From the Director:

Dear OSO Astro Newsletter readers,

As many will be aware there is at present extreme pressure on the VR budget for infrastructures. The consequence of this has been a reduction in the budgets of nearly all Swedish science infrastructures which, like OSO, applied for operations funding in May 2015. OSO was no exception to this reduction, although due to a positive review of our funding request, OSO suffered a smaller reduction than many other Swedish infrastructures. The tighter financial environment has required us to make savings in a number of areas. However, we have sought to implement these in ways that maintain our services to the Swedish astronomical community. On a lighter note, this newsletter highlights the wide range of excellent science from the instruments that OSO supports - from comets to extragalactic jets. On the technical side highlights include the completion of the 20m telescope upgrade (4mm receiver and spectrometer), the installation of a new Band 9 receiver at APEX, and the delivery of the first SKA Band 1 feed/receiver prototype. Also completed in early 2016 was an external scientific evaluation of APEX which enthusiastically recommended a continuation of the project beyond 2017.

Sincerely,

John Conway
Call for Proposals

Proposals are invited for observations with the APEX telescope, the Onsala Space Observatory 20 m telescope, and the Swedish LOFAR station in stand-alone mode in the period August/September 2016 to March 2017.

Deadline for proposals: 4 May 2016.

APEX is a 12 m diameter submillimetre telescope in Chile. The available facility receivers are the Swedish Heterodyne Facility Instrument covering a wide frequency range (currently 211–500 GHz) and the LABOCA bolometer array camera (345 GHz). (There are also partner instruments.) Swedish time on APEX is open for scientists from all countries (but see below about SEPIA).

Proposals for observations with the SEPIA instrument (159-211 GHz and 600-722 GHz receiver for spectral line observations) must have a PI or co-I with a Swedish affiliation.

The partner instrument ArTeMiS (350 micrometer bolometer array) will be available to all users on Swedish APEX time.

The Onsala 20 m diameter telescope in Sweden is equipped with receivers for 18-50 GHz and 67-116 GHz. The telescope is open for scientists from all countries. Note in particular the new receiver for 67–87 GHz and the new spectrometer with 2 x 4 GHz bandwidth.

The Swedish LOFAR station at Onsala Space Observatory is an array of antennas for the frequency bands 10-90 MHz and 110-240 MHz. It is part of the International LOFAR Telescope (ILT), but is offered here in stand-alone mode.

The EVN is a collaboration of the major radio astronomical institutes in Europe (including OSO), Asia and South Africa and performs high angular resolution observations of cosmic radio sources. Deadline for EVN proposals: 1 June 2016


Support at OSO

The National Facility offers a wide variety of support to Swedish astronomers. For example, we host one of the European ALMA regional centres, supporting ALMA users throughout the Nordic region. We also offer support in several other areas.

Data Reduction: We support the reduction of all types of radio/(sub-)mm interferometric and single-dish observations. We welcome visitors who need reduction support and offer them the use of our National Facility Computing Infrastructure (NaFCI) for reduction of large data sets.

Student projects: We also specifically encourage visits by students who want to learn how to reduce and analyse their radio/(sub-)mm observations.

Specialised Courses: National Facility support staff will be able to assist with specialised lectures on for example interferometry, radio/(sub-)mm data analysis and/or the use of National Facility instruments.

Workshop/School support: Similarly, we can assist in planning and lecturing at schools or workshops, when these include topics related to National Facility activities and instruments. This includes but is not limited to, for example, radio/(sub-)mm interferometry and single dish observing and analysis, ALMA, APEX, LOFAR, SKA.

Seminars: National facility staff are also available for scientific and technical seminars on the aforementioned instruments.

More Information: For more information, please contact Wouter Vlemmings, Head of Astronomy User Support (wouter.vlemmings@chalmers.se).
News Items

10 years of operations of APEX

A celebration of APEX’s 10 years of operation was held at the APEX base in Sequitur, Chile, in late January. Overviews of the project and scientific highlights based on APEX observations were presented to an audience that included the German Ambassador to Chile, the President of the Max Planck Society, representatives from the local Chilean community, and representatives from the three APEX partners (ESO, MPIfR, OSO). A much appreciated visit to the high site by the guests was also part of the programme.

The celebration coincided in time with an international evaluation of the APEX project, its scientific impact and its place in the scientific landscape, including a recommendation of a continuation of the project beyond the present agreement which expires at the end of 2017. The expert panel, consisting of Andrew Harris (U. of Maryland, chair), Raymond Blundell (Director of Submillimeter Array, Harvard), Michael Grewing (former IRAM director), and Jesus Martin Pintado (Centro de Astrobiologia, Madrid), listened to a number of presentations related to the APEX project, had discussions with the partner representatives, and visited the high site. The report, that was delivered to the APEX board by the end of February, noted the high current scientific productivity of APEX and the innovative plans for future instrumentation. The report enthusiastically recommended the continuation of the APEX project through the 2018-2022 period.

First results from the new OSO 20m receivers and spectrometer

The previously announced 67-87 GHz (4 mm) receiver was commissioned according to plan during the autumn of 2015, and used for Science Verification projects during the first quarter of 2016. The HEMT-based receiver has performed exceptionally well and provides a low noise and stable performance over broad bandwidths, comparable to the existing (but still very recent) SIS 3 mm receiver. The two receivers are housed in the same cryostat and that, in combination with the innovative design of the new beam-switch, means that switchovers from one receiver to the other are near-instant without any need for mechanical modifications to the optical path.

Figure 1: Participants at the APEX 10th anniversary celebration visiting the telescope at the high site. Credit: ESO
The spectrometer capacity was in addition expanded further to now simultaneously cover 4 GHz of bandwidth in two polarisations. Having a broad bandpass with a stable performance throughout allows for more efficient observations where multiple lines with large spectral separations can be observed simultaneously, even in extra-galactic sources where only the strongest lines are visible within reasonable observation times.

ALMA Band 9 receiver installed on APEX

In February of 2016, an ALMA Band 9 receiver for the frequency band 600-722 GHz was installed into the SEPIA cartridge in cabin A of the APEX telescope. Note that the tuning range is slightly extended by a couple of GHz at both ends compared to previous announcements. Since 2015 SEPIA already houses an ALMA Band 5 receiver, and now a second slot of the cryostat was filled with a Band 9 cartridge built by NOVA (NL). The installation was a joint effort by teams from NOVA and GARD/OSO and appears to have been successful based on the first light spectrum shown in Fig. 3, taken towards OMC1 under poor weather conditions. However, much of the on-sky commissioning of the Band 9 front end remains to be carried out during the first Swedish run in March/April. This will be followed by science verification observations during ESO and Swedish time in the early summer. Pending successful commissioning and verification, the receiver will be offered for normal science operation during observing period P98. In exchange for their hardware contribution, the Dutch community will be able to carry out Band 9 observations during guaranteed time. The receiver is initially offered as a dual polarisation, double sideband receiver with 4 GHz of IF bandwidth per polarisation. An upgrade to 2SB operation is planned for next year.
A prototype system for SKA Band 1

OSO is continuing its technical involvement in The Square Kilometre Array (SKA), an international project aiming to build a new astronomical facility serving the radio waveband at metre and centimetre wavelengths. In June 2013, contracts were awarded to 11 multi-national design consortia that (managed by the central SKA Office) will accomplish the final detailed engineering design of SKA Phase 1. Sweden, represented by OSO, is part of two such design consortia, the Dish and the Wide Band Single Pixel Feed consortia (SKA-DC and SKA-WBSPF). Here we present an update on our involvement in SKA-DC during 2015.

OSO is work package (WP) leader for the Band 1 Single Pixel Feed (SPF) WP within SKA-DC. Within this WP, OSO has the overall responsibility to design, build a prototype and characterise a feed and low-noise receiver package that covers 350–1050 MHz frequency range. During the second half of 2015 extensive work was done on the design, building a prototype and characterising two alternative systems for Band 1 – one with Low Noise Amplifier (LNA) mounted in cryostat 20 K physical temperature that will be attached to the feed, and another one with LNA operating at ambient temperature mounted inside the feed. Extensive testing and analysis concluded that the system with LNA at ambient temperature will have a sensitivity that is comparable to the cryogenic system. The ambient feed has the advantage that it will provide significantly lower power and operations costs, with limited loss in sensitivity. The design and testing of the ambient system was made possible due to the close collaboration with Low Noise Factory, a Gothenburg based company that has developed, manufactured and delivered LNAs with an equivalent noise temperature of 5 K to the Band 1 team but at 300 K ambient temperature. This is an unique achievement. The Band 1 feed prototype is shown in Fig 4.

Next generation VLBI recorder

OSO has for a long time contributed, not just with its telescopes, but also with our technical expertise to the EVN (European VLBI Network). As part of the EU RadioNet3 Joint Research Activity DIVA (Developments for VLBI in Astronomy), a system called the FILA40G has been developed at OSO for recording of VLBI data at rates up to 32 gigabits per second (Gbps). Combined with a digital backend called DBBC3, also developed in DIVA, and broadband receivers, observational sensitivity can be increased by four fold compared to the recently improved maximum data rate of 2 Gbps used in the EVN today. The DBBC3 and FILA40G can also serve well in providing a backend and recorder for the geodetic VGOS (VLBI Global Observing System) system, which includes the twin telescopes currently being built at OSO. Late 2015, two sets of test observations were performed, recording at 16 Gbps at OSO and Effelsberg in Germany, and in the beginning of 2016 data recording tests have been performed on the FILA40G to verify its capability to successfully record at 32 Gbps. In once such test, more than 280 TB were recorded across 54 hard disks over an uninterrupted period of 21 hours with no data lost.
Science Highlights

We would like to introduce you to a few of the recent science highlights produced using the instruments at, and supported by, Onsala Space Observatory. We especially welcome short contributions by you, the users of our telescopes, so please do not hesitate to contact us if you have results you would like to share in future newsletters.

HCN observations in comets with the OSO 20m telescope

HCN J=1–0 emission from the long-period comet C/2013 R1 (Lovejoy) was observed with the Onsala 20 m telescope on multiple occasions during the month before its perihelion passage on December 22, 2013. HCN is one of the cometary molecules whose production rate follows most closely that of water, typically with a mixing ratio close to 0.1 %. This molecule is therefore commonly used as a proxy to the water production rate. Wirström et al. (2016) report on HCN detections for seven different dates, spanning heliocentric distances (R_h) decreasing from 0.94 to 0.82 au. Estimated HCN production rates are generally higher than previously reported for a partially overlapping time period, but the implied increase in production rate with heliocentric distance, scaling as R_h^{-3.2}, represent well the overall documented increase since it was first observed at R_h=1.35, see Figure 5. The implied mean HCN abundance relative to water in R1 Lovejoy is reported to be 0.2 %.

Wirström et al (2016) also report on a detection of HCN with the new 3 mm receiver system at OSO in comet C/2014 Q2 (Lovejoy) on January 14, 2015. The comparison in data quality between the presented cometary observations with the OSO 20m demonstrates the high performance of the upgraded 3 mm receiver system and its potential for future coma monitoring of relatively bright comets.

This publication - the first on comet observations with the 20 m since the 1980's - is based on data analysis made by four Chalmers students as part of their Bachelor thesis project during the spring of 2015. The students are also co-authors on the publication: Wirström et al., 2016, A&A 588, A72.
A spectral line survey of R Dor using SEPIA/Band-5

Cool evolved stars drive the chemical evolution of matter in the Universe. Asymptotic giant branch (AGB) stars are among the major contributors. Their steady winds deposit a substantial fraction of their stellar mass in dust and molecular gas into the interstellar medium (ISM), material that will eventually form new stars and planets. Characterising the winds' gas and dust properties chemically and physically is hence crucial to understand the mass-loss history and the role of AGB stars in the overall chemical enrichment of galaxies.

Unbiased spectral scans can systematically detect a large number of lines, allowing astronomers to set up an extensive molecular inventory. The enormous wealth of gas-phase species in outflows of evolved stars has until now only been mapped out for very few, extreme objects.

De Beck & Olofsson performed a spectral line survey of the nearby oxygen-rich AGB star R Dor, covering the entire SEPIA/band-5 frequency range 159 - 211 GHz (Fig. 6; De Beck & Olofsson, in prep.). They obtained SEPIA/band-5 observations within 9 hours of total observing time, reaching a sensitivity better than 6 mK at 2 km/s resolution throughout the range, except for close to the H$_2$O line at 183GHz, where the water content of the atmosphere contributes to extra noise in the observations. Thanks to the sideband-separated setup of the receiver, where both the lower and upper sidebands are recorded simultaneously and separated from each other, the entire range is covered in only 8 separate tunings. The authors detect around 70 emission features, including e.g. HCN, PO, PN, SiO, SO, and SO$_2$.

These APEX/SEPIA observations, in combination with their APEX/SHeFI line survey of R Dor and similar surveys of other evolved stars, will form a legacy for the entire astronomical community, by allowing one to constrain the evolution and role of evolved stars on a Universal scale, and by probing a large variety of astrochemical networks.

Figure 6: Spectral line survey of R Dor. (Top) SEPIA/band-5 observations, (bottom) combined SEPIA/band-5 and SHeFI observations. Credit: E. De Beck
A precessing molecular jet signalling an obscured, growing supermassive black hole in NGC1377?

Aalto et al. discovered a high-velocity, very collimated nuclear outflow using high spatial resolution (0.25"x0.18") observations with ALMA in CO(3-2) at 345 GHz. They interpret the outflow as a molecular jet with a projected length of about 150 pc. The launch region is unresolved and lies inside a radius \( r < 10 \) pc. Along the jet axis they find strong velocity reversals where the projected velocity swings from -150 km/s +150 km/s. A simple model of a molecular jet precessing around an axis close to the plane of the sky can reproduce the observations. The velocity of the outflowing gas is difficult to constrain due to the velocity reversals, but they estimate it to be between 240 and 850 km/s and the jet to precess with a period \( P = 0.3-1.1 \) Myr. The CO emission is clumpy along the jet and the total molecular mass in the high-velocity gas lies between \( 2 \times 10^6 \) \( M_\odot \) (light jet) and \( 2 \times 10^7 \) \( M_\odot \) (massive jet). There is also CO emission extending along the minor axis of NGC1377 and may be a slower, wide-angle molecular outflow.

The molecular jet is either powered by a (faint) radio jet or by an accretion disk-wind similar to those found towards protostars. It seems unlikely that a massive jet could have been driven out by the current level of nuclear activity which should then have undergone rapid quenching. The light jet would only have expelled 10 % of the nuclear gas and may facilitate nuclear activity instead of suppressing it. The nucleus of NGC1377 harbours intense embedded activity and the authors find large columns of \( \text{H}_2 \), which may be a sign of a high rate of recent gas infall.

Jet precession is the likely signature of a warped accretion disk and/or a binary supermassive black hole. A precessing jet has the potential to impact and stir up a large volume of ambient gas. The results by Aalto et al. demonstrate that outflows/ jets even from low-power AGNs can have substantial impact on the evolution of the galaxy, also beyond the innermost pc.

NGC1377 is the first galaxy with evidence for a precessing, highly collimated molecular jet. The low radio to infrared ratio for NGC1377, the short apparent time-scale of the molecular jet (< 1 Myr), and the gas-rich nuclei are all signs consistent with the notion that NGC1377 is in a transient phase of its evolution. The project was supported by the Nordic ARC node in Onsala, and will soon be published in A&A by Aalto et al. (accepted).

News on SKA/LOFAR
For more specific SKA and LOFAR related news, register for the SKA/LOFAR newsletter: http://www.chalmers.se/en/centres/oso/radio-astronomy/lofar/Pages/SKALOFAR-mailing-list.aspx