Onsala Space Observatory
astronomy newsletter

October 2, 2017 — Volume 7

From the Director:

Dear OSO Astro Newsletter readers,

Since the last newsletter the Onsala Twin Telescope (OTT) for geodetic VLBI has been officially inaugurated. Pictures from the birth celebrations of our new "twins' can be seen on page 3. The wide band receiver technology used for the OTT is being further developed at OSO (funded by an EU grant) to apply to astronomical VLBI (BRAND see p. 6) and to SKA Band 1 (p. 7). OSO has the unique distinction of being the only institution in the world that has designed receivers for both SKA Band 1 and for ALMA Band 5. As well as being responsible for the ALMA Band 5 receiver design, the Group for Advanced Receiver Development has shared with NOVA, Netherlands, the work on the construction of the full complement of Band 5 receivers for ALMA. This receiver band on ALMA is now producing exciting scientific results (see Arp220 results p. 8). Swedish users continue to be highly successful in applying for ALMA time (p. 6); users should also note the increasing capability for doing ALMA archive science. Likewise at metre wavelengths increasingly large areas of the sky have been surveyed by LOFAR with data available in the archive (p. 4).

Sincerely,

John Conway

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Editor: Michael Lindqvist

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 to August 2018.

Deadline for proposals: Monday 16 October 2017

APEX is a 12 m diameter submillimetre telescope in Chile. The receivers offered in this Call are the heterodyne receivers **SEPIA** (B5, 159–211 GHz, B7, 272–376 GHz, and B9, 600–722 GHz) and **PI230** (B6, 200–270 GHz), and the bolometer arrays **ArTeMiS** (350 and 450 µm) and **LABOCA** (870 µm). In general, proposals for Swedish time on APEX must have at least one co-I with a Swedish affiliation; however a maximum of 20% of the observing time will be open to international proposals. Note that APEX is presently undergoing major upgrade activities, including upgrades to the suite of heterodyne receivers**.**

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 67–87 GHz band, which includes low-energy or ground state transitions of important deuterated molecules, 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. It is open for scientists from all countries.

The **European VLBI Network (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. **The next deadline for EVN proposals** is 1 February 2018 (http://www.jive.eu/jivewiki/doku.php?id=evn:guidelines)

More information: http://www.chalmers.se/en/researchinfrastructure/oso/radio-astronomy/proposals/Pages/default.aspx

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: Contact Wouter Vlemmings, Head of Astronomy User Support.

News Items

Onsala Twin Telescope inauguration

On 18 May, the Onsala Twin Telescope (OTT) was inaugurated. The telescopes will be used for geodetic VLBI, see earlier Newsletter. This week in May 2017 was fully packed with VLBI activities in Gothenburg and at the Onsala Space Observatory (OSO). First, the 23rd Working Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA) was held at Chalmers University of Technology in Gothenburg. Almost 100 participants from 20 countries, both from inside and outside Europe, contributed with many interesting presentations on the current status of geodetic and astrometric VLBI and corresponding technical development and scientific results. Thereafter followed workshops and splinter meetings and, finally, the inauguration of the OTT.


Figure 1. *The OTT were inaugurated by Lena Sommestad and Lisbeth Schultze, the governors of Västra Götaland and Halland, respectively. Some 200 guests followed the ceremony.*

The weather was sunny and rather windy, as can be expected for a site located right on the coast. More than 200 guests, including the EVGA participants, witnessed this ceremonial inauguration and listened to speeches given by John Conway, Director of OSO, Stefan Bengtsson, President of Chalmers University of Technology, Axel Nothnagel, Chair of the International VLBI Service, and twin sisters Malin and Josefin Flyckt from the Swedish Astronomical Youth Association. After viewing NASA's cartoon film on the principles of VLBI, simultaneously moderated in Swedish by Maria Sundin, the actual inauguration ceremony was held. The governors of Västra Götaland and Halland, the two counties that are hosting Chalmers and OSO, respectively, Lena Sommestad and Lisbeth Schultze took the lead. They gave speeches reflecting on the importance of the forefront research carried out in West Sweden and specifically that at Onsala and Chalmers. Finally, together they pressed the two starter buttons in order to set the new telescopes into action, Fig. 1.

Accompanied by Mikael Högdahl's saxophone music, the telescopes began to dance and for the next a couple of minutes they demonstrated their abilities in terms of coordinated telescope motion. This gave the spectators a glimpse of how future geodetic VLBI operations at Onsala will look like.

The twin telescopes are presently undergoing scientific commissioning with the goal to participate in regular VLBI observations before the end of 2017.

Increased LOFAR capabilities at OSO

LOFAR's data processing infrastructure has been deployed on Chalmers' Centre for Computational Science and Engineering (C3SE) computer cluster. This allows us to work with the large data volumes produced by the LOFAR telescope. The deployment has been commissioned using one of the 3000 planned observations from the LOFAR Survey, a project that will ultimately produce 50 Petabytes of data, Fig. 2. With this commissioned system, OSO offers automated processing of LOFAR observations to the Swedish community. OSO can support Swedish users with new observations and processing of existing data.

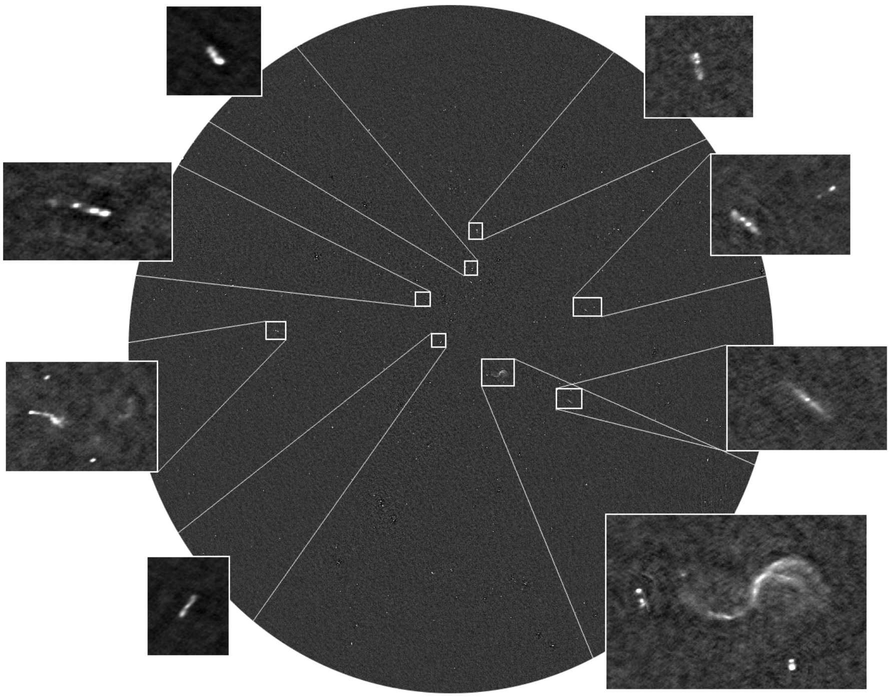

Figure 2. *The field of a single LOFAR observation with selected objects highlighted. Diameter: 5 degrees, resolution: 7.5 arcseconds, frequency: 150 MHz. The sensitivity of the image is about 0.45 mJy/Beam Higher resolution (down to 0.2 arcseconds) is available using LOFAR's full array. For a high quality version of the image, see :*
http://skogul.oso.chalmers.se/Lofar_Tier1_Survey/sample/

Onsala maintains the LOFAR survey progress web application. It allows users to quickly search the sky using the standard Aladin astronomical tools to determine if a region has been observed by the LOFAR survey. If the region has been observed, links to the archive are provided.
http://skogul.oso.chalmers.se/Lofar_Tier1_Survey/status/

New software to process data from cross-correlations between individual antenna elements of the Onsala LOFAR station has been developed. This software allows images to be made at Low Band (10–80 MHz) of the whole sky at high time resolution for transient detection, with cadence down to seconds, and angular resolution of order 1 degree. For High Band (110–240 MHz) simultaneous images of regions 20 degrees in diameter, limited by analogue beamforming, can be made with spatial resolution 1.8 deg. Python modules are provided to handle metadata generation, coordinate systems and geometric phase calibration and to support data output in standard Measurement Set format, making the data compatible with most commonly used interferometric imaging software suites. OSO also provides software to produce interferometric products from LOFAR's Transient Buffer Boards (TBBs). These allow the telescope to capture intense transient events for later detailed analysis. Using the tools developed at OSO, one can produce from this buffered data sky maps with extremely fine control over time (sub milliseconds) and frequency resolution (sub kHz).

New APEX MoU signed

An extension of the agreement between the partners of the Atacama Pathfinder Experiment (APEX) has been signed, ensuring that this very productive collaboration will continue until the end of 2022, Fig. 3. The 12 m APEX telescope saw first light in 2005 and has provided astronomers with detailed views of the coldest objects and processes in the Universe.

From 2018, the Swedish share of APEX observing time will decrease from 23 % to 13 %. In order to maintain the level of access to Swedish users, in future most proposals for Swedish APEX time will require a Swedish Co-I (see Call for proposals summary on page 2 for details of the new time allocation policies).

Figure 3. *ESO's Director General, Tim de Zeeuw (right), Karl Menten, Director at the Max-Planck-Institut für Radioastronomie (centre) and John Conway, Director of the OSO (left) signing the new APEX MoU. Credit: ESO/A. Kaufer.*

In order to prepare APEX for continued operation, the telescope will undergo major upgrade activities from September 2017 to January 2018. Also, as part of the upgrade, the suite of single pixel heterodyne receivers on APEX is being replaced and greatly upgraded in performance so that all bands will be covered by dual polarisation/dual sideband receivers, in many cases also with increased IF bandwidth. When fully completed in 2019, the receiver upgrade will provide APEX receivers covering from ALMA Band 5 to Band 10 inclusive. A new bolometer camera, A-MKID, will replace older ones. See the Newsletter from March 2017 for some more details.

ALMA Cycle 5 proposal review results

The results of the ALMA review panel were released in the end of July. Of 1661 submitted proposals, 695 proposals received Grade A, B, or C. A total observing time of 4000 hours will be scheduled for projects with Grade A and B, and carry-over projects from Cycle 4, constituting the expected available time for science observations in Cycle 5. A detailed breakdown of the proposal review results can be found on the ALMA Science Portal (http://almascience.eso.org).

The Nordic region has a continued high success rate in accepted proposals, including one of four accepted large programs. The Nordic ARC node will continue supporting the Nordic Cycle 5 observations through quality assessment of the observed data, as well as face-to-face visits for advanced data reduction and analysis.

As Cycle 5 begins in October 2017, the ALMA archive is continuously populated with data from previous cycles, and an increasing amount of data is becoming publicly available to the entire community. The Nordic ARC node is happy to support Nordic astronomers in archive searches, data reduction, and advanced analysis.

BRAND: A very wide-band receiver for the EVN

OSO is involved in the RadioNet Joint Research Activity (JRA) BRoad bAND (BRAND) EVN. The JRA started in 2017 and will run for 3.5 years (see also earlier Newsletter). The aim of the project is to develop a very wide-band "digital" VLBI receiver for the EVN and also other telescopes (in fact, it may be of interest also for SKA2). The frequency range of the BRAND receiver prototype will be from 1.5 GHz to 15.5 GHz. Until now, a radio astronomical receiver with a frequency ratio of 1:10 has never been realised. BRAND EVN is a truly European project with partners in Germany (MPIfR), Italy (INAF), Sweden (OSO), Spain (IGN), The Netherlands (ASTRON), and Latvia (VIRAC). OSO is leading the feed design for BRAND, with a first prototype currently under development for the primary focus of the Effelsberg 100 m telescope.

Astronomers will be able to measure variations of polarised emission over a very wide frequency range with very precise, unambiguous rotation measures. Studies of several different maser types in different frequency bands can be made simultaneously with proper alignment of the different maser species. Further opportunities arise for flux variation studies in several bands simultaneously, which is especially interesting for intraday variability investigations. Pulsar searches and observations can be performed over a wide frequency range without timing ambiguities. In addition, the receiver will be very useful for studies of Fast Radio Bursts.

SKA Band 1

Onsala Space Observatory is involved in the design phase of the SKA project with the responsibility to design the feed package for Band 1 of SKA-mid. The frequency coverage of 350–1050 MHz will open the possibility to map highly redshifted HI with very high special resolution. The first prototype of the Band 1 receiver was shipped to Canada for tests on the Dish Verification Antenna-1, an SKA prototype antenna, at the Dominion Radio Astrophysical Observatory, Fig. 4. These measurements were carried out in June 2017 and showed very good agreement with the design prediction.

Figure 4. *SKA Band 1 receiver tests at the Dominion Radio Astrophysical Observatory, Canada.*

Science Highlights

We would like to introduce you to a few of the recent science highlights produced using the instruments at, and supported by, OSO. 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.

Probing the gravitational redshift with an Earth-orbiting satellite

An international team of scientists, including people from OSO, led by Dmitry Litvinov from the Sternberg Astronomical Institute, Russia, have performed a test of general relativity using the 10 m space radio telescope RadioAstron. The ultra-stable on-board hydrogen maser frequency standard and the highly eccentric orbit make RadioAstron an ideal instrument for probing the gravitational redshift effect, which constitutes a test of the Local Position Invariance aspect of the Einstein Equivalence Principle (EPP). The highly eccentric orbit around the Earth evolves due to the gravitational influence of the Moon, as well as other factors, within a broad range of the orbital parameter space (perigee altitude 1,000–80,000 km, apogee altitude 270,000–370,000 km). The large gravitational potential variation, occurring on the time scale of ~24 hr, causes a large variation of the on-board H-maser clock rate, which can be detected via comparison with frequency standards installed at various ground radio astronomical observatories, including the OSO 20 m telescope.

Litvinov et al. (2017) presents the techniques as well as some preliminary results. They expect to reach an accuracy of the gravitational redshift test of order 10^{-5}, a magnitude better than that of Gravity Probe A mission, which yielded the best such test to date. All data has been taken and data processing is ongoing, their preliminary results agree with the predictions of the EPP.

The above results will be published in Litvinov et al. 2017.

ALMA band 5 imaging of the water maser in Arp 220

Water emission is an excellent probe of the physical conditions (e.g., temperature and density) in the molecular gas in the highly obscured innermost parts of galaxies. Extragalactic megamaser emission is typically excited as the result of activity from an active galactic nucleus (AGN), either in the accretion disk or torus close to the AGN, or due to the interaction between the AGN jet and molecular clouds in the surrounding interstellar medium. However, other masers, e.g., OH megamasers, are known to be associated with star-forming regions. Arp 220 makes for one of the most interesting objects in the nearby Universe. As the result of a merger, two remnant nuclei, Arp 220 East and Arp 220 West, are separated by only 380 pc at the center of Arp 220. They are each embedded in their own rotating gas disks in the foreground of a kpc-scale molecular gas disk. Whether AGN or the powerful starburst associated with the central activity, or a mixture of the two, facilitates the bright appearance this prototypical ultraluminous infrared galaxy at many wavelengths is still under debate.

ALMA band 5 science verification observations (testing the receiver band delivered by the GARD group at Chalmers) made it possible to image the 183 GHz water line arising from the central region of Arp 220 for the first time, Fig. 6 (left). Water maser emission is found in both Arp 220 East and Arp 220 West, with the western nucleus being the brighter of the two. The same is seen for the water line at 325 GHz, Fig. 6 (right). A comparison with previous observations with the IRAM 30 m telescope and APEX showed that the line shapes and intensities of both water lines are surprisingly stable over time scales of up to a decade. This is quite unexpected for water maser lines, for which line shapes and intensities can change in as little as a few days. Considering the properties of the three water lines at 22, 183 and 325 GHz, the authors suggest that the water maser emission in Arp 220 is originating from many individual masers in star-forming regions distributed throughout the two nuclei, and not from AGN activity as is usually assumed for extragalactic water megamaser emission. Higher spatial resolution observations with ALMA in band 5 and 7 are necessary to observe the water emission in Arp 220 in such detail that the individual emitting regions can be identified.

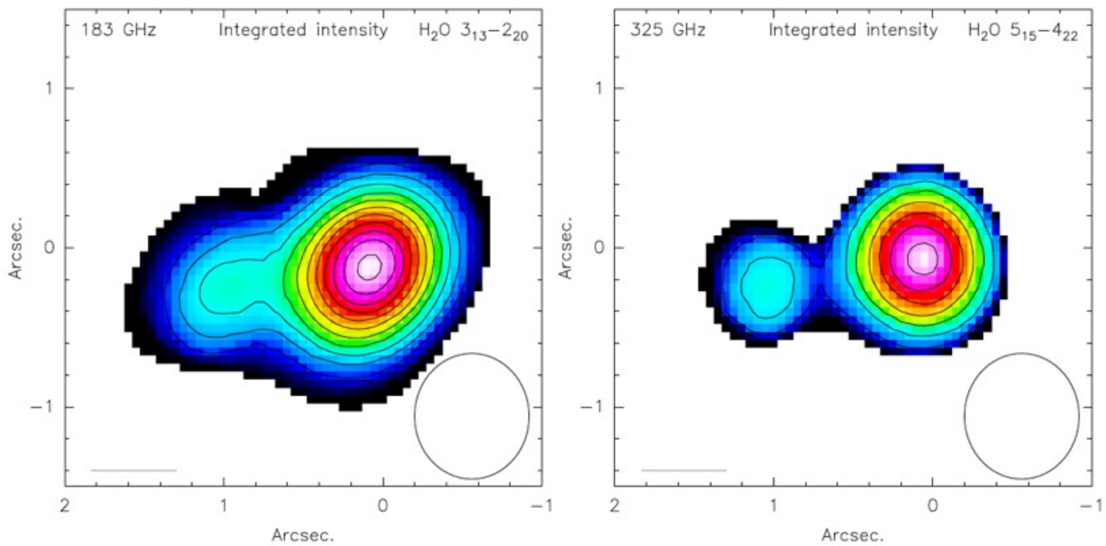

Figure 6. *Distribution of the 183 (left) and 325 GHz (right) water emission in the two nuclei of Arp 220.*

The above results are published in [König et al. 2017](#).

First detection of methanol towards a post-AGB object, HD101584

Methanol (CH_3OH) is an abundant molecule in the interstellar medium, and it is, in particular, used as an excellent probe of the star formation process. Many attempts have also been made to detect it in the medium surrounding evolved stars. None have been successful until now when it was for the first time detected towards an object called HD101584, using ALMA. In addition, APEX has provided crucial information on the evolutionary status of HD101584 in the form of estimated $^{12}C/^{13}C$ and $^{18}O/^{17}O$ isotope ratios that strongly support that it is an object in transition from being a red giant to becoming a white dwarf, Fig. 7.

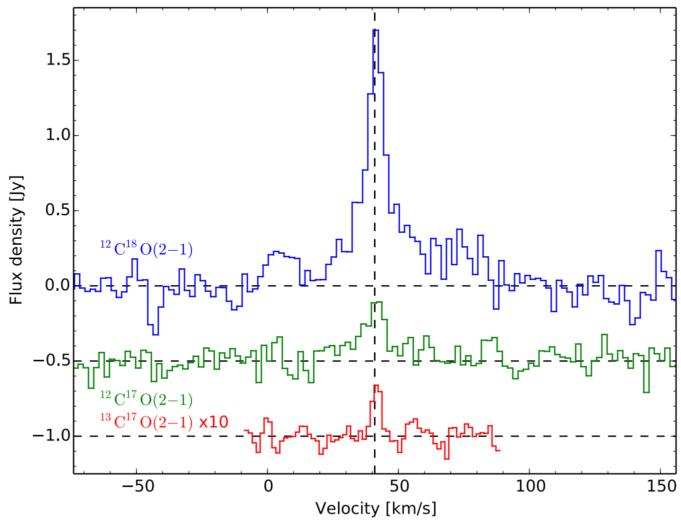

Figure 7. *Observations of three CO isotopologues towards HD101584. The $C^{18}O(2-1)$ (upper) and $C^{17}O(2-1)$ (middle) lines are observed with APEX, while the $^{13}C^{17}O(2-1)$ (lower) line is observed with ALMA.*

This object, which is the result of a low-mass companion being captured by the red giant, has some remarkable characteristics, see Newsletter September 2015. Among them is a high-velocity outflow of molecular gas expanding at a speed of about 150 km/s in two diametrically opposed directions. This is illustrated by the SiO(5-4) emission which is particularly sensitive to shocked gas, Fig. 8. The high-velocity gas ends in two spots about 4 arc seconds on either side of HD101584. The methanol was detected in these spots, Fig. 8.

In addition to methanol, emissions from other molecules like CO, SiO, CS, SO, OCS, and H_2CO were detected in the spots. It is estimated that it has taken the gas, ejected by the red giant, about 7000 years to reach the position of the spots. Only CO would survive in the harsh environment of interstellar space for such a long time, so the other molecules must have their origin in a local chemistry in the spots. A similar situation occurs also around young stars, and there it is believed that shock chemistry in combination with the release of molecules from dust grain surfaces explain the chemical composition. It is possible that the same applies to HD101584, with the difference that here circumstellar rather than interstellar dust grains are affected by the high-velocity gas colliding with the surroundings.

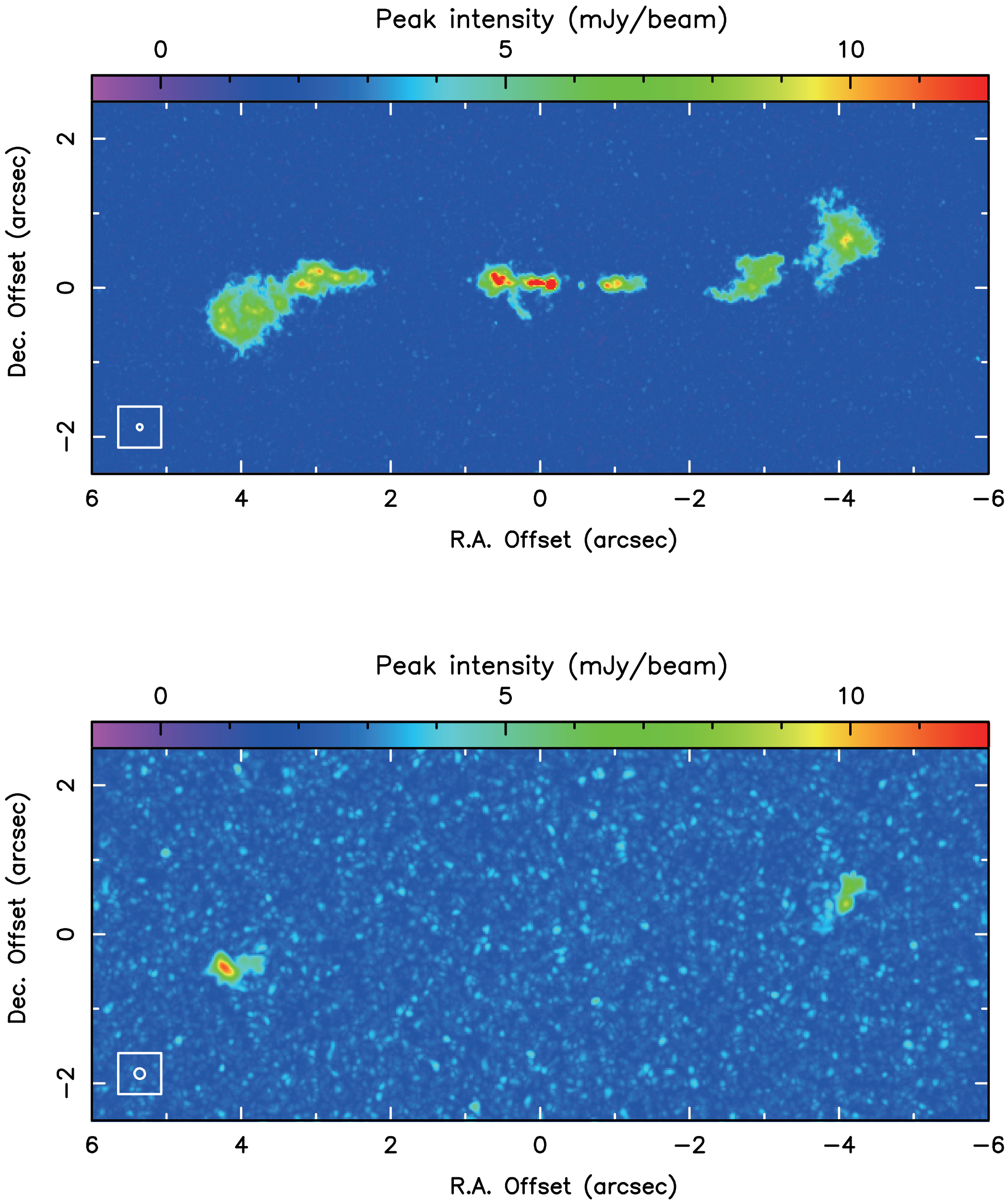

Figure 8. Upper: *A colour image, produced from the SiO(J=5-4) peak emission in each pixel using ALMA data, outlines the high-velocity molecular gas outflow from HD101584 (located at the centre).* ***Lower:*** *A similar colour image produced from the CH_3OH ALMA data. CH_3OH emission is only seen from the two outer spots where the high-velocity outflow ends.*

The above results are published are published in [Olofsson et al. 2017](#).

Onsala Space Observatory
astronomy newsletter

March 22, 2017 — Volume 6

From the Director:

Dear OSO Astro Newsletter readers,

This newsletter highlights new results involving observations from sub-millimetre through centimetre to metre wavelengths. ALMA observations reduced at Onsala's Nordic ALMA Regional Centre node, and published in Nature, demonstrate for the first time that winds from protostars are formed in the surrounding disk rather than close to the protostar surface.

Another exciting result, involving Onsala's 25 m telescope, has been the first identification of Fast Radio Bursts (FRBs). The origin of these very fast (1 ms - 10 ms) yet very powerful pulses is still mysterious. While it has previously been surmised that FRBs are extragalactic, this has been confirmed for the first time by the location of the repeating FRB 121102 to the nucleus of a dwarf galaxy at $z \sim 0.2$. Initial observations made using the Jansky VLA found bursts from this source to occur closer than 100 mas from a weak persistent radio source. Subsequent VLBI observations, including the Onsala 25 m telescope, showed the burst and persistent radio source to be coincident to 12 mas, with the persistent source being more compact than 0.2 mas. Models of FRB's which are consistent with these results include AGN or supernova remnant origins.

Sincerely,

John Conway

Contents

Editor:

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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 August/September 2017 to March 2018.

Deadline for proposals: Friday, 05 May 2017

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 µm and 450 µm bolometer array, can be requested for use on Swedish time under the same conditions as facility instruments. Other APEX partner instruments, including **FLASH+,** can also proposed for use during Swedish time but use of the instrument must be discussed with the instrument PI before the submission of the proposal.

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More information: http://www.chalmers.se/en/centres/oso/radio-astronomy/proposals/Pages/default.aspx

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

News Items

GARD-developed Band 5 receivers make their debut at ALMA

ALMA Cycle 5, with deadline on 20 April 2017, will be the first cycle to offer the Band 5 receivers for regular observations. The receivers were developed by the GARD in Sweden together with NOVA in The Netherlands. They cover the 163 - 211 GHz spectral range and are available in all the 56 antennas offered for Cycle 5. Proposals with Band 5 will be accepted for spectral line (12-m, 7-m and Total Power arrays) and continuum (12-m and 7-m arrays) observations, and will be possible at all available polarisation modes.

Observations with the Band 5 receivers are expected to begin only in March 2018, after the scheduled February shutdown. This means that the most extended array configuration available for observations in Band 5 will be C43-5, comprising baselines up to 1.1 km. Since the Observing Tool does not check these scheduling constraints, ALMA users are responsible for verifying that the requested angular resolution and the corresponding antenna configurations are available in the appropriate months. Please contact the ARC node in Onsala if you need assistance.

The APEX telescope renewed into the next decade

The APEX partners (OSO, ESO and MPIfR) have agreed to continue to operate the telescope for the period 2018 - 2022. As part of the agreement, several changes have been introduced. Among them is that the Swedish share will now be 13% (down from 23%) which amounts to about 30 observing days every year, with the new requirement—starting in 2018—that there must in general be a Swedish affiliated co-I on all proposals submitted to the Swedish TAC.

In preparation for the new APEX extension period, starting in October this year the APEX telescope facility will undergo a major upgrade. The ageing antenna surface and sub reflector will be replaced, making the telescope even more efficient when observing at high frequencies. An updated suite of sub-mm receivers will also become available to Swedish astronomers when observations resume in late March 2018. The OSO-GARD contribution will be a new 345 GHz receiver (Band 7) which will be placed inside the SEPIA cryostat already hosting the 183 GHz (Band 5) and 650 GHz (Band 9) receivers. Receivers for the remaining bands will be contributed by MPIfR. Most of the single-pixel dual-polarisation receivers will utilise an 8 GHz bandwidth per sideband, which will require a new set of spectrometers covering a total bandwidth of 32 GHz. As before, Swedish astronomers will have access to the ArTéMiS 350/450 μm bolometer camera. A new revolutionary instrument, A-MKID, is planned to replace the old bolometer cameras LABOCA and SABOCA. This new bolometer camera will increase the number of pixels tenfold at 850 μm, and by a factor 700 at 350 μm.

Taken together, the antenna upgrade and the new suite of receivers, APEX will provide Swedish astronomers with a unique sub-millimetre facility equipped with state of the art receivers well into the next decade.

Preparing for the SKA era

In November last year the city of Goa in India was host to the "Science for the SKA generation" conference, organised by the international SKA Organisation with local support from the National Centre for Radio Astrophysics (NCRA-TIFR) in Pune, which represents India in the SKA project.

Some 200 astronomers, among them several from Uppsala and Stockholm, attended the conference. The meeting focused on bringing together early career and senior researchers from the radio astronomy community, to develop new collaborations and preview the science that SKA will do in 2023 and beyond.

The meeting highlighted results obtained with SKA pathfinder and precursor telescopes from around the world. The next few years will see a wave of new results emerging from the suite of radio telescopes such as FAST in China, GMRT in India, LOFAR in Europe, MeerKAT and HERA in South Africa, and MWA and ASKAP in Australia. Scientists who are using these facilities will become the first generation of users to make exciting discoveries with the SKA.

Many areas of astrophysics were covered at the Goa Meeting; including the epoch of re-ionization and the study of the cosmic dawn of the Universe; the distribution of hydrogen in the Universe; the study of transient phenomena such as fast radio bursts; cosmic magnetism; monitoring the Sun's activity; mapping pulsars in our galaxy; and the search for life in the Universe.

Sources: SKA telescope news: https://www.skatelescope.org/news/science-for-the-ska-generation-the-2016-ska-science-conference-opens-in-goa-india/ - Conference webpage: https://indico.skatelescope.org/event/391/overview

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

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.

First unambiguous localisation and characterisation of a Fast Radio Burst

Fast radio bursts (FRBs) are bright (~Jy) and short (~ms) bursts of radio emission of unknown physical origin. Until now, unambiguous associations with multi-wavelength counterparts have uncertainty regions of at least several square arcminutes.

Chatterjee et al. (2017) have for the first time pinpointed the location of an FRB. Using Expanded Very Large Array observations of the only known repeating FRB, named FRB 121102, they were able to determined its sky position with an uncertainty of ~100 mas, and reported an unresolved, persistent radio source and an extended optical counterpart at this location, neither of them corresponding to any known class of Galactic source.

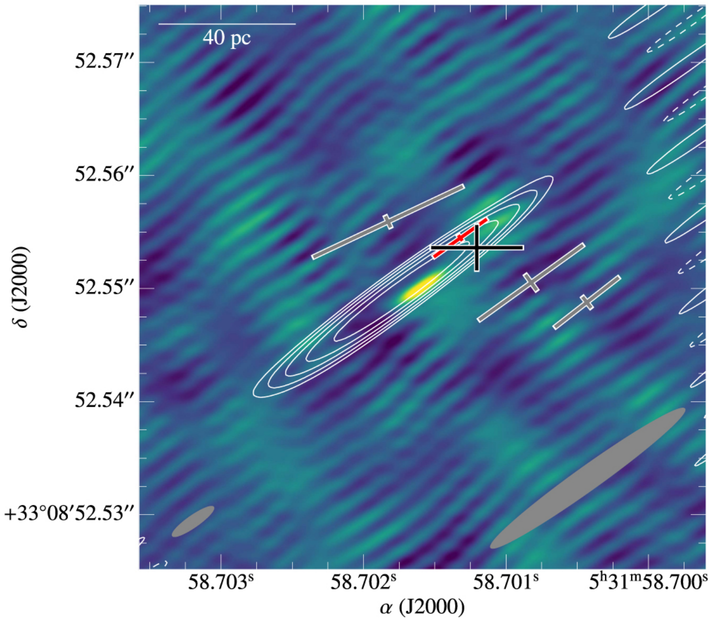

Figure 1: EVN image of the persistent source at 1.7 GHz (white contours) together with the localisation of the strongest burst (red cross), the other three observed bursts (grey crosses), and the position obtained after averaging all four bursts detected on 2016 September 20 (black cross). From Marcote et al. (2017)

Marcote et al. (2017) report EVN observations which simultaneously detect both the bursts and the persistent radio emission at milliarcsecond angular scales and show that they are co-located to within a projected linear separation of 40 pc (12 mas angular separation, at 95% confidence). The EVN observations included the Onsala 25 m antenna and were correlated with the SFXC correlator at JIVE. The observations also limit the size of the suspected source of origin to ~0.2 mas. It is argued that the two scenarios for FRB121102 that best match the observed data are a burst source associated with a low-luminosity active galactic nucleus, or a young (< 1000 year) supernova remnant (SNR) powered by an energetic neutron star.

Further Gemini North observations by Tendulkar et al. (2017) show that the bursts originate about ~200 mas away from the center of a low-metallicity dwarf galaxy at z~0.2. The optical properties they report do not add support to the AGN interpretation, although they cannot conclusively rule it out.

Sources:
JIVE press release: http://jive.eu/astronomers-pinpoint-radio-flashes-long-long-ago-galaxy-far-far-away - JIVE science highlights: http://www.jive.nl/jivewiki/doku.php?id=evn:evn_science - S. Chatterjee, et al. 2017, Nature, 541, 58 - Tendulkar, S. P., et al. 2017, ApJL, 834, L7 - Marcote, B., et al. 2017, ApJL, 834, L8

High-resolution imaging of metre-wave emission from Arp 220 with LOFAR

An international collaboration of researchers led by astronomers at Chalmers have used the SKA precursor LOFAR telescope to obtain a radio continuum image and spectral information of the starburst galaxy Arp 220 at 150 MHz. Arp 220 is a galaxy merger with two nuclei about 1" apart, and is well known from observations at higher frequencies. Using the high angular resolution provided by the full international LOFAR network, it was possible to, for the first time at metre wavelengths, separate the emission from the two nuclei from their immediate surroundings. The final image was made from 44 LOFAR stations in multiple countries with a resolution of 0.65" x 0.35" and a sensitivity 0.15 mJy/beam, a performance similar to the groundbreaking images of M82 obtained by Varenius et al. (2015).

By combining the LOFAR images with observations at higher frequencies it is possible to map the absorption of radio emission by ionised gas in the galaxy. Both nuclei of Arp 220 are found to be significantly absorbed at LOFAR frequencies. However, LOFAR also finds elongated steep-spectrum structures extending from the nuclei. These are interpreted as outflows, which may be driven by the intense star formation in the two nuclei, known from e.g. VLBI studies of radio supernovae, but could also be powered by AGN activity.

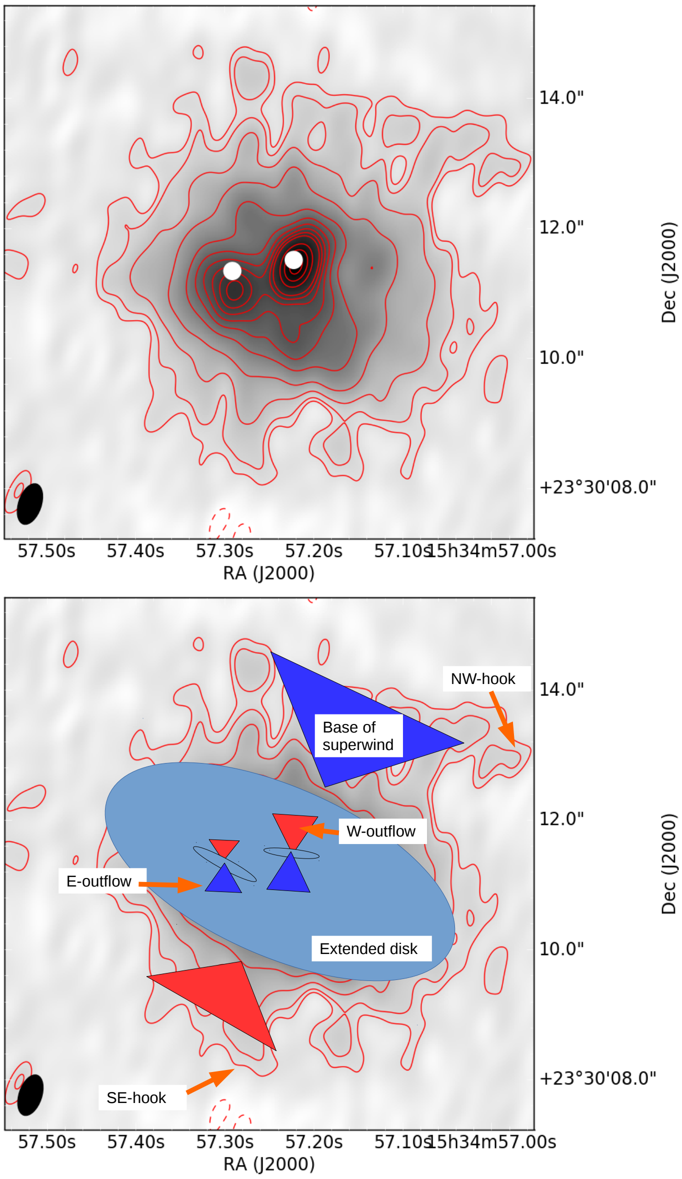

Figure 2: Top: The 150 MHz continuum emission shown in greyscale and contours. The white dots mark the GHz positions of the nuclei. Bottom: A sketch of a possible configuration of outflows which could explain the observed morphology. (Varenius et al. 2016)

The LOFAR images also show that more than 80% of the detected flux comes from a previously unknown extended (6" ~ 2.2 kpc), steep spectrum ($\alpha = -0.7$) emission surrounding the two nuclei, likely generated by star formation (i.e. by radio supernovae and supernova remnants) in the molecular disk surrounding them.

International LOFAR observations show great promise to detect steep spectrum outflows and probe regions of thermal absorption. Furthermore, in luminous infrared galaxies such as Arp 220, the emission detected at 150 MHz does not necessarily come from the main regions of star formation. This implies that high spatial resolution is crucial for accurate estimates of star formation rates for such galaxies at 150 MHz. This may be of importance for future surveys with, e.g., LOFAR or the SKA.

The full results are presented by Varenius et al. in Astronomy & Astrophysics 593, A86 (2016).

Resolved images reveal a protostellar outflow launched by an extended disk wind

Molecular outflows from young stellar objects were first discovered already in the 80's. At that time, they came as a surprise. The expectation was to detect gas moving inwards towards the protostar, not away from it.

Outflows are now known to be critical during the star formation process. They are believed to remove angular momentum from the protostellar system, thus allowing stars to grow by accretion. The mass-loss likely takes place in a region very close to the protostar, but exactly how the material is being accelerated has been debated for a long time. Limited angular resolution meant that the outflow launching could only be probed by indirect methods. Models explaining outflow launching can roughly be divided in three different groups. The main difference between these sets of models is where the acceleration takes place, close to the protostar itself (X-wind or stellar wind) or in a wider region throughout the disk (disk wind). In fact, the solution to the problem may lie in a combination of the processes.

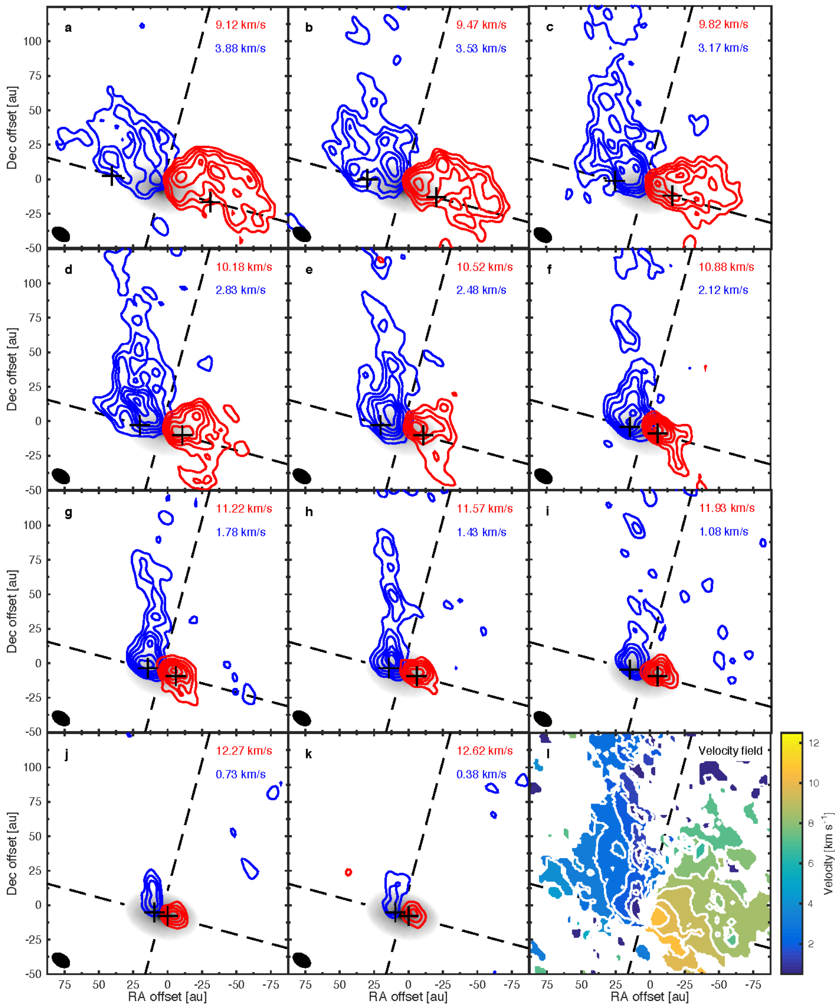

Figure 3: ^{12}CO channel map of the region. Contours start at 3σ, in steps of 1.5σ and only show emission from the rotating outflow. The emission from the NW and SE cavity walls are blocked by foreground material. Blue and red contours show blue- and red-shifted emission, respectively, with reference to the systemic velocity. In each panel the central channel velocities and the radii for the corresponding Keplerian velocities (plus signs) are indicated. Dashed lines show the direction of the disk and the perpendicular outflow axis. Greyscale is continuum. In the lower right panel, a map of the velocity field is presented.

Direct observations of the molecular gas in the launching region have not been possible, until now. ALMA can reach milliarcsecond resolutions, allowing the mapping of the inner regions on scales of less than 10 AU (for nearby sources). In a recent ALMA program, Bjerkeli et al. (2016) reported ^{12}CO(2-1) observations towards the Class I source TMC1A. They show that the ^{12}CO emission indeed arise from the outflow and not the disk, allowing for a detailed study of the morphology and kinematics. Both from the morphology and magnetohydrodynamic wind theory, they find that material is being launched from a region extending out to more than 25 AU from the protostar. These results provide the first direct evidence of a disk wind from a young protostar.

The results were published by Bjerkeli et al. in Nature, vol 540 (2016) — arXiv: https://arxiv.org/abs/1612.05148