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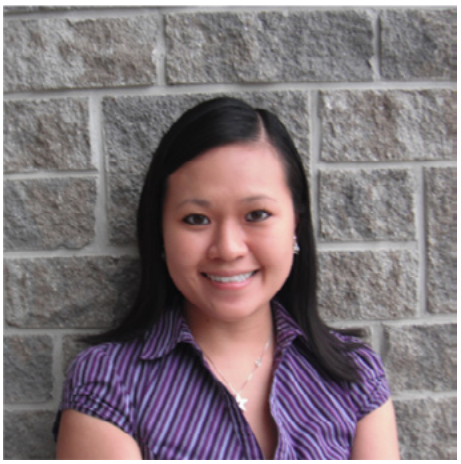
Foreword

It's a pleasure to bring you another edition of the Wallaby newsletter. It's also a pleasure to introduce the new WALLABY logo. As you can see above, we've incorporated a representation of the ASKAP telescope and the PAF design, both of which are, of course, key to the implementation of WALLABY! On a more serious note, the last few months has seen the publication of the first WALLABY (and ASKAP) science paper from the BETA array. The WALLABY team is working hard to assist CASS deliver processing pipelines and is working even harder on post-processing pipelines which will be let loose on ASKAP-12 WALLABY data due to be arriving in 2017. The serious process for planning for Early Science has started, and we expect much of this preparation to come together at the Early Science workshop planned in Perth from 15 to 19 February 2016 (www.icrar.org/news/wallaby-early-science-workshop). If you haven't registered for the meeting, but have an important reason to attend, please contact the organizing committee and we'll put you on the waiting list!

People Profiles

Karen Lee-Waddell (CSIRO Astronomy and Space Science)

I am excited to be part of the WALLABY project, especially with ASKAP Early Science on the horizon. I recently completed my PhD at Queen's University (Ontario, Canada) and started a postdoc at ATNF just a few weeks after my final thesis submission.



Karen Lee-Waddell

My graduate research focused on low-mass objects in interacting galaxy groups. Using HI observations from the Arecibo Legacy Fast ALFA Survey (ALFALFA), I identified nearby groups showing signs of previous and/or on-going interaction events. Degree-scale HI mosaics from the Giant Metrewave Radio Telescope (GMRT) and deep optical photometry from the Canada-France-Hawaii Telescope (CFHT) MegaCam enabled detailed analysis of the gas-rich dwarfs and various tidal features in each of these groups (see Lee-Waddell et al. 2012, 2014, 2015).

I am using my expertise with radio observations to contribute to the RSS Imaging Spectroscopy Nearby Galaxy Survey (RINGS) collaboration, which will combine Southern African Large Telescope (SALT) observations, high-resolution HI maps and multi-band optical imaging of 19 spiral galaxies to model their mass distribution. I am also currently working on a handful of other HI projects looking at interacting dwarf galaxies as well as more isolated systems.

During my first couple of months with CASS, I have become quite familiar with the current and projected capabilities of the ATNF. I am actively involved in the CSIRO Scientists in Schools program and hope to continue my military service through an exchange program with the Australian Army Reserve. I am eager to extend my research on galaxy evolution in group environments and anticipate ground-breaking science from ASKAP.

References:

Lee-Waddell et al. 2015, submitted

Lee-Waddell et al. 2014, MNRAS 443, 3601

Lee-Waddell et al. 2012, MNRAS 427, 2314 ⊙

Juan Madrid (CSIRO Astronomy and Space Science)

I am thrilled to be part of CSIRO and to belong to the active team led by Bärbel Koribalski. I am looking forward to meeting the Wallaby team and working together with them.

Juan Madrid

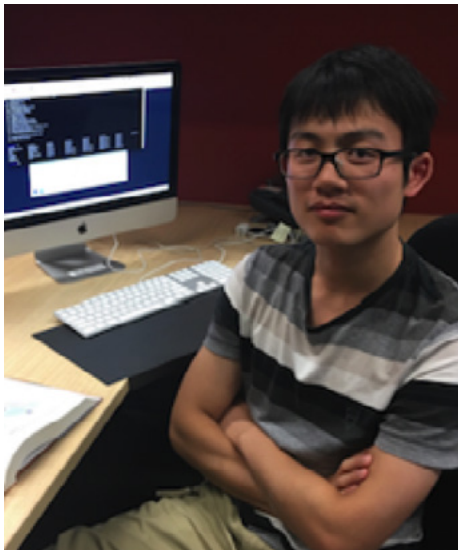
As it has been for many of us, my career path in Astronomy has been one that involves many trips in long range airplanes. I joined CSIRO from the Gemini observatory where I was a science fellow. Prior to that I did my PhD thesis at Swinburne University in Melbourne where I concentrated on observations and simulations of dwarf galaxies and globular clusters. Carrying out simulations on the dynamics of globular clusters was an interesting experience that introduced me to the world of supercomputers and computations with Graphic Processing Units (GPUs). During my time in Melbourne I not only did my PhD but also fell in love with Australia and its unique no worries attitude.

Before coming to Australia for my PhD I lived for nine years in North America, seven years in the US and two in Canada. I worked for the Space Telescope Science Institute in Baltimore after completing my honours degree in physics. In a way, NASA was my first job! While at the STScI, I carried out several science projects in different topics ranging from extragalactic novae to powerful radio galaxies, always using Hubble data. I continue working with HST data for its unique resolution. I am also still interested in radio galaxies and AGN, who isn't fascinated by black holes? I often collaborate with other teams that keep a watchful eye on the M87 jet. Indeed, this fascinating object has shown extraordinary variability in recent years. At the STScI I was also involved in several aspects of science administration including the HST TAC and production of publication statistics for different governing committees.

This new position at CSIRO is a great opportunity for me to be part of the first science team to use ASKAP data. We are living a new dawn in radio astronomy with the advent of several new telescopes ALMA, ASKAP, and the SKA. I am happy to have the opportunity to ride this big wave as a member of the Wallaby team. ☉

New PhD student: Qinxiang Chen (ICRAR/UWA)

I am very glad having the chance to join WALLABY. I recently joined ICRAR as a PhD candidate sponsored by an ICRAR/UWA China SKA Scholarship. Before coming here, I did research using cosmological simulations to study the formation and evolution of structures at the National Astronomical Observatories of China. Using two series of very high resolution simulations (Aquarius and Phoenix), I compared the different behaviour of mass growth history, accretion process domination, accretion time profile, inner structure stability between halos on the Milky Way and galaxy cluster scale. I found that the mass accretion behaviour between the two is similar but with a more violent mass exchange in the inner region of clusters.



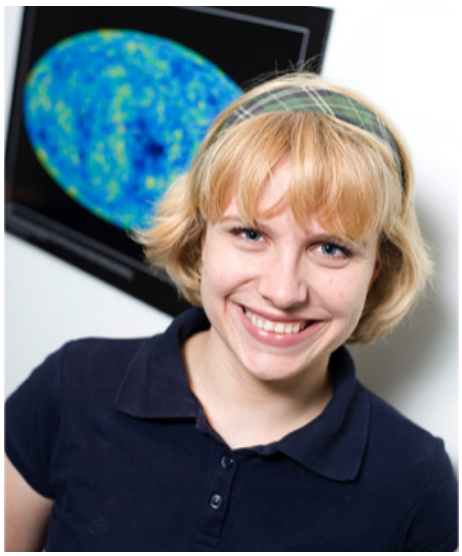
Qinxiang Chen

Now my interest will focus on studying the gas content of universe using the HI stacking technique. Data from Parkes, VLA, and ASKAP will be used. The HI content of galaxies is an extremely important component but is hard to detect at large distances. Using the stacking technique, we can study the gas density evolution of the Universe and certain populations of galaxies over a large time scale, which will bring insights into the processes behind galaxy formation and evolution.

As a new ICRAR member of Wallaby, I am getting familiar with the technique used in this area. I am eager to attend the forthcoming early science workshop since ASKAP will certainly bring exciting discoveries! ☉

Submitted PhD Theses

Laura Hoppmann (ICRAR/UWA)



Understanding how and at what rate stars form from cool ($<10^4$ K) atomic and molecular gas is one of the crucial question of modern astrophysics. It is understood that HI inside galaxies is a reservoir for star formation and therefore an important building block in galaxy formation. However, the knowledge of the co-evolution of HI and the star formation rate (SFR) is still incomplete. My thesis 'Deep studies of the Universe at 21 cm' is part of substantial new observational and theoretical effort to fill in missing details, in particular the evolution of the cosmic HI density, Ω_{HI}.

My thesis uses deep observations with the Arecibo telescope, the Arecibo Ultra Deep Survey (AUDS), and a WSRT survey consisting of 35 pointings in Sloan Digital Sky Survey (SDSS) fields to examine the evolution of the cool atomic hydrogen via the 21 cm line. For each of these surveys, we directly detect distant galaxies and also use a statistical stacking technique to determine the average HI properties of all galaxies with newly acquired and existing optical redshifts. The results of my thesis include the most accurate measurements to date, and show that there is no detectable evolution of Ω_{HI} between today and z=0.16. In addition to the constraints of Ω_{HI} this thesis uses the available data sets to study related topics relevant to galaxy formation and evolution, such as the HI mass function, the influence of the environment (halo mass in particular) on the gaseous properties of galaxies, and the Tully-Fisher relation. I also discuss the reduction of uncertainties due to cosmic variance.

The first paper from my thesis is available at: http://adsabs.harvard.edu/abs/2015MNRAS.452.3726H. ☉

WALLABY Early Science and Field Selection

T. Westmeier and B. Koribalski

Early science observations with the first 12 ASKAP antennas equipped with Mk2 PAFs are currently expected to begin in the second half of 2016. The WALLABY team successfully made a case for a substantial HI survey to be carried out on ASKAP–12. The current version 1.1 of the ASKAP Early Science Program assigns approximately 800 h of observing time to an "*18.5 kHz spectral line survey, over 1150–1450 MHz and targeted toward a small number of fields, with 120 hours integration time per field*". The main aim of the WALLABY early science observations is to study environmental effects on the morphology and evolution of galaxies across a range of densities by targeting a selection of group and cluster environments in the nearby universe.

A crucial step in our preparation for early science observations is the selection of a suitable, representative and scientifically valuable sample of **target fields**. As a result of the higher-than-expected system temperature of the MkII PAFs of $T_{sys} / \eta \approx 90$ K at 1.4 GHz, we would require about 120 h of integration time per field on ASKAP–12 to achieve nominal WALLABY sensitivity of about 1.6 mJy per 18.5 kHz channel. This will allow about **6 to 7 fields** to be targeted in total, with a 3 σ HI column density sensitivity at 30" resolution of approximately 5×10^{19} cm^{-2} after spectral smoothing to 100 kHz (21 km/s at z = 0). Assuming about 500 to 600 detections per field, we expect a total sample size of about 3000 to 4000 galaxies detected in HI emission.

To get the field selection process started, a page has been set up on the official WALLABY wiki where suggestions for potential target fields are listed and motivated. We invite all members of the WALLABY team to contribute to that list. A discussion of early science fields will also occur at the WALLABY Early Science Workshop in Perth in February 2016. Registration for the workshop is now closed, and the workshop programme (talks + hands-on sessions) will be made available on our website as soon as possible. Apart from technical and observational constraints, useful selection criteria for target fields include:

- Galaxy density as a function of redshift;
- Availability of supplementary data;
- Foreground targets of interest.

To enable systematic environmental studies, the overall sample of fields should cover a wide range of environments from loose groups to dense clusters across a redshift range of z ≈ 0 – 0.1. The main **science goals** of the WALLABY early science programme include:

- Variation of the HI mass function, Tully–Fisher relation and different HI scaling relations with environment;
- HI deficiency and relation to star formation activity as a function of environment;
- Effects of ram pressure and tidal stripping on the morphology and evolution of galaxies in different environments.

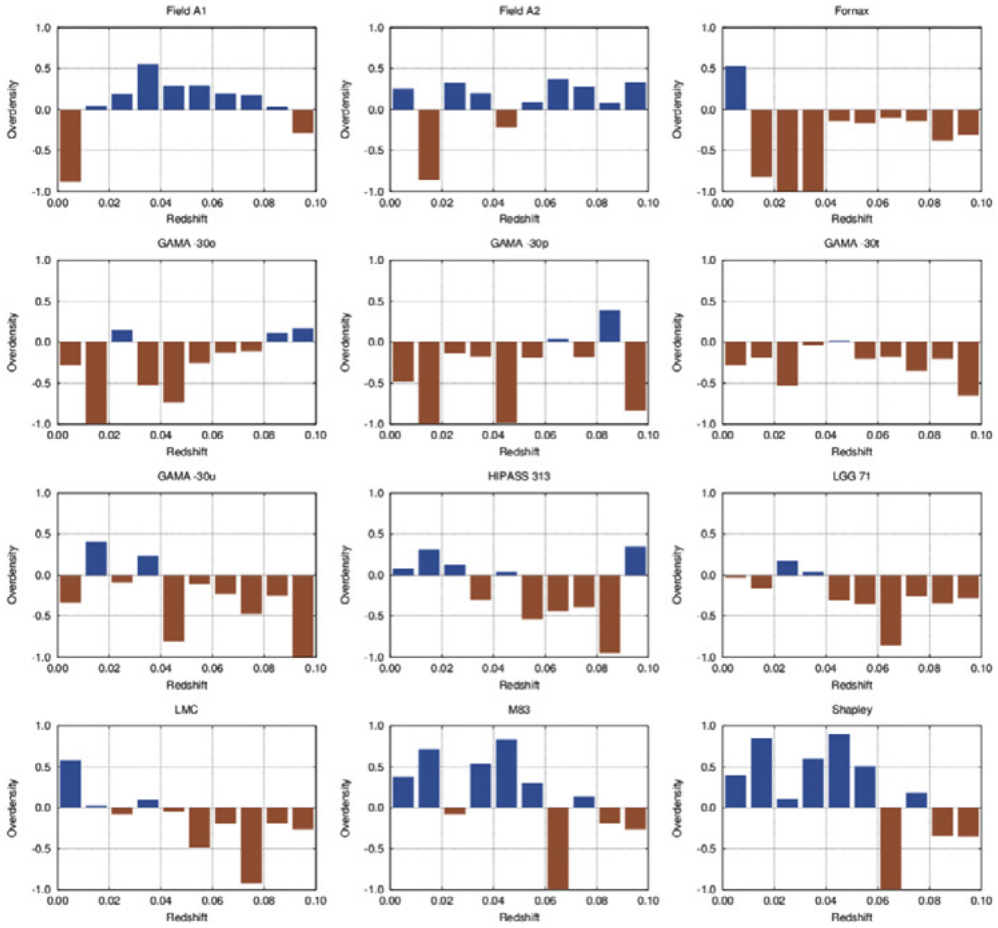


Figure 1. Histograms of galaxy overdensity in the 6dFGS catalogue as a function of redshift in the range of z < 0.1 for some of the proposed WALLABY early science fields. Overdensities are logarithmic, relative to the average galaxy density across the sky in each redshift bin, and have been averaged across a circle of 3° diameter on the sky centred on each target.

In addition to these statistical studies, we will also be able to choose our fields such that they encompass specific **targets of interest** in the foreground that are worth studying with the capabilities of ASKAP–12, in particular the telescope's moderately high angular resolution of 30" and large field of view of about 30 square degrees. Some possible examples include the Large Magellanic Cloud, the M83 group or the Fornax cluster. Galaxy overdensity histograms for some of the proposed targets are shown in Fig. 1 based on the 6dFGS galaxy catalogue.

For further information on the field selection process and potential target fields, please see the WALLABY wiki as well as WALLABY memos 8 ("BETA commissioning plan for WALLABY") and 16 ("Galaxy overdensity in potential target fields for WALLABY early science"). ☉

WALLABY Early Science Facts

Field parameters: field size = 5.5° × 5.5°; rms = 1.6 mJy/beam per 3.9 km/s channel; resolution = 30″ (same as full WALLABY).

Preliminary time allocation: 800 h from mid 2016 (initially with 12 PAF-equipped ASKAP antennas; more antennas later). This allocation would allow us to observe 6 – 7 fields, integrating about 120 hours each to achieve WALLABY depth. We expect to detect a total of 3000 – 4000 galaxies in HI emission (including ≈ 100 well-resolved, nearby galaxies) plus HI debris.

Likely data products: large HI data cubes and 20-cm radio continuum maps; HI source catalogues; sub-cubes and moment maps for each HI source. We will use SoFiA, our spectral line Source Finding Application (Serra et al. 2015) to find and characterise all HI sources; SoFiA info & download: https://github.com/SoFiA-Admin/SoFiA/.

ASKAP Update

Paolo Serra

2015 has been an exciting year for the ASKAP Commissioning and Early Science team (ACES) and for the overall ASKAP community. Having enjoyed in 2014 a first taste of what phased array feeds can do, we have now made further progress towards better understanding the new telescope as well as the data reduction software that comes with it (ASKAPsoft) - and we have published the first ASKAP astronomy articles!

A major area of activity has been the characterisation of ASKAP beams' position and shape. This has been done through an extensive campaign of imaging and holography, leading to a better understanding of the properties of beams formed with the maximum S/N algorithm. These beams do not necessarily have a circularly symmetric shape, and may in principle differ significantly from one another. For this reason, we are currently developing methods to better constrain the beam shape and minimise their variance.

The performance of the MkI receivers has been characterised in a variety of ways including drift scans of the Galactic plane and imaging of large fields in both continuum and spectral line. Measurements of Aeff/Tsys agree with previous results and with recent simulations. The methods developed for this purpose are soon going to be used to improve the measurements of the new MkII receivers performance.

MkI data have been useful to make progress with the commissioning of ASKAPsoft. Different subgroups within ACES are focusing on different aspects of the software (e.g., calibration, continuum imaging, continuum subtraction, spectral line imaging). A key approach has been to compare ASKAPsoft data products with those obtained previously with well established software. The good interaction between astronomers and the software group is proving important to make progress in this area.

All the while, we have continued to pursue astronomy research goals by dedicating a significant amount of time to continuum and spectral line observations of commissioning value. This effort has resulted in first articles being published (Allison et al 2015; Serra et al. 2015 - both MNRAS), with a few more submitted. In this respect, BETA is proving a successful array, and continues to deliver exciting new data such as very large continuum images and new detection of HI absorption systems at high redshift.

Last but not least, as the roll-out of MkII receivers continues first astronomy images are being made. For the moment these are done over a limited bandwidth of ~50 MHz, but already the number of beams is almost twice that available for the MkI-equipped BETA array. This is just an appetiser for the exciting data to come throughout 2016! ☉

Reports from recent meetings

"Annual PHISCC meeting"

(Rutgers University, US, 16-18 March 2015)

This was a very-well attended PHISCC meeting (over 80 registered participants) with strong representation from the US community, including members of the ALFALFA and CHILES consortia, and simulators. Andrew Baker was chief organiser. There was a strong and focussed science program designed around a number of key science questions. Talks from Wallaby members talking about science results from ASKAP and (mostly) other telescopes was strong, and included Kristine Spekkens, Karen Lee-Waddell, Tobias Westmeier, Megan Johnson, Jonghwan Rhee, Paolo Serra, Se-Heon Oh and Bi-Qing For. Talks are available at: http://phiscc.rutgers.edu/program.html

"Frontiers in Radio Astronomy and FAST Early Sciences Symposium"

(Guiyang, China, 29-31 July 2015)

This symposium was organised by FAST Project Scientist Di Li (NAOC), and touched on many science themes that the telescope will touch, including Milky Way and Extragalactic HI astronomy. Progress towards completion in 2016 is good, although initial operations will be limited to drift scans at low frequencies. Some discussion was held about the possibility of FAST undertaking a shallow HI drift scan survey of the northern sky. Such a survey may be very useful if Wallaby and/or its northern counterpart WNSHS is required to decrease sky coverage as a result of system performance or time allocation issues.

"The SKA Key Science Workshop"

(Stockholm, Sweden, 25-27 August 2015)

This SKA workshop was invitation-only, but nevertheless had well over 100 attendees. Stockholm put on an amazing display of excellent weather for the attendees who discussed the wide range of SKA science topics.

Of particular interest for Wallaby members were the discussions held by the HI Science Working Group, now chaired by Erwin De Blok and Martin Meyer. A revised 'wedding-cake' of HI key projects was presented to attendees, and a serious discussion of commensal surveys with other working groups was begun. Slides from the workshop are available at https://indico.skatelescope.org/event/342/page/4, including the final HI SWG presentation given by Erwin De Blok which is available at: http://astronomers.skatelescope.org/wp-content/uploads/2015/08/DAY4_08_HI.pdf.

Perhaps one of the most interesting outcomes from a WALLABY perspective was the possible re-emergence of a large (10k hrs) all-sky SKA1-mid survey. Several SWGs had such a survey on their wish-list, despite the demise of the SKA1-survey telescope. Whereas an all-sky survey of 1-2k hrs would be too shallow to be much of an advance on WALLABY, a larger commensal survey even with SKA1-mid would be interest for HI cosmology.

"SKA in Seoul: Asia-Pacific Regional Workshop on HI Science"

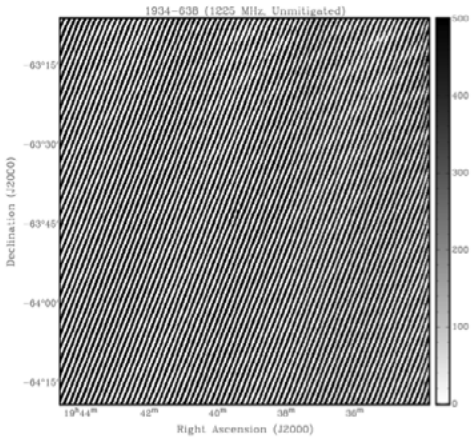
(Seoul, Korea, 2-4 November 2015)

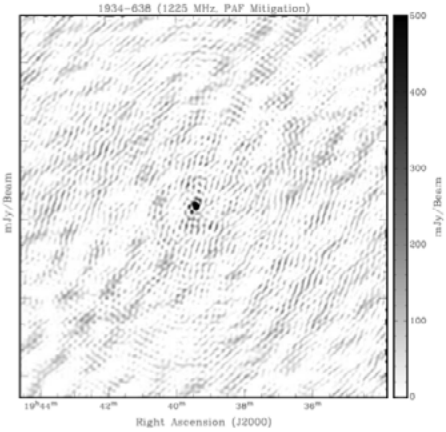
This meeting was co-chaired by Aeree Chung (Yonsei) and Se-Heon Oh (ICRAR) to highlight HI science and to showcase the potential of the SKA to make dramatic discoveries in the field. There were around 60 attendees including a large number from Australia and, courtesy of a CHILES busy week, a large number of US, Dutch, Korean and Australian members of the CHILES consortium. The potential of the not-yet-complete CHILES survey to detect distant galaxies was realised when Ximena Fernandez showed an image of a z=0.37 direct detection, and Attila Popping showed a stack of galaxies from the wall of galaxies at a similar redshift. ☉

RFI Mitigation

Keith Bannister

The phased array feeds (PAFs) on the Boolardy Engineering Test Array (BETA; Hotan et al. 2014) afford a unique capability of removing interference. In a recent experiment, we observed the well-known calibrator source, PKS B1934-63 with BETA at 1225 MHz, a frequency that is well known to be plagued by interference from GPS satellites. We trialed a number of different mitigation techniques, known as 'projection' algorithms. Projection algorithms work by finding the source of the interference and steering a 'null' in the antenna pattern towards the interfering satellite, while leaving the rest of the pattern intact. Such a procedure is only possible because of the flexible beamforming made possible by a focal plane array. In our case, we updated the beamforming weights every 8 seconds.





The projection algorithms performed extremely well, as shown in the two figures to the bottom left. The unmitigated data (beam0; left) would have been useless for astronomy, while the mitigated data (beam3; right) showed our friend PKS B1934-638 exactly where it should be, and surrounded by quite low levels of noise and artifacts. The mitigated data still outperformed the unmitigated data after we had applied the traditional flagging techniques used for standard radio telescopes. Thanks to such encouraging results, we'll be trying these techniques with ASKAP as it grows, and see how well we can get it to work. ☉

TWG 4 – Source Finding and Cataloguing

Tobias Westmeier on behalf of TWG 4

Work in TWG 4 has mainly been focusing on expanding and improving SoFiA, the HI source finding pipeline. An overview of the design and functionality of the pipeline is given in the official SoFiA paper which was accepted for publication in MNRAS earlier this year:

Serra, P., Westmeier, T., Giese, N., et al., 2015, MNRAS, 448, 1922

We also had the opportunity to showcase SoFiA during a half-hour presentation at the 2015 PHISCC workshop at Rutgers University in March. In addition, Nadine Giese and Bärbel Koribalski presented a SoFiA poster at the Annual Meeting of the Astronomische Gesellschaft in Kiel, Germany, and at the ADASS XXV conference in Sydney, Australia, respectively.

Following a short, two-day "busy week" at Rutgers University after the PHISCC meeting, we released SoFiA 0.5 in September this year. This latest stable release comes with several improvements in terms of speed and robustness of some of the algorithms as well as usability of the graphical user interface. SoFiA can be downloaded from the official SoFiA web page on GitHub (https://github.com/SoFiA-Admin/SoFiA/). We also created a SoFiA tutorial to introduce

new users to the software and give several examples of how to run SoFiA on an HI data cube. The tutorial is available online at https://github.com/SoFiA-Admin/SoFiA/wiki/SoFiA-Tutorial.

Another addition to SoFiA is our new mailing list through which we intend to disseminate information about new stable releases of SoFiA and other important updates. To sign up to the mailing list, simply send an e-mail to sofia-request@atnf.csiro.au with the word "subscribe" in the e-mail body (note that the e-mail subject will be ignored).

One of the major items on our agenda for the next few months is the issue of parallel processing of data in preparation for the anticipated start of WALLABY early-science observations next year. The two most pressing problems to be tackled include speed-up of SoFiA through parallelisation of time-critical algorithms as well as the requirement to split large data cubes into manageable chunks that will fit into the memory available on a particular node.

Some of these outstanding problems will be addressed at the next SoFiA busy week currently scheduled to take place in Perth during the week of 8–12 February 2016, which is the week before the WALLABY Early Science workshop at ICRAR/UWA. As part of an ongoing collaboration with Sarah Blyth and Michelle Kuttel from the University of Cape Town, one of their students, Jarred de Beer, is already looking into parallelisation of the Smooth+Clip finder module in SoFiA.

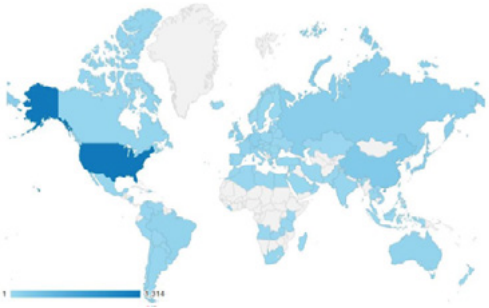
SoFiA info and download:

http://www.atnf.csiro.au/people/Tobias.Westmeier/tools_software_sofia.php

https://github.com/SoFiA-Admin/SoFiA/ ⊙

Busy Function download stats

Russell Jurek



The Busy Function (Westmeier, Jurek, et al. 2013) was created to parameterise HI sources as a function of frequency. It is unique in that it can smoothly transition from a top hat profile to a Gaussian, and then a double horn profile, while accommodating for asymmetry. In addition to the Busy Function itself, we published free Python and C/C++ libraries that allow users to fit the Busy Function. Crucial to the performance of this software was the creation of Jurek's extension of the LVM algorithm, which is known as LVM-J. This software will have been available for two years this December via google code and now github. In that time over 3,100 individuals have visited these sites. There are users from every continent and most countries in the world, with the top 10 countries being: US, China, Russia, Japan, Germany, UK, Netherlands, Australia, Brazil and South Korea. These users aren't all astronomers located at universities like Yale, MIT, Oxford and UCT. Many of the users are from completely different fields. These organisations are very varied and include: US Department of Defense, US Army Information Systems Command, Apple, Hewlett-Packard, GE, Ford Motor Company, Halliburton, Xerox and the Bank of America. The Busy Function, and our software, is proving tremendously popular and useful. I expect the next version, which both fits a slightly `busier' Busy Function as well as multiple Busy Functions simultaneously, will be even more so. ⊙

WALLABY

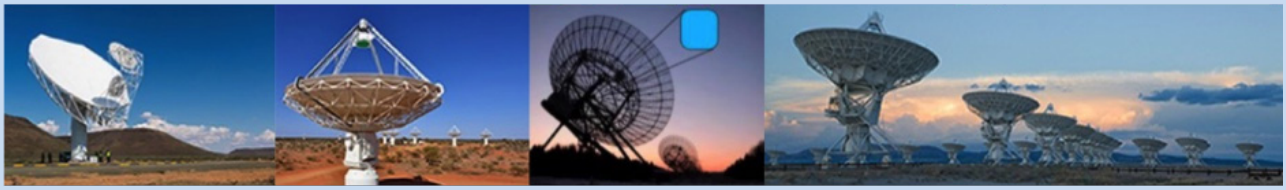
Congratulation to the ASKAP team, winner of the 2015 CSIRO Chairman's Medal.

Congratulations to the entire ASKAP team on winning CSIRO's most prestigious award, the 2015 Chairman's Medal, for "*revolutionising astronomy by developing a spectacular new capability for observing wide areas of the sky using the world's first wide-field imaging receivers for radio astronomy on the antennas of the ASKAP radio telescope*".

Upcoming Meetings

Capetown, 3 - 5 Feb 2016: 9th International PHISCC Workshop – Upgrading our tool kit

In February 2016, commissioning of the first several antennas of MeerKAT, ASKAP and APERTIF will be well advanced. Meanwhile results from the deep HI survey, CHILES, on the JVLA are coming out. For PHISCC 2016 we aim to bring together the people designing specific tools for the upcoming large HI surveys with the astronomers that are going to use them. It is crucial that the two groups are well represented. The discussion will be as much on the tools already developed as on the ones that still need to be developed. Since 2009, the SKA Pathfinders HI Science Coordination Committee (PHISCC) has been holding regular science meetings to share information about planning for these surveys and their common needs.



Perth, 10 - 12 Feb 2016: Source-finding busy week

Following the tradition of successful busy weeks associated with science meetings, there will also be one in Perth in the week before the WALLABY Early Science workshop, organised by Tobias Westmeier & Paolo Serra.

Perth, 15 - 19 Feb 2016: WALLABY Early Science workshop

Around 30 people will be attending this workshop, consisting of ~25 talks and several hand-on sessions over five days. Our aim is select suitable early science fields, get science teams organised while also learning about the ASKAP calibration procedure and other valuable analysis tools (SoFiA, FAT, etc). All preparations for the workshop are happening on our wiki, where ~10 fields have already been proposed. Juan Madrid is making finding charts for each field, which will be displayed during the workshop.

Sydney, 6 - 10 June 2016: ASKAP 2016: The Future of Radio Astronomy Surveys

This conference will focus on early science results and technical learnings from ASKAP and APERTIF, particularly in relation to the unique capabilities of PAFs.

Sydney, 13 - 15 June 2016: ASKAP calibration meeting

On June 14–16, 2016, following the meeting "ASKAP 2016: The Future of Radio Astronomy Surveys", CASS will host a workshop aimed at discussing progress in our understanding of phased array feeds. The workshop aims at bringing together international experts in the field, including the teams currently commissioning PAFs on ASKAP and APERTIF. The workshop will take place at a time when both teams will have made substantial experience with their respective telescope. We expect much of the focus to be on beam forming and calibration techniques.

Further updates can be seen/posted at:

http://www.atnf.csiro.au/research/WALLABY/meetings.html

WALLABY Publications

2015 articles which mention WALLABY (according to ADS Bumblebee)

Acosta-Pulido, J. A., Agudo, I., Alberdi, A., Alcolea, J., Alfaro, E. J., Alonso-Herrero, A., Anglada, G., Arnalte-Mur, P., Ascasibar, Y., Ascaso, B., and 109 colleagues (2015) 'The Spanish Square Kilometre Array White Book' , arXiv, arXiv:1506.03474

Bland-Hawthorn, J. (2015) 'The Hector Survey: integral field spectroscopy of 100,000 galaxies' , IAUS, 309, 21

Blyth, S., van der Hulst, T. M., Verheijen, M. A. W., Catinella, B., Fraternali, F., Haynes, M. P., Hess, K. M., Koribalski, B., Lagos, C., Meyer, M., and 5 colleagues (2015) 'Exploring Neutral Hydrogen and Galaxy Evolution with the SKA' , aska.conf, 128

Bundy, K., Bershady, M. A., Law, D. R., Yan, R., Drory, N., MacDonald, N., Wake, D. A., Cherinka, B., Sánchez-Gallego, J. R., Weijmans, A.-M., and 58 colleagues (2015) 'Overview of the SDSS-IV MaNGA Survey: Mapping nearby Galaxies at Apache Point Observatory' , ApJ, 798, 7

Carrick, J., Turnbull, S. J., Lavaux, G., Hudson, M. J. (2015) 'Cosmological parameters from the comparison of peculiar velocities with predictions from the 2M++ density field' , MNRAS, 450, 317

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