From the Director:

Dear newsletter readers,

A major physical change at Onsala over the last months has been the construction of the Onsala Twin Telescopes (OTT), two 13 m diameter dishes for geodetic VLBI. Geo-VLBI is the modern technique which continues the long historical connection between astronomy and position finding on the Earth. When fully operational the OTT will join a worldwide network of similar next generation geodetic telescopes to measure global baseline lengths to <1 millimetre accuracy. This network will constrain tectonic motions, Earth orientation parameters and rotation rate to unprecedented precision. A highly accurate Earth reference frame is a fundamental requirement for a myriad of geoscience applications, including measuring sea level relative to the Earth’s centre to distinguish between different models of global warming. The OTT construction and installation has been funded by a generous grant from the Knut and Alice Wallenberg Foundation and by Chalmers University of Technology. The OTT continues the long history of geodetic VLBI at Onsala and its VR funded mission of geoscience measurements.

Sincerely,

John Conway

Credit: Onsala Space Observatory/R. Cumming

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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 April 2017 to August 2017.

Deadline for proposals: 14 October 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 PI instrument ArTeMiS, a 350 micrometer bolometer array, can also be requested for use on Swedish time under the same conditions. Other APEX partner instruments, including FLASH+, can also be requested for use during Swedish time but use of the instrument must be discussed with the instrument PI before the submission of the proposal.

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 October 2016 (http://www.jive.nl/jivewiki/doku.php?id=evn:guidelines)


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 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 and EVN.

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

Nordic ARC node support for ALMA archive mining

At the end of September, ALMA will complete Cycle 3 observations. At that time, ALMA will have successfully observed the millimetre and submillimeter sky for 5 years. All along, the ALMA project has populated the ALMA archive with full ALMA datasets - a resource of a wealth of scientific data that is accessible to the entire astronomical community! The number of papers based entirely or partially on archive data is steadily increasing (see for example the science contribution on page 6).

In order to provide an efficient and comprehensive search of the ALMA data archive, and to maximise the scientific output of the data, the Nordic ARC node supports the Nordic community in archive searches, data retrieval, calibration, and imaging, and advanced analysis of the results. The ARC node supports any project based on ALMA archival data just as for regular ALMA projects, including face-to-face visits and the use of our computing infrastructure.

We support and encourage master’s thesis projects based on ALMA archive data. Students are welcome to visit us for extended periods to learn how to navigate the archive and how to reduce and analyse ALMA observations. They will be assigned an ARC node member who will supervise the data part of the thesis throughout the duration of the project. This is an exciting opportunity to allow students to be a part of the most powerful telescope of its kind, making their first experience with front-line science.

Science verification observations with SEPIA on APEX

In our last newsletter we reported the successful installation of an ALMA band 9 (600-722 GHz) receiver at APEX, thereby becoming the second channel after band 5 (157–212 GHz) in the SEPIA cryostat. Science verification observations of the band 9 receiver on Swedish time took place in June and August. Figure 1 shows a CO 6-5 spectrum at 691.5 GHz towards the red giant Mira variable R Dor obtained during Swedish science verification.

The currently ongoing P98 observing period is the first one to offer both SEPIA receivers for regular observations and in August the first band 9 projects were successfully carried out in Swedish time.

The September 2016 issue of the ESO Messenger will have a summary of the technical specifications of the SEPIA instrument. See also our Science Highlight on the detection of water megamasers using SEPIA on page 6.
OSO participates in Horizon 2020 projects

OSO is part of three successful Horizon 2020 projects (proposals submitted in March 2016). Below you can find short summaries of the projects. More details will follow in future Newsletters.

RadioNet4
RadioNet4 joins together 28 partners, amongst them institutions operating world-class radio telescopes, as well as organisations performing cutting-edge research, education, and development in a wide range of technology fields that are important for radio astronomy. OSO will be part of the TransNational Access (TNA) program via APEX and the EVN. Of particular interest for you as an astronomer is the possibility to get TNA support for observations and data reduction with TNA telescopes: APEX, EVN, e-MERLIN, IRAM, LOFAR, Effelsberg. RadioNet4 will also offer access to Westerbork Apertif Long Term Archive (ALTA). In addition, OSO will play a major role in all of the Joint Research Activities which includes both software and hardware development.

AENEAS
The large scale, rate, and complexity of the data that the Square Kilometre Array (SKA) will generate, present challenges in data management, computing, and networking. The objective of the Advanced European Network of E-infrastructures for Astronomy with the SKA (AENEAS) project is to develop a concept and design for a distributed, European Science Data Centre (ESDC) to support the astronomical community in achieving the scientific goals of the SKA. AENEAS brings together all the European member states currently part of the SKA project as well as potential future EU SKA national partners, the SKA Organisation itself, and a larger group of international partners including the two host countries Australia and South Africa.

Jumping JIVE
Joining up Users for Maximising the Profile, the Innovation and the Necessary Globalisation of JIVE (JUMPING JIVE) aims to prepare and position European Very Long Baseline Interferometry (VLBI) for the SKA era, and to plan the role of the ERIC JIVE, as well as the EVN, in the future European and global landscape of research infrastructures. On a European scale, the proposed activities will raise the profile of JIVE/EVN among scientists and operators of radioastronomical facilities, by widely advocating its science capabilities and its role as research infrastructure provider within the international radio astronomy community. These activities will focus on outreach and on reinforcing science cases for the next decade.

Figure 2. Logos of the H2020 projects that OSO participates in. Left to right: RadioNet4, AENEAS, and Jumping JIVE.
The new Onsala Twin Telescopes: an important milestone reached for OSO

The reflectors for the Onsala Twin Telescopes (OTT) were mounted on 18 August 2016. This is a milestone for the installation of two new VGOS-type radio telescopes.

VGOS is the VLBI Global Observing System and will realise the next generation geodetic and astrometric VLBI system of the International VLBI Service for Geodesy and Astrometry (IVS). It is expected to achieve an order of magnitude improvement in accuracy for the derived results. The most important results and products are the International Celestial Reference Frame (ICRF), the Earth Orientation Parameters (EOP), and station positions that contribute to the International Terrestrial Reference Frame (ITRF). VGOS is currently in its build-up phase with several VGOS telescope projects worldwide. Once it reaches its operational stage, every day several hundreds to thousands of radio sources will be observed with the global VGOS network, producing a very valuable database for astrometry.

The new telescopes at Onsala are 13.2 m in diameter and can move with up to 12°/s in azimuth and 6°/s in elevation which will allow to perform more than 2500 VLBI observations per day per telescope. The telescope surfaces are suitable for frequencies up to 30 GHz and the initial receiving equipment will be broadband dual linear polarised covering 2–15 GHz. The remaining installation work and the deployment of the receiving equipment will be completed in the autumn of 2016 with the aim to be able to start first VGOS test observations as soon as possible in 2017.

The official inauguration of the OTT will be in connection with the 23rd Working Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA) in May 2017. The attached photo depicts the Onsala radio telescope cluster, with the new OTT in the centre. Onsala Space Observatory is unique amongst the world’s fundamental space geodetic sites in having a direct access to sea level measurements with co-located VLBI, GNSS and gravimetry instruments. OSO is thus an important co-location site for the Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG).
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.

Water Megamasers Using APEX SEPIA Band 5

Water megamaser galaxies have become the object of extensive study at 22 GHz, since the discovery that the emission traces a sub-parsec scale portion of the circumnuclear disk in NGC 4258, within 1 pc of the supermassive black hole (SMBH). Very Long Baseline Interferometry (VLBI) observations of the masers have provided detailed information on the kinematics and structure of active galactic nucleus (AGN) circumnuclear disks. Geometric modelling of VLBI disk maser data, provided that acceleration or proper motion measurements are also possible, is used to perform maser cosmology and has yielded high-accuracy Hubble constant estimates. Additionally, water megamasers can originate from the interaction of AGN radio jets with the interstellar medium, yielding masers in shocked gas within radii of 1 — 10 pc of the central regions. Detection and study of mm/submm water masers could also make unique contributions to the study of disk and radio jet structure.

Using APEX SEPIA Band 5, Humphreys et al. (2016) searched the southern megamaser galaxy NGC 4945 for water (mega)maser emission at 183 GHz, achieving a 1-sigma rms sensitivity of 0.24 Jy in 25 km/s and making a detection of this line. With a peak flux density of ≈3 Jy near the galactic systemic velocity, this is the strongest mm/submm water maser detected to date. The isotropic luminosity of the line classifies it as a megamaser. The line is believed to originate from the circumnuclear disk of the AGN central engine.

Further study of this megamaser should be made using Band 5 on ALMA when this becomes available in the next cycle. On 15 km baselines, an angular resolution of 23 milliarcseconds could be achieved. Indeed, APEX SEPIA Band 5 now provides an ideal 183 GHz survey instrument for performing pathfinder observations of megamaser candidates, which can then form the groundwork for spatially resolved ALMA studies. The above results are published in Humphreys et al. 2016, ApJ, vol. 826, article id. 191.
Detection of vibrationally-excited CO in AGB stars with ALMA

Khouri et al. (2016) reported serendipitous detections with ALMA of pure-rotational $J=3-2$ transition of the CO molecule within its first vibrationally-excited ($v=1$) state from a sample of five asymptotic giant branch (AGB) stars, R Aqr, o Cet, R Scl, W Aql, and $\pi^1$ Gru. Thanks to the high gas densities needed to populate the $v=1$ state of CO and to its high excitation energy ($\sim 3100 \text{ K}$), the observed lines are formed very close to the cool ($T_{\text{eff}} 3000 \text{ K}$), extended ($R \sim 1 \text{ AU}$) central stars.

The wind-acceleration mechanism during the AGB is considered a two-step process because the formation of dust is only made possible by stellar pulsations and convective motions, which levitate gas to where low-enough temperatures are reached. Although considerable advances have been made in recent years, the complexity of the dust formation process and our poor understanding of the stellar pulsation mechanism still does not allow us to predict the mass-loss rates of AGB stars from first principles. In this context, empirically characterising the properties of both the gas and the dust in these regions is paramount to advance our understanding of the AGB mass-loss process.

As shown by Khouri et al., the pure-rotational $J=3-2$ transition of CO is a very good probe to study the distribution and kinematics of the levitated gas around AGB stars. The optical depths in this line ($\tau - 1$) are found to be much lower than those in the ro-vibrational CO transitions, which are usually observed to study this region. This allows for a global view of the conditions in the extended AGB atmospheres and facilitates the interpretation of the data. In Fig. 5, the observed line profiles are shown together with model fits. The models constrain the line-formation region to extend only to a few stellar radii and the gas mass in this region to be at least about an order of magnitude larger than the mass lost per pulsation cycle for the five stars. Interestingly, R Aqr and R Scl show inverse P-Cygni line profiles which indicate infall of material back onto the stars.

The serendipitous detection towards these five sources shows that vibrationally-excited rotational lines can be observed towards a large number of nearby AGB stars using ALMA. This opens an interesting new possibility for the study of the innermost regions of AGB circumstellar envelopes. The above results are published in Khouri et al., 2016, accepted by MNRAS, arXiv:1608.03271

Figure 5: Left panels: best fit models (dashed red line) compared to the observed line profiles (blue histogram). Right panels: best fit models (dashed red line, same as in left panels) compared to the contribution from lines of sight that intersect the star, producing absorption against the stellar continuum (dotted green line), and those that do not intersect the star (dotted-dashed black line).
The tidal disruption event Swift J1644+5734 — Revealing an extremely compact and steady radio structure with the EVN

Tidal disruption events (TDE) provide a unique view of episodic accretion in the centres of galaxies which can help to understand black hole formation and growth as well as jet formation in a newly activated galactic nuclei (AGN).

Swift J1644+5734 is the first TDE detected to have extremely luminous non-thermal emission from radio to gamma-ray wavelengths and thus likely to come from a newborn relativistic jet. In order to directly explore this jet scenario, an international team of radio astronomers, led by Jun Yang (Onsala Space Observatory, Sweden), carried out very long baseline interferometry (VLBI) observations at 5 GHz with the European VLBI network (EVN). The goal of the observations was to search for the apparent motion in the potential radio jet.

Initial EVN observations first detected a sub-mJy compact radio background source, about three-arcminutes apart from Swift J1644+5734. This reference source was then utilised as a stationary astrometry reference point in the later five deeper EVN observations. With respect to the reference source, the observations achieved a statistical astrometric precision about 12 micro-arcsecond (68% confidence level) per epoch. This is one of the most accurate phase-referencing radio astrometry measurements made to date.

Surprisingly, Swift J1644+5734 has a quite compact and steady radio structure with no proper motion detected. The apparent speed of any jet components between 2012 and 2015 is constrained to be less than 0.3c (99% confidence level). It is believed that the slow motion is caused by either a very small viewing angle to the jet or a strong jet deceleration due to interactions with a dense circum-nuclear medium. The above results are published by Yang et al. in 2016, MNRAS Letters, vol. 462, p. 66.

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