemented successfully in Gallium Arsenide, higher integration density and a lower cost technology is required to meet EMBRACE cost targets. The new chip has therefore been designed for a Silicon Germanium process, which retains the benefits of mainstream Silicon technology but with Germanium added for high frequency performance.



Robots in the focal plane

ASTRON and partners have recently demonstrated a cryogenic positioning robot for use on future large optical/ infrared telescopes.

Observing time on large telescopes is very expensive and observing procedures must be carefully planned to maximize the rate of scientific return. In recent years instruments have increasingly been designed to acquire data on many faint objects in a given region of sky at the same time. Remote operation requires that robots be placed in the focal plane to isolate the objects of interest.

ASTRON is participating in a project to develop such 'smart focal planes'. The effort includes the design and construction of a demonstrator robotic system whose task is to position many small mirrors on a curved focal plane. The mirrors in turn relay light from a selected, tiny piece of sky into the instrument. The robot automatically positions a hundred or more tiny mirrors with magnets onto a curved metallic plate, which is then tumbled into position in the telescope's focal plane to permit the spectra of many objects to be recorded simultaneously. The system incorporates cryogenic capability so it may be used for both infrared and visible spectroscopy. It is designed for Cassegrain operation and can operate in any orientation.

This work was undertaken as part of an EU FP6 I3 OPTICON Joint Research Activity contract. The project is led by the UK's ATC, with ASTRON and CSEM in Switzerland as partners.

Star-picker robot fully assembled and operating.

Receivers for Shanghai Observatory

New cryogenic C-band and L-band receivers have been designed and built at ASTRON for the Seshan radio telescope outside Shanghai in China.

ASTRON has cooperated closely for many years with Shanghai Astronomical Observatory staff to make VLBI observations with extremely long baselines. Now, our technical and astronomical staff have jointly designed and built new C-band (6cm) and L-band (20cm) receivers for this research. The C-band receiver was completed and taken into operation in the Cassegrain focus of the Seshan telescope during the second half of 2004. Now the the L-band receiver has been completed and installed in the telescope's prime focus. The telescope is now equipped with state-of-the-art cryogenically cooled receivers for VLBI and other radio astronomical applications.

During the two and a half years of the project two young Chinese engineers participated in the design of state-of-the-art cryogenic low noise amplifiers and other receiver electronics. They spent a total of two man-years at ASTRON, making extensive use of the available knowledge and facilities at the R&D Division.

Besides project management and knowledge transfer, ASTRON made a considerable contribution with the efforts of our mechanical engineers in the design and construction of the mechanical infrastructure of the receivers and their interface to the telescope.

A happy receiver team admires Shanghai's L-band receiver (cover removed to reveal the receiver boxes, refrigerator and L-band feed) just prior to its shipment to China.

Workshops at ASTRON

The Fate of the Gas in Galaxies

ASTRON will host, on the 12-14 July 2006, the Workshop "The Fate of the Gas in Galaxies". This meeting is part of a series of scientific workshops sponsored and organized by the EU RadioNet Consortium within the Sixth Framework Program of the European Commission.

The workshop aims at bringing together scientists working on topics related to how gas is acquired by galaxies, how gas is lost by galaxies through the effects of outflows and what is the fate of the gas that remains in galaxies. It also aims to bring together specialists working in different spectral bands, as well as theoreticians. The organizing team includes: Raffaella Morganti (chair), Susanne Aalto, Willem Baan, Tom Oosterloo, Jacqueline van Gorkom, Montse Villar-Martin and Nanuschka Csonka (secretary). Information about the workshop can be found at www.astron.nl/wsrt/FateOfGas.

YERAC (Young European Radio Astronomers Conference)

The 36th YERAC will be organized by ASTRON and JIVE in 2006, and will take place in the Netherlands. The dates of the meeting are:

12-15 September 2006, and the venue will be:
Conference Centre De Bron, Dalfsen (near Zwolle)
Information on the venue can be found at: www.conferencecentre.nl
For information on the conference, please contact:
Richard Strom (strom@astron.nl)
Nanuschka Csonka (csonka@astron.nl)

Thijs van der Hulst

From the ASTRON Board

The year 2006 started with a number of new perspectives and challenges. The first challenge for the Board is to find a highly qualified successor to Harvey Butcher, whose third term as General Director of ASTRON ends in August this year. The search has started and as I mentioned in my New Year's speech to ASTRON personnel: ASTRON deserves the best director in the world, so we are looking around the world to identify the best candidates for this demanding position.

Under Harvey's directorship ASTRON has grown from a fairly small Institute with the WSRT as its main focus, to a major institute with some two hundred skilled scientists, engineers and technicians who are deeply involved in a wide variety of scientific, technological and organizational activities.
A major current activity, of course, is the LOFAR project, which is exploring innovative design concepts quite different from the classical radio telescopes such as the WSRT. With this project and various other activities (such as SKA Design, optical/IR instrumentation efforts) well on-track, the time has come after fifteen years to consider a handover of the helm to a new captain. No moment is right for a change of director, but the director and the Board considered various options carefully and decided to launch a search.

The second challenge is to prepare for when ASTRON will have to operate two observatories: the WSRT and LOFAR. This really is a challenge as the modes of operation of LOFAR have entirely new aspects, because it is not a classical radio telescope. The team that has been operating the WSRT skillfully and successfully over the past many years has taken up the challenge. I am confident that ASTRON is preparing itself and the entire user community in the best possible way to the era of new radio telescopes.
It is very encouraging to note that LOFAR really is going international with the commitment from our German colleagues to host a number of LOFAR stations. The German LOFAR consortium GLOW has already found the funds to build a LOFAR station near Effelsberg and there is the perspective of more LOFAR stations elsewhere. Our ministry has agreed to provide funding so that our academic research network, SURFnet, can connected to the German science network through a new, very wide band connection. This is an important milestone for LOFAR and will make international remote access in Europe straightforward.
Finally, we celebrated the 50th anniversary of the Dwingeloo telescope, which was officially put into use by Her Majesty Queen Juliana on April 17, 1956. The ceremony was on Monday April 18, with two hundred guests present. A grander scale celebration for the general public is planned for October this year. The most important aspect in my opinion is that the history of the Dwingeloo telescope marks a very exciting era of development and scientific discovery, with excellent people across a wide range of disciplines involved. We may safely conclude that this era is still continuing, with young and equally skilled people now working on scientific challenges of comparable magnitude. This is a clear trademark of ASTRON and Dutch astronomy.

Michelle Zuliani

SKADS of antennas

ASTRON coordinates activities Europe-wide for the SKA Design Study project (SKADS). We also lead major SKADS work packages including the antenna demonstrator, EMBRACE (Electronic Multi-Beam Radio Astronomy ConcEpt). The challenge for the EMBRACE team is to realize a wide-band, flat-panel, all-sky antenna at very low cost.

ASTRON's research on SKA antennas has entered a new phase following signing of the EU FP6 SKADS contract. The design of the EMBRACE demonstrator antenna builds on our previous work on the Thousand Element Array (THEA) and on our previous commercial antenna work. Bilateral Vivaldi radiators are being integrated with strip-line feeds to enable a dual polarized antenna that is readily assembled into a flat-panel array. Careful

Towards a Lunar observatory

On 9 March 2006, the EADS Space Transportation company, ASTRON and the LOFAR Foundation formally agreed to work together towards realization of a LOFAR-like infrastructure on the Moon.

For decades astronomers have dreamt of observing from the Moon. In principle, the stable surface and lack of atmosphere make the Moon an ideal site for long duration observing of the Universe at frequencies inaccessible to ground-based facilities. For radio astronomers this means especially extremely low frequencies, below about 30MHz where the Earth's ionosphere goes opaque to radio signals. At these frequencies the distant Universe is completely unexplored but is predicted to exhibit a wealth of new sources and phenomena made detectable by coherent plasma emission mechanisms.

In the political arena, exploration of the Solar System has become a driver for investment in spaceflight in Europe and China as well as in the USA. The establishment of permanent bases on other planets is an important goal, which will require using the Moon as stepping stone to prove the necessary technologies. Following workshops in March and September 2005, EADS-ST identified an IT-infrastructure incorporating arrays of sensors, data processing and transport, and a durable energy supply as both feasible technologically and achievable economically (e.g. an initial mission would require but a single launch).

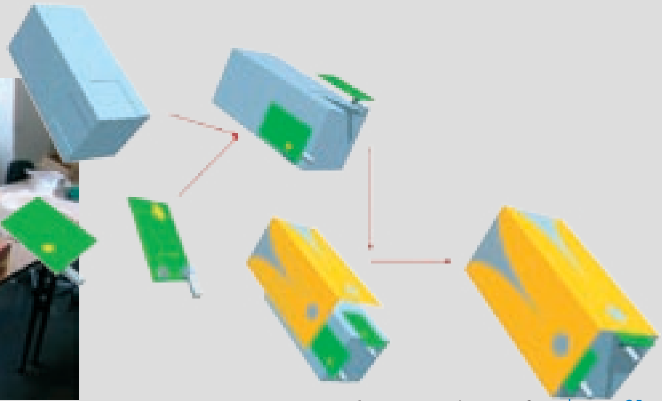
Representatives of EADS-ST and ASTRON/LOFAR met at the offices of LOFAR partner, Dutch Space b.v. in Leiden on 9 March to formalize this conclusion with an MoU, and to present the plans to the press. The project was given the name, LIFE: Lunar Infrastructure For Exploration. The bi-lateral cooperation aims to develop the project sufficiently, using the ground-based LOFAR infrastructure as demonstration and test facility, that it may be put to the ESA ministers' conference in 2008 for adoption as part of ESA's subsequent program with a view to launch in the 2013-2015 time frame.

MoU signatories celebrating the deed on 9 March 2006, left to right: E. de Geus (Managing Director, LOFAR), S.F. Graul (Executive Vice President, Business Development, EADS Space Transportation), H. Butcher (General Director, ASTRON), E. Dudok (President and General Director, EADS Space Transportation).

For readers not familiar with the EADS group of companies, EADS Space Transportation is the European specialist for access to space and manned space activities. It develops and produces Ariane launchers, the Columbus laboratory and the ATV cargo carrier for the International Space Station, atmospheric re-entry vehicles, missile systems for France's deterrent force, propulsion systems and space equipment.

selection of materials and adopting design-for-production methodologies are the keys to achieving low cost.

Risks and rewards are positively correlated, of course, and our design team has adopted a novel implementation. Metallic Vivaldi patterns are being printed on continuous, very thin, flexible substrates that are then cut to size and folded around polystyrene blocks. These blocks are then assembled in an array, integrated with ground plane and packaged for protection against the external environment.



'LOFAR week' at local schools

On 19 April 2006 thirteen hundred local elementary school pupils descended on the LOFAR Initial Test Site in Exloo to see the prototype antenna array and help 'calibrate' the prototype geophone array.

The event also marked the start of 'LOFAR week' at 23 schools in the township Borger-Odoorn, which includes the town of Exloo. ASTRON and LOFAR staff members gave talks to pupils aged 5 to 12, who then did exercises on the planets, built models of LOFAR antennas, and several groups walked the Milky Way path in nearby Hooghalen, along which they had to seek answers to a list of questions.

Guy Drijkoningen from Delft University and ASTRON's own Peter Bennema and Frederiek Westra van Holthe hosted the pupils at the Exloo site. Guy is chairman of LOFAR's geophysics research committee and an avid proponent of outreach as well as scientific supervisor of the LOFAR geophone array.

The current geophones are buried about ten meters under the surface to eliminate much unwanted surface noise. But they are still sensitive enough to detect footsteps directly overhead. For the calibration experiment the children were asked to jump up and down some distance away. They were then asked to look at the recorded vibrations and note the difference in arrival times across the array. Knowing the distance between the geophones, one could 'calibrate' the speed of travel of the vibration signal in the ground. Answer: 932 km/hour!

Geophone calibration team at work *(Photo courtesy Dagblad van het Noorden)*

Inter-Agency group studies SKA

On 6 February 2006 most of the interested national and regional funding agencies met in The Hague to discuss the status of the SKA project and the interest in participation in that project within their countries. Presentations by a delegation from the International SKA Steering Committee (ISSC) informed the meeting of progress and thinking to date among working radio astronomers.

The gathering agreed to form an Inter-Agency Working Group to look at several issues and prepare for further discussion and eventually also for SKA-related decision making. At least the following issues will be considered: (i) timescale imperatives and schedule for construction, (ii) the governance of such global projects, and (iii) how site selection for the SKA antennas might proceed.

The next funding agencies meeting will likely be in September 2006.

Market potential recognized

For several years now, ASTRON has worked with other scientific and educational institutions in the northern Netherlands to make our technologies available to interested companies. An important vehicle to do this has been the Integrated Development Lab (IDL) foundation. The IDL partners aim to make it possible for small and medium sized enterprises to have new ideas studied for technical feasibility and worked out though the prototyping phase.

The market looks set to attach sensors in intelligent networks to every conceivable environment. The central technologies currently available through IDL, therefore, are wireless communications, networked sensors and embedded processing systems.

On 16 January 2006, our regional governments recognized the potential and granted € 5,1M to IDL to ensure that our technologies do indeed become exploited by our local industries.

LOFAR gets a new Logo

LOFAR

New logo

The LOFAR foundation has adopted a new logo, displayed above. LOFAR management denies that the change in any way is related to the discovery of crop circles incorporating the previous logo, see below.

Old logo and mysterious crop circles

Northern provinces support LOFAR

On 13 December 2005, welcome letters appeared in our postbag. The letters notified us that the provinces of Drenthe, Friesland and Groningen had decided to grant ASTRON a total of € 22M to further the LOFAR project. The grants will allow us to do several things.

Manufacture of the high-band (100-240MHz) antenna system together with industry is financed – good news for our astronomers! The planned research in geophysics and seismology, and in precision agriculture will now be extended to the level originally proposed. And necessary IT development to prepare for operations including optimal use of Stella can now proceed.

In return for this support we are required to ensure that the expertise acquired during the project leads to strengthening of the region's economic competitiveness.

Chair at Chalmers for Van Ardenne

Chalmers University, Gothenburg, Sweden, has appointed Arnold van Ardenne as Adjunct Professor in Radio Astronomy at the Department of Radio and Space Science. Arnold is head of ASTRON's Emerging Technologies section and will now also work with students and staff at Chalmers on the technologies of future radio telescopes. We have for some years hosted Chalmers masters students and this professorship will strengthen our ties even further.

Jülich to support LOFAR

On 10 May in Düsseldorf, representatives of ASTRON and LOFAR signed an agreement to work together with the Research Center Jülich on the LOFAR project.

The signing ceremony took place in the State Chancellery in the presence of Prof.dr. Andreas Pinkwart, Minister for Innovation, Science, Research and Technology of the Federal State of North Rhine-Westphalia, and of Mr. Jan Giesen, Netherlands Consul-General in Düsseldorf. The cooperation falls under an inter-governmental umbrella arrangement that aims to promote closer ties between the high-tech communities of the two states.

The specific agreement relating to LOFAR follows installation in the John von Neumann Institute for Computing at Jülich of an IBM BlueGene/L having over 20,000 processors (making it currently the most powerful supercomputer in Europe), and the financing through the Dutch and German academic networks of a dedicated λ-connection between Jülich and our own Stella in Groningen (which has a mere 12,000 processors).

In addition to dramatically increasing the possibilities for supporting LOFAR users across Europe, the new agreement aims to bring the considerable experience at Jülich in high performance computing and data management to bear on some of the most data intensive LOFAR applications. Together with our own facilities in Groningen and at SARA and NIKHEF in Amsterdam, all connected by dedicated high-capacity links, we believe we now have the necessary computing and storage capacities to handle the most demanding requirements of our user community.

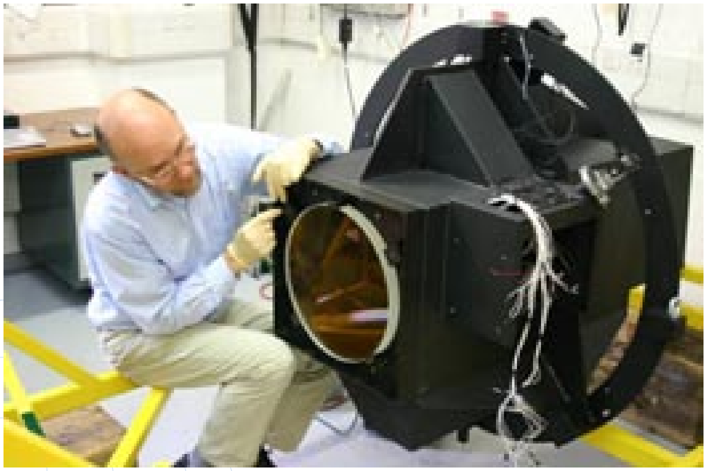
Laser guide star for WHT

A laser guide star system is being installed on the William Herschel Telescope. ASTRON developed the beam launch telescope (BLT) and the wave front sensor (WFS).

The Isaac Newton Group (ING) of Telescopes on La Palma is currently running a project named GLAS. The purpose of the Ground Layer Adaptive Optics System (GLAS) project is to realize a Rayleigh laser beacon for the adaptive optics system, NAOMI.

The fraction of the sky available to high-order adaptive optics at visible wavelengths will increase from ~5% to ~95%. This enables astronomers to exploit adaptive optics for the widest possible science goals.

The BLT is a mechanical structure that contains one big lens accurately aligned with two mirrors and a focusing mechanism. Concept studies started in September 2004 and delivery was planned for the end of March 2006. Thanks to a maximum effort of the team and our suppliers, we succeeded in completing the BLT on schedule. In May it will be mounted on the WHT, and in June the WFS will be integrated. Commissioning is expected after the summer.



BLT with optics during assembly and alignment on La Palma

Hidden Rhythms

On 19 and 20 January 2006, the WSRT became part of an international contemporary art project, 'Hidden Rhythms'. In live radio broadcasts the citizens of the city of Nijmegen were able to 'tune into the stars' as part of artist Susan Philipsz' exploration of the relationships between sound and architecture, and the alteration of the listener's perception of the self in a particular place and time. The sound comprised signals from PSR B1933+16 being relayed into listeners' homes via an abandoned and ramshackle flour factory in Nijmegen. The architecture featured the derelict factory as a former home to a pirate radio station, surrounded by houses that can no longer be entered from the street and having no official address.