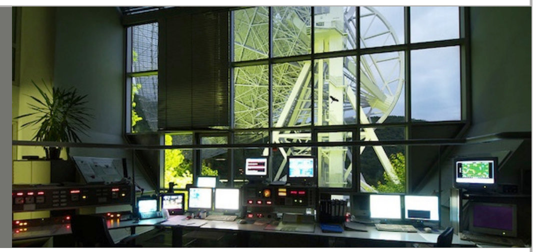
Effelsberg Newsletter

September 2016

Call for Proposals

Deadline: October 5, 2016, 15:00 UT



Observing proposals are invited for the Effelsberg 100-meter Radio Telescope of the Max Planck Institute for Radio Astronomy (MPIfR).

The Effelsberg telescope is one of the World's largest fully steerable instruments. This extreme-precision antenna is used exclusively for research in radio astronomy, both as a stand-alone instrument as well as for Very Long Baseline Interferometry (VLBI) experiments.

Access to the telescope is open to all qualified astronomers. Use of the instrument by scientists from outside the MPIfR is strongly encouraged. The institute can provide support and advice on project preparation, observation, and data analysis.

The directors of the institute make observing time available to applicants based on the recommendations of the Program Committee for Effelsberg (PKE), which judges the scientific merit (and technical feasibility) of the observing requests.

Information about the telescope, its receivers and backends, the Program Committee and selection process can be found at the observatory's web pages:

http://www.mpifr-bonn.mpg.de/effelsberg/astronomers

(potential observers are especially encouraged to visit the wiki pages!).

Observing modes

Possible observing modes include spectral line, continuum, and pulsar observations as well as VLBI. Available backends are several FFT spectrometers (with up to 65536 channels per subband/polarization), a digital continuum backend, a number of polarimeters, several pulsar systems (coherent and incoherent dedispersion), and two VLBI terminals (dBBC and RDBE type with MK5 recorders).

Receiving systems cover the frequency range from 0.3 to 96 GHz. The actual availability of the receivers depends on technical circumstances and proposal pressure. For a description of the receivers see the web pages.

How to submit

Applicants should use the NorthStar proposal tool for preparation and submission of their observing requests. North Star is reachable at

https://northstar.mpifr-bonn.mpg.de

For VLBI proposals special rules apply. For proposals which request Effelsberg as part of the European VLBI Network (EVN) see:

http://www.evlbi.org/proposals/

Information on proposals for the Global mm-VLBI network can be found at

http://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/index.html

Other proposals which ask for Effelsberg plus (an)other antenna(s) should be submitted twice, one to the MPIfR and a second to the institute(s) operating the other telescope(s) (e.g. to NRAO for the VLBA).

After October, the next deadline will be on February 6, 2017, 15:00 UT.

by Alex Kraus

Scientific Highlights

Occultation of a radio galaxy by an asteroid

By U. Bach, K. Lehtinen, K. Muinonen, M. Poutanen, and L. Petrov

We have used the 100m Effelsberg radio telescope to observe an occultation of a radio galaxy by the asteroid Thyra at 5 GHz. The observed pattern in the light curve, caused by Fresnel diffraction, was modeled and allowed to derive the size of the asteroid.

Occultation is a phenomenon where a distant object, usually a star, is hidden by the Moon, a planet, or a small body in our solar system. Stellar occultations by asteroids observed at visual wavelengths have been an important tool for studying the size and shape of asteroids and for revising the orbital parameters of asteroids. Usually, it requires several simultaneous observations at different distances from the center of an occultation path to obtain the shape and size of an asteroid.

At radio frequencies, the shadow of an asteroid on the Earth is dominated by diffraction effects. The limb of the asteroid works as a sharp edge for the plane wave coming from the background object, producing diffraction that is mathematically expressed by the Fresnel–Kirchhoff diffraction formula for monochromatic radiation. The shadow at radio frequencies is larger than at visual wavelengths, and it is possible to determine the distance of the occulter if the size of the shadow on the Earth is known. The size of the occulter mainly affects the amplitude of the interference fringes of the diffraction pattern. More details can be found in Lehtinen et al. 2016.

We used the LinOccult program, made by A. Plekhanov[1], to predict possible occultation events of compact radio sources. The asteroid Thyra was predicted to occult the radio source J0014+0854 on 2015 March 23 at 09:43:32 UT. The distance of the Effelsberg radio telescope from the center of the occultation path was predicted to be 70 ± 90 km. The velocity of the shadow of Thyra on the Earth was 52.5 km/s during the occultation.

Thyra is a main-belt asteroid, categorized as a stony S-type asteroid (DeMeo et al. 2009). Estimates of the diameter range from 79.8 ± 1.4 km (Tedesco et al. 2004) and 80.7 ± 0.9 km (Usui et al. 2011), derived by the modeling of infrared data with the Standard Thermal Model (STM; Lebofsky et al. 1986), to 92 ± 2 km (Delbò & Tanga 2009) based on thermophysical modeling (Delbò et al. 2015 and references therein).

The geocentric distance and angular size (assuming a diameter of 80 km) of Thyra were ~2.97 AU and 37 milliarcseconds during the occultation. We used a 3-d model of Thyra from the Database of Asteroid Models from Inversion Techniques (DAMIT)[2] to obtain a sky projection at the time of the observations (Fig. 1).

The radio source J0014+0854 is classified as a radio galaxy or possibly a low-luminosity BL Lac object (Rector et al. 1999). The 4.8 GHz flux density on milliarcsecond scales was estimated from Very Long Baseline Array (VLBA) data taken in the framework of the wide-field calibrator survey VCS8/9 at 4.3 GHz

(C-band) and 7.6 GHz (X-band) (L. Petrov 2016, in preparation). The source shows a typical core-jet morphology and linear interpolation in time and frequency yield a total flux density of 39 mJy for the core of J0014+0854 that was occulted by Thyra.

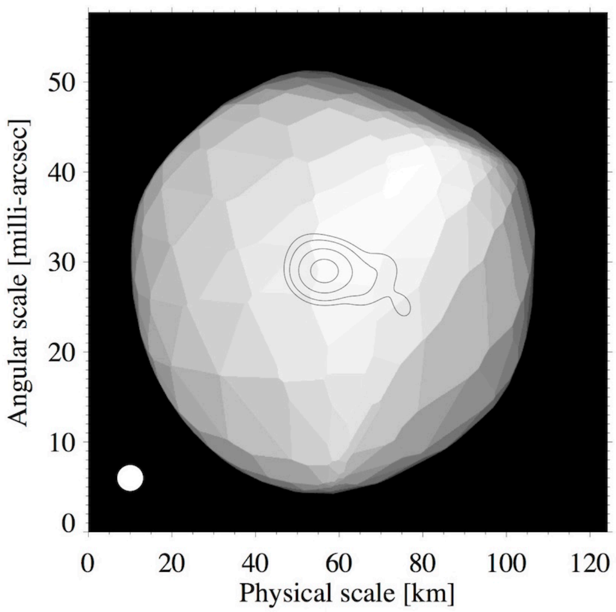


Fig. 1: A 3D model of Thyra as seen by an observer on the Earth at the time of the occultation (see text for details). The contours show the structure of J0014+0854 as based on C-band (4.3 GHz) VLBI observations on 2015 October (Astrogeo[3]), with contour levels of 0.3, 1, 5, and 20 mJy/beam. Both the physical and angular scales are valid for Thyra, while for J0014+0854 and the beam only the angular scale is valid (© 2016. The American Astronomical Society. All rights reserved).

For the observations at the Effelsberg 100-m telescope the "S60mm Double Beam" receiver at 4.85 GHz (500 MHz bandwidth) was used. At this frequency the FWHM beam size of the 100m telescope is about 146 arcseconds. The VLA FIRST[4] (Faint Images of the Radio Sky at Twenty-cm) survey at 1.4 GHz reveals that, within a distance of 200" from the position of J0014+0854, there is one companion at a distance of 18.7'' from J0014+0854 with a flux density 25% of the main component that is probably a radio lobe. The flux density measured with the 100m telescope is thus the total flux density from (at least) two sources. Therefore, when deriving the relative change of intensity of J0014+0854 during the occultation, we use the flux density from VLBI observations, not the flux density measured with the Effelsberg telescope.

The 4.85 GHz receiver at Effelsberg was chosen because it is less affected by weather than higher frequencies and has a relatively low noise. A one second integration should yield a noise of 1.4 mJy. A signal from a noise diode calibrator, with a noise temperature of 1.8 K, is periodically inserted into the measured signal, giving the relation between temperature and instrumental units. The antenna temperatures were converted to Jansky units using an observation of the flux density calibrator 3C48. The derived sensitivity of 1.56 K/Jy is in good agreement with the theoretical estimate of 1.55 K/Jy. The original data were averaged over two samples to give a time resolution of about 0.03 s. The standard deviation of the occultation profile is about 8 mK, corresponding to about 5 mJy.

J0014+0854 was found to be linearly polarized by 6.6% ± 0.4%, with no change of polarization during the occultation. We do not expect polarization to play an important role for the diffraction pattern (Muinonen 1989).

The calculations of the diffraction model are described in detail in Lehtinen et al. 2016. A silhouette image of Thyra obtained from the sky projection (Fig. 1) is used to calculate the theoretical diffraction pattern on the Earth (Fig. 2). Models of different complexity have been taken into account. Firstly, a spherical asteroid and a point-like occulted object, secondly a spherical asteroid and a spherical occulted object with a finite diameter, and finally an asteroid with an arbitrary shape and a point-like occulted object. In view of the relatively low signal-to-noise ratio of our observations, we find that neither the true, finite size of the occulted object, nor the true shape of Thyra has a noticeable effect on the diffraction pattern. Thus, it is justified to make Fresnel–Kirchhoff diffraction calculations by assuming a point-like occulted object and a spherical asteroid.

The observed occultation profile is shown in Figure 3; panel (a) shows the whole profile, while panel (b) shows the mean value of the two halves located symmetrically around the center of the profile, giving a better signal-to-noise ratio. The main features of the observed profile are the following: (1) At the center of the occultation, there is a plateau where the relative intensity is close to unity; (2) The first diffraction maxima are asymmetrical. On the edges facing the center of the occultation, the intensity changes more gradually than on the outer edges where the change of intensity is abrupt; (3) The observed values of the first interference fringe peaks are about 1.4 in units of relative intensity. The double structure of the second positive interference fringe in Figure 3b may be caused by noise and we do not consider it further.

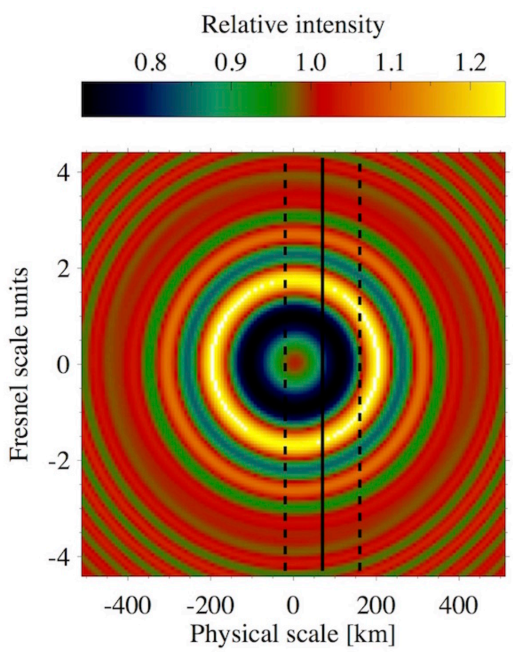


Fig. 2: Theoretical diffraction pattern (shadow) of Thyra on the surface of Earth at the time of the occultation. The model is based on the actual silhouette of Thyra at the time of the occultation (Fig 1). Thus, small deviation from spherical symmetry can be seen. Color indicates the amount of relative change of flux density of the occulted object. The vertical black solid line is located at a distance of 70 km from the center of the occultation, corresponding to the predicted distance of Effelsberg radio telescope. The dashed lines indicate the uncertainty of the predicted distance (© 2016. The American Astronomical Society. All rights reserved).

The modeling of the occultation has three free parameters: the size of the occulter, the distance of the observer from the center of the occultation path, and the time of the occultation. The best fit model is shown in superimposed in Figure 3. The derived diameter of Thyra is 75 ± 2 km and the distance from the center of the occultation is 41 ± 5 km. Figure 4 is showing the likelihoods of the diameter and the distance from the center of the occultation based on Bayesian estimation of parameters. Given the uncertainty in the relative flux of J0014+0854, which we estimate to be 15%, the derived diameter of Thyra varies from 69 to 81 km. This is compatible with the diameter of about 80 km, based on modeling IRAS or AKARI data with an STM (Tedesco et al. 2004; Usui et al. 2011). However, our result disagrees with the diameter of about 92 km (shown in Figure 3 as a red line), based on modeling IRAS data with a thermophysical model (Delbò & Tanga 2009).

In general, the obtained fit is good, but it fails to fit in detail the maximum values of the interference fringes and the asymmetry of the first positive interference fringes. Optimization of the parameters to better match the profile would either lead to an unrealistically large diameter for Thyra, or require a large variability for the flux density of the radio galaxy, which we believe is unlikely. Other possible explanations are that Thyra is a binary asteroid, or, more speculatively, that there is material surrounding the asteroid in the form of a cloud or a ring, but it is beyond the scope of this work to model these in detail.

In conclusion, we could show that a good determination of the diameter of asteroids is possible with a single observation at radio wavelengths if the flux density of the occulted object is accurately known. The knowledge of the asteroid's physical properties, as required for thermal and thermophysical modeling at visual wavelengths, is not needed. Compact radio sources with known VLBI structure are well suited because they reduce the number of free parameters in the modeling.

Inspired by successful observations of Thyra, we consider two promising applications of such observations. First, we propose obtaining accurate positions of asteroids relative to radio sources and investigating the feasibility of using these measurements for aligning the dynamical reference system of solar system objects with the kinematic reference system defined by VLBI observations of extragalactic objects. Second, we are going to investigate the feasibility of a serendipitous search for Kuiper belt objects, as has been done at optical wavelengths (e.g. Bickerton et al. 2009; Schlichting et al. 2012; Liu et al. 2015).

For more details on the diffraction model and the analysis see Lehtinen et al. 2016, ApJL, 822, 21.

Footnotes:

[1] *http://andyplekhanov.narod.ru/occult/occult.htm*
[2] *http://astro.troja.mff.cuni.cz/projects/damit*
[3] *http://astrogeo.org/rfc*
[4] *http://sundog.stsci.edu*

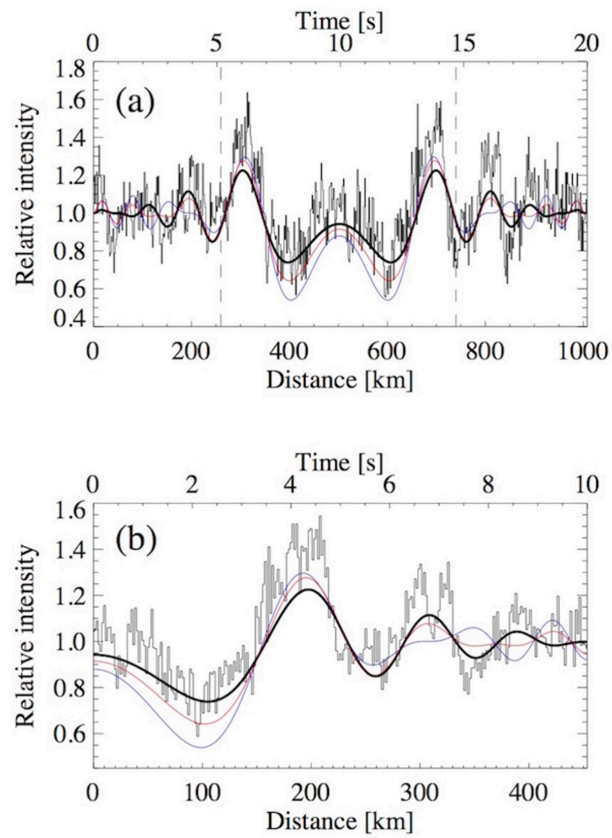


Fig. 3: Observed occultation profile, showing the relative intensity of the occulted radio galaxy as a function of time. Panel (a) shows the whole observed profile. The dashed lines delineate the region that has been used for model fitting. Time is in seconds after 09:43:17.25 UT. Panel (b) shows the profile after folding the profile in panel (a) through the center of the occultation. Distance is obtained by multiplying the time with the speed of the shadow on the Earth. The best-fit model of Fraunhofer diffraction, giving a diameter of 75 km, is plotted with a thick solid line. The blue line shows the profile for a diameter of 110 km, which gives the theoretical maximum of the first interference peaks. The red line shows the profile for a diameter of 92 km, derived by thermophysical modeling (Delbò & Tanga 2009.(© 2016. The American Astronomical Society. All rights reserved)).

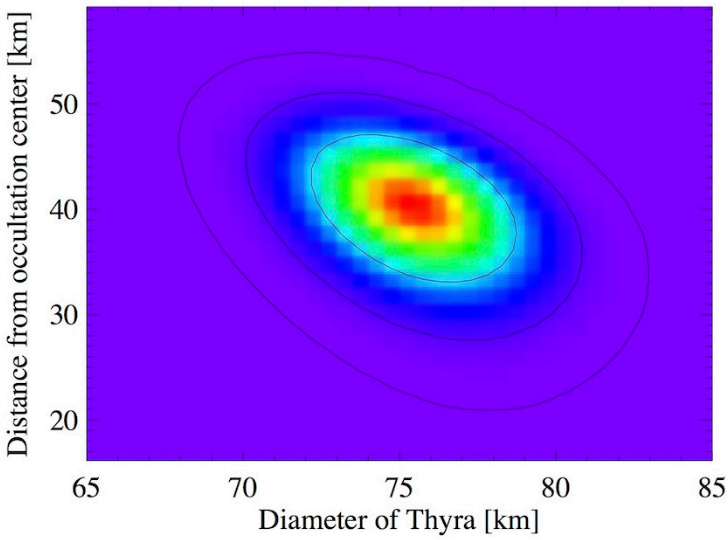


Fig. 4: Likelihoods for two model parameters, the diameter of Thyra, and the distance between the observer and the center of the occultation path, after fixing the third model parameter, the time of the occultation. Contours show the 1σ, 2σ, and 3σ probability regions.

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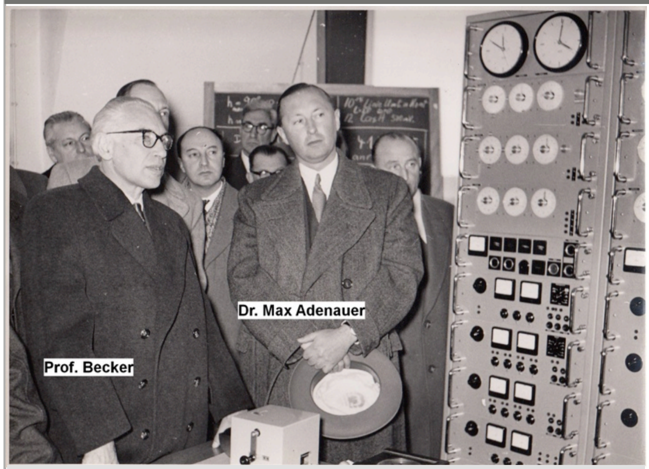
60 Years Astropeiler Stockert

By Wolfgang Herrmann



Prof. Becker explaining the control system to Dr. Max Adenauer, city director of Cologne during the inauguration ceremony 1956

On September 17th, 1956, Radio Astronomy in Germany saw a great step forward with its first big telescope: The "Astropeiler Stockert" was handed over to the scientists of the University of Bonn in an opening ceremony. Given today's timeline for building projects it is worthwhile noting that this was only about 10 months after the building permit was granted.

Drivers behind the project were Prof. Friedrich Becker of the "Universitätssternwarte Bonn" and State Secretary Prof. Leo Brandt of the Ministry of Economics and Traffic of Northrhine-Westfalia which secured the financing.

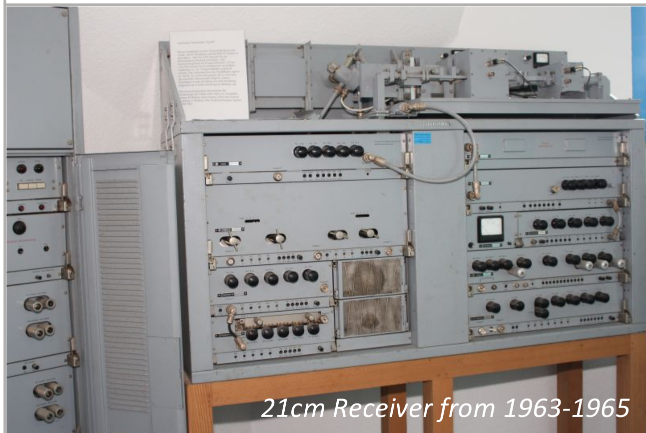
Jointly with another instrument of the same size, the Dwingeloo telescope which was opened only a few months earlier, the 25m dish represented the biggest fully steerable radio telescope at that time. In the late 50s, neither computers nor power electronics were available. Therefore the challenge to move the 90 tons of the dish precisely in order to track celestial objects had to be solved by electromechanical means: The technology to provide accurately controllable current to the motors for telescope motion was an "Amplidyne". The Dutch company Rademakers provided the electromechanical coordinate converter to transform the celestial coordinates to azimuth and elevation.

Scientific work started in January 1957 after a few months of preparation and technical tests. Since the emission from the neutral Hydrogen was the "hot topic" in these early days of radio astronomy, observations at 21cm were the first focus of research. After continuum measurements in that spectral range in the first year, HI line observations followed from 1958 onwards.

The instrument was shared, in the early years, between the radio astronomers and military radar research. Some of the design criteria were influenced by the radar application: The telescope is standing on a mountain top to allow 360° visibility down to the ground, and a ring construction carried the electrical signals between the receiver and the control instruments to allow continuous rotation of the dish. Quite a few stories are related to the military applications, but most of them are probably more fiction than reality. The most persistent myth is that the air traffic in the "Berlin Corridor" was monitored. However, the radar horizon and elevated terrain like the "Harz" in between make this application quite unlikely.

On the scientific side, 21 cm work continued to be the dominant research area in the early to mid 60s. A receiver still exists from that time (albeit no longer functional) and is on display in the historical exhibition in the Stockert Telescope.

In 1963, planning started to complement the 25m dish with a 10m dish for solar observation at higher



frequencies. This instrument was inaugurated in 1965. Even today it is still called “Sonnenspiegel” (sun mirror) in reference to its original purpose.

A year later the Max Planck Institute for radio astronomy was founded and the Stockert telescopes became part of this organization. About this time, research activities at 21cm were complemented by 11cm continuum observations.

Every radio astronomer always has appetite for more collecting area and resolution. Consequently the researchers were looking at the option to build a large telescope. This became reality with the inauguration of the 100m Effelsberg telescope in 1972. With this new fine instrument at hand, science gradually moved more and more from Stockert to Effelsberg. Eventually the MPIfR closed the operation of the Stockert telecope in 1976, handing it back to the University of Bonn.

The university did renovation of the instrument to enable it to be used for the upcoming research campaigns. Again this started at 21cm with a survey [1,2], which was a continuation of work already started in earlier years. This was followed by a comprehensive survey at 11cm wavelength, which was the most important observation program with this instrument all through the 80s [3]. In the 90s, the instrument was used mostly for diploma thesis and graduate student programs.

Finally, the scientific merit of the instrument no longer justified the operational and personnel cost associated with keeping the telescope going. Therefore, the University took the decision to close the operation and the premises were sold to a private company.

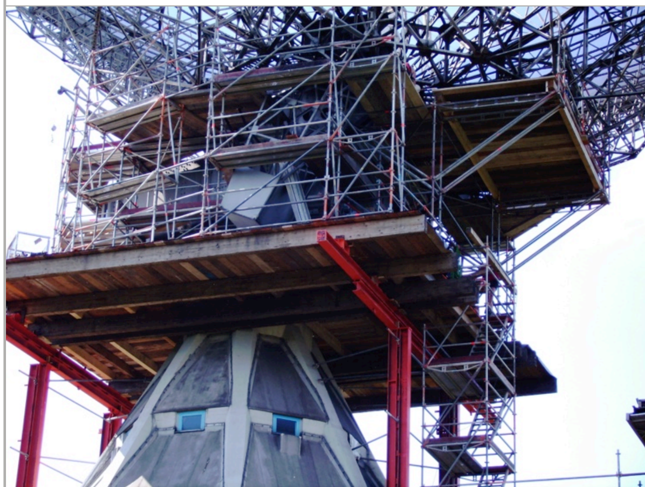
This company had no specific interest in the dish itself, but found the facilities of the buildings and the site compatible with their business, which was the development and production of hardware for electronic music.

Saddened by this development, a group of people from the MPIfR and others founded an association with the name “Förderverein Astropeiler Stockert e.V.” with the intention to do everything they could to keep the instrument for posterity. They also concluded an agreement with the owner, under which they were granted limited access to the 10m dish in order to use it for amateur radio.

An important step for keeping the instrument was the granting of the status of a protected monument in 1996.

Another change in ownership opened the path into the future: As the owner company went into insolvency, the Förderverein got the “Northrhine-Westfalia Foundation” interested in acquiring the site in 2005. This Foundation engages in various projects dealing with preservation of historic sites and nature. Major restoration of the dish structure and the buildings were necessary, as negligence and missing maintenance had taken its toll. Also, the instrumentation was completely renewed. This included a new prime focus receiver and modern backends. All this had been supported and financed by the Foundation, which has to be given credit for the fact that the Astropeiler is still there and in good condition. The Förderverein took the task, among many other efforts, to completely rebuild the control system and to write the software for instrument control and observation tasks.

All this effort culminated in the “first light” after restoration in 2011.



Major construction work to restore the disk structure

While the instrument has been upgraded and modernized, care was taken to leave historical infrastructure in place wherever it was possible. Therefore the instrument features an interesting mixture of old machinery combined with modern electronics. Even the original “Amplidyne” is still in operation and used for everyday observations.

Control room today

Over the following years the association (now renamed to just “Astropeiler Stockert e.V.” and grown to about 150 members) has constantly improved and expanded the capabilities, learning at the same time more and more about applications suited for an instrument of this size.

As it stands today, the Astropeiler Stockert is the largest and most capable radio astronomy facility in the hand of amateurs world wide. It is used for various observation programs which are set up by the association. One of the focal points in recent years has been pulsar observations.

Historically, the Astropeiler has served for student training (Praktikum). This opportunity is now used again by various universities. These contacts have further evolved into a more comprehensive cooperation. This year, the instrument was used again for the first time for a bachelor thesis which involved joint observations of the Astropeiler with MAGIC and the Fermi Satellite’s Large Area Telescope investigating flat spectrum radio quasars.

The general public is given the opportunity to tour the site every Sunday from May to October. Historical equipment is on display and visitors are given the opportunity to see live observations. Schools are invited to do programs with the intention to raise interest in science.

"Astropeiler" proudly standing on the Stockert mountain for 60 years

After 60 years, the Astropeiler Stockert is still standing strong, providing valuable data on the radio sky and to serve as an outreach facility to promote science. Even though time has left a few dents and scratches, due to the modern instrumentation it is more capable in many aspects than ever before. This motivates the team from “Astropeiler Stockert e.V.” to continue to take care of the old lady, hoping that eventually she will see her 100th anniversary.

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Astron. Astrophys. Suppl. Ser. 48, 219-297
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[3] K.Reif, W.Reich, P.Steffen, P.Müller, H.Weiland,
The Stockert 2.72 GHz Radiocontinuum Survey of the Galactic Plane - Part I
Mitteilungen der Astronomischen Gesellschaft, Vol. 70, p.419

Astropeiler Stockert Website: http://www.astropeiler.de

Further reading:

R. Wielebinski: Fifty Years of the Stockert Radio Telescope and what came afterwards, AN 328, No.5, 388-394

Other News in Brief

Meeting announcement:

Science with the Effelsberg 100-m telescope

During April 4-5, 2017 the MPIfR in Bonn will host a workshop "Science with the Effelsberg 100-m telescope". This meeting is intended to bring together various user groups of the 100-m telescope with the support staff of the observatory and the technical developers. We are looking forward to the opportunity to discuss recent observational results and technical developments with the users of the 100-m telescope.

Furthermore, this meeting will give us the possibility to learn about new idea for observing projects allowing us to plan the technical and software development for the next years.

More information about the meeting will be published in the next issue of this newsletter as well as on the webpages of the MPIfR soon - stay tuned!

MPIfR's 50th Anniversary: Summer Party at Effelsberg

Fig. 1: Summer party in the direct vicinity of the Effelsberg 100m radio telescope (from left to right): Simon Johnston (CASS Sydney), Michael Kramer (MPIfR), Harald Lesch (Universitätssternwarte München)

Photo: Aristeidis Noutsos, MPIfR

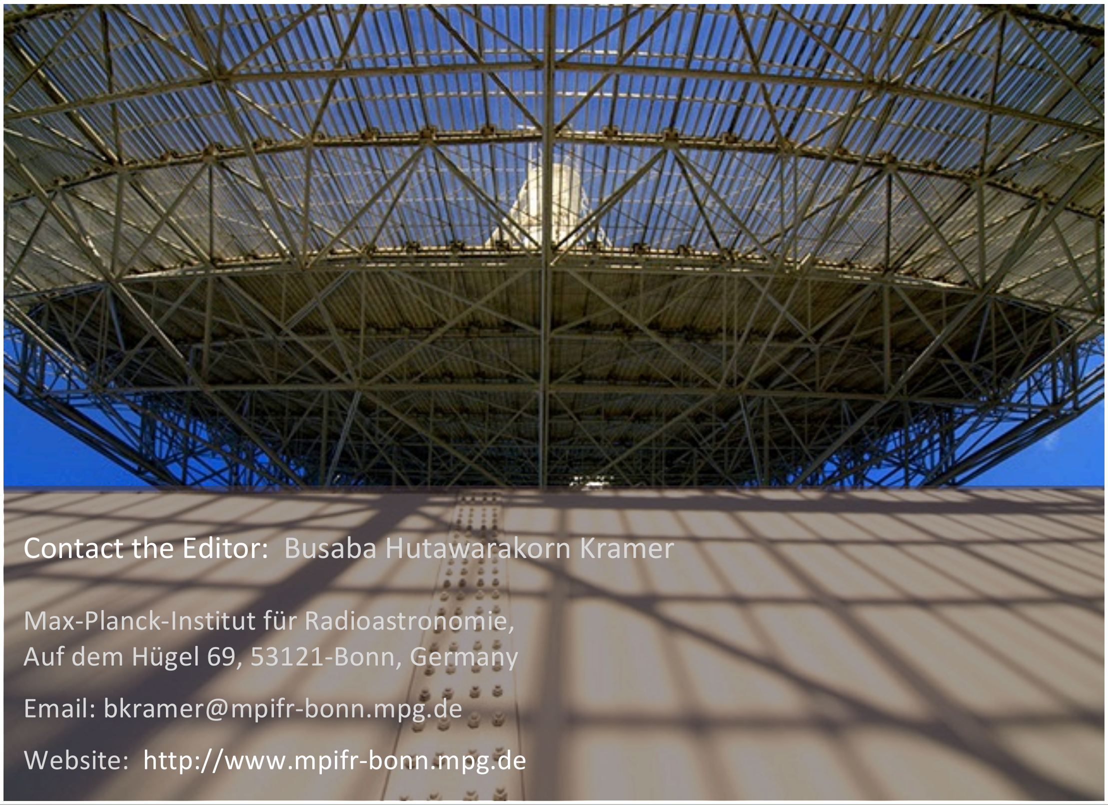
In June 2016 the Max Planck Institute for Radio Astronomy (MPIfR) celebrated its 50th anniversary at the Effelsberg Radio Observatory. Approximately 180 staff members and alumni were attending the summer party at the observatory. Some staff members of the Bonn institute had their first opportunity to see the huge 100m radio telescope "live and in action" and they could attend a guided tour to the elevation platform of the telescope 20 m above the ground. For the general public that would only be possible at special occasions like "Open Days" at the observatory.

The celebration included a talk by Harald Lesch who finished his doctorate at MPIfR in 1987 and is now professor at the Ludwig-Maximilian-Universität (LMU) in Munich. A larger audience might know Harald as host of a number of science programs at ZDF, one of the major German TV stations. The photo shows Harald at Effelsberg, together with Michael Kramer, director and head of the "Fundamental Physics in Radio Astronomy" research department at MPIfR and Simon Johnston from the CSIRO Astronomy and Space Science (CASS) institute in Sydney/Australia who was attending MPIfR as guest scientist for three months.

Links:

Harald Lesch at ZDF: http://www.zdf.de/harald-lesch-24458212.html

Simon Johnston at CASS:
http://www.atnf.csiro.au/people/Simon.Johnston/index.html



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