POSSUM Newsletter 3

October 2012

From the PIs

The last couple of months have seen some important changes in personnel within POSSUM:

- Ilana Feain has stepped down as ASKAP Project Scientist. We are very grateful to Ilana for all the time, patience and guidance she has provided to POSSUM and to the other ASKAP surveys, and are very pleased that she will remain a key member of the POSSUM team.

- Lisa Harvey-Smith has now commenced as ASKAP Project Scientist. This means Lisa will have to reduce the amount of time she has to work on POSSUM, but we look forward to working with her on ASKAP and POSSUM and to her ongoing involvement in our activities on ASKAP polarisation.

- We welcome Cormac Purcell as the new chair of POSSUM WG5 (data format and access), replacing Lisa. We extend POSSUM's deep thanks to Lisa for her leading WG5 for the last few years.

- Shane O'Sullivan (see profile in POSSUM Newsletter #2) has commenced as a Super Science Fellow at The University of Sydney working on POSSUM. Shane will continue his work for POSSUM on ionospheric calibration, and will also pursue relevant science projects on wide-field polarimetry.

- Jamie Farnes has commenced as a postdoctoral researcher at The University of Sydney. Jamie's main focus initially will be data quality assessment for GALFACTS, but there will be many common issues with POSSUM and he will be working closely with the rest of the POSSUM team.

- Takuya Akahori has commenced as a Fellow of Japan Society for the Promotion of Science (JSPS), and will be a visiting scholar at the University of Sydney for the next two years. Takuya will work on simulations of magnetic fields and polarisation in the Milky Way and in the intergalactic medium.

- Joanne Daniels, the executive assistant to the POSSUM project, has left The University of Sydney and we wish her well in her future endeavours. The new executive assistant to POSSUM, Michelle Sullivan, will commence on 29th October 2012.

An important new activity being conducted within POSSUM is the RM Synthesis Data Challenge, which is being coordinated by Larry Rudnick. A series of simulated polarisation data sets have been distributed to several teams, who are now applying their algorithms for RM synthesis and RM deconvolution and will report back their results. The results of this challenge will be used to decide which algorithms to adopt as part of the POSSUM pipeline.

In August 2012, we held a POSSUM meeting in Beijing during the IAU General Assembly. Sixteen attendees discussed several key issues in detail, including coordination between POSSUM and EMU, the status of the POSSUM pipeline and the POSSUM science case, and the addition of single-dish data to ASKAP observations. Slides and notes from this meeting are at:
http://askap.org/possum/Meetings/BeijingIAU .

CSIRO has informed us that there will be no internal review of the ASKAP survey projects this year. The next internal review of POSSUM is expected to take place in April 2013.

We will convene a face-to-face POSSUM meeting over 20-24 May 2013 in Penticton, Canada, adjoining an EMU meeting and a GALFACTS meeting. Details will be circulated soon.

In this newsletter you can read updates on the POSSUM science cases and on the RM synthesis data challenge, and learn about a new catalog of RM and redshifts for extragalactic radio sources. We also profile POSSUM PhD student Niloofar Gheissari.

Bryan Gaensler, Tom Landecker and Russ Taylor

POSSUM Activities

Updates on POSSUM science cases

Xiaohui Sun according to George Heald's talk

Are the four main scientific cases in the original POSSUM proposal still relevant? Do we need to upgrade them? George Heald and Jeroen Stil are working on POSSUM Report #18 to answer these questions. Some initial thoughts from George that he reported at the POSSUM Beijing Meeting are summarised below.

- *The Galactic large-scale magnetic field.* Many studies have been made using the RM catalogue by Taylor et al. (2009) and other databases.

POSSUM will produce a much denser RM grid (about 100/deg^2) than the Taylor et al. catalogue (about 1/deg^2). This, however, will probably not help improve our current understanding of the large-scale magnetic field.

- *Local structures.* We can search for correlations between the dense POSSUM RM grid and small-scale structures in the Galaxy to study magnetic fields in local structures, e.g. comparing RM data with the all-sky Hα map of Finkbeiner (2003).
- *Extended sources.* According to Stepanov et al. (2008), to reconstruct an external galaxy's magnetic field with background sources needs at least 20-30 RMs per galaxy. This limits the applicability of the POSSUM grid to galaxies with angular size larger than about 20′.
- *Variance stacking.* RMs as a function of impact parameter (e.g. Clarke et al. 2001) are a powerful tool to recover the average scale of magnetic fields in galaxies or clusters even in the absence of sufficient RM density for individual sources.
- *Source counts.* Source counts can be extended to polarised flux densities as faint as tens of μJy.
- *Diffuse emission in galaxies.* WSRT-SINGS has already shown that an rms level of about 10-15 μJy/beam is sufficient for the detection of diffuse emission in spirals. But how the image is made is crucial to recovery of faint diffuse structures. Comparison of HI structures from WALLABY with RM variations can give new leverage on the physics of the magnetised interstellar medium.
- *Complicated Faraday dispersion spectra.* These spectra might indicate multiple components or turbulent magnetic fields in sources. For full reconstruction, commensal with FLASH is essential.
- *IGM magnetic field.* Low measurements errors of order 1 rad m^{-2} will be required to make a statistical detection.

Update on RM synthesis data challenge

Xiaohui Sun

The goal of the RM synthesis data challenge is to produce a suite of tests for any proposed Faraday decomposition method, a definition of figures of merit, and figures of merit for each method. To achieve this goal, we have planned four steps:

- Identify participants;
- Reach consensus on the initial test suite;
- Run blind tests and report results;
- Make recommendations.

A group page called "Benchmarks for Faraday decomposition" has been built under the RM Synthesis Group at CyberSKA. To access the page, one needs to register in CyberSKA by following the link http://www.cyberska.org.

There are currently 13 participants covering nearly all available methods such as: Heald-style RM clean (AIPS, Miriad and python versions), modified RM clean for LOFAR and GMIMS, QU fitting, compressive sampling, sparse RM synthesis, 3D Faraday synthesis and wavelet-based RM synthesis. We encourage more people who are interested in RM synthesis to join. The first set of test data containing 17 scenarios all with signal to noise ratio of about 31.6 produced by Larry Rudnick have been put to the group page for downloading.

We have received results from 10 participants. One interesting fact we can already see is that even wrong results yield very low χ^2. We are currently working on how to grade these results.

A new catalog of Faraday rotation measures and redshifts for extragalactic radio sources

Alison Hammond, Tim Robishaw, Bryan Gaensler

We present a catalog of Faraday RMs and redshifts for 4003 extragalactic radio sources, derived by identifying optical counterparts and spectroscopic redshifts for linearly polarised radio sources from NVSS.

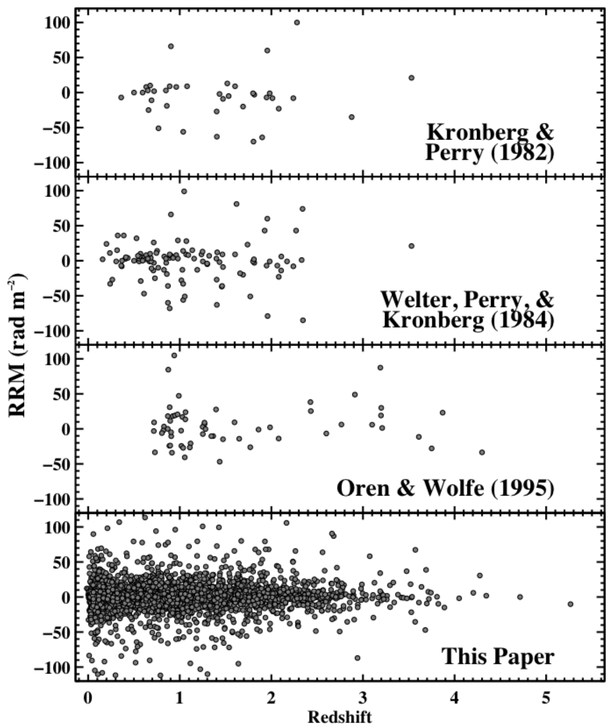

Figure 1: A comparison of the new RRM-redshift catalog (bottom panel) with previously published data sets.

This catalog is more than an order of magnitude larger than any previous sample of RM vs. redshift (Figure 1), and covers the redshift range $0<z<5.3$; there are more than 1500 sources at redshifts $z>1$. For 3650 of these sources at Galactic latitudes $|b|>20°$, we have corrected for the foreground Faraday rotation of the Milky Way, resulting in an estimate of the residual rotation measure (RRM).

We find no significant evolution of RRM with redshift (Figure 2), but observe a strong anti-correlation between RRM and fractional polarisation that we argue is the result of beam depolarisation from small-scale fluctuation in the foreground magnetic field or electron density.

In future, POSSUM will provide a much denser RM grid, with each RM determined far more robustly than from the two frequency channels of NVSS data used here, so that the foreground contribution can be accurately accounted for to identify subtle trends of polarisation properties with redshifts.

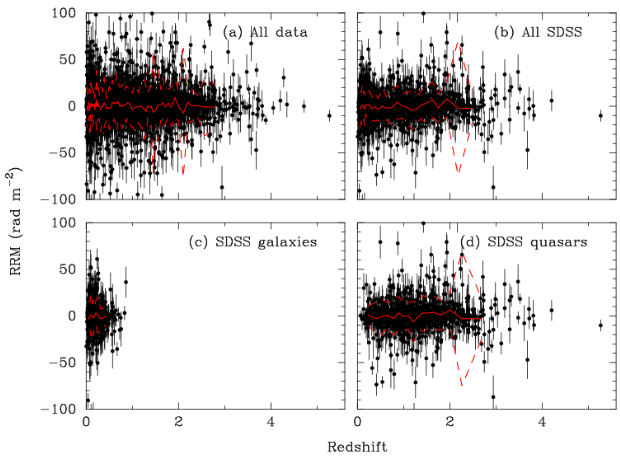

Figure 2: RRM vs. redshift. In each panel, individual data points are shown in black, while the mean RM and ±1σ values of RRM on either side of this mean are shown by the solid red line and dashed red lines, respectively.

Hammond et al. 2012, ApJS submitted (arXiv: 1209.1438)

Profile – Niloofar Gheissari

Niloofar is currently a PhD student at the University of Sydney. She received her first PhD degree in computer vision from Swinburne University in 2004. She then worked as a researcher and lecturer for a number years in Australia, England and Iran. Now she is pursuing her second PhD on radio astronomy.

What is computer vision? What have you been doing on that?

Computer vision gives computers the ability to see. It benefits from algorithms, graph theory, optimisation, image processing, statistics and machine learning. My favourite topic is analysing motion that is the black sheep of computer vision like magnetism and turbulence in radio astronomy.

Why do you want to work on radio astronomy?

I had no idea about radio astronomy, except that it exists! After I visited Bryan at ATNF I started to search about it and then I applied for the PhD scholarship. I enjoy learning about it.

What excites you about POSSUM?

Its significance, its technical and scientific contribution to our understanding of the universe. But mostly its cool name.

What projects are you working on? What are the main challenges?

Characterising turbulence in interstellar medium. Having no background in astronomy, every single thing is a challenge. Thinking of statistical and morphological features that are stable and robust enough to be used in a wide range of surveys, is the current problem I am trying to solve.

What do you enjoy outside work?

I like reading about poetry history, mythology, Persian rugs and literature. I have a teddy bear that will not sleep unless I tell him a story about his adventures.

Other Related Science Results

Magnetic field transport from disk to halo via the galactic chimney process in NGC 6946

George Heald

The connection of magnetic fields to the gaseous medium and its evolution remains poorly understood. We present the detection of an RM gradient, co-located with an HI hole in the disk of nearby spiral galaxy NGC 6946 (Figure 3). The gas kinematics in the same location show evidence for infall of cold gas.

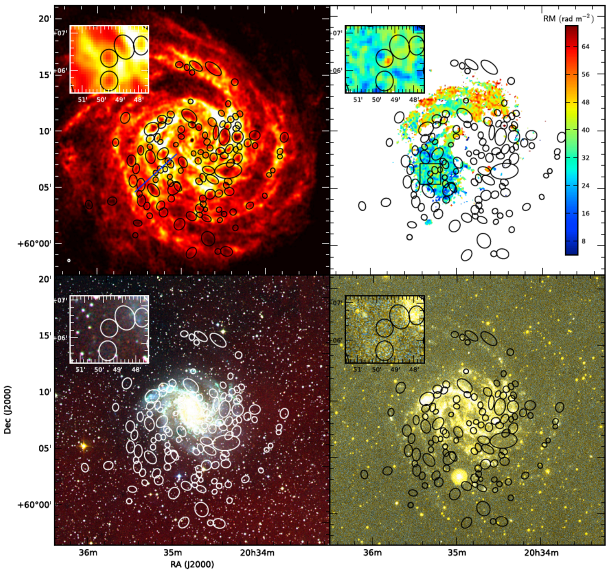

Figure 3: Images of NGC 6946: HI (upper left), RM (upper right), optical (lower left) and FUV-NUV (lower right).

This co-location indicates a substantial vertical displacement of the initially plane-parallel-ordered magnetic field, driven by a localised star formation event. The large-scale magnetic field pattern in galaxy disks is directly influenced by internal energetic phenomena. Conversely, magnetic fields play an important role in disk-halo interactions.

Heald 2012, ApJ, 754, L35

Polarisation properties of Milky-Way-like galaxies

Xiaohui Sun, Wolfgang Reich

We simulate synchrotron emission and RMs from the Milky Way Galaxy seen from outside at various inclinations (Figure 4). We analysed the simulated maps with techniques frequently used to obtain magnetic field strength and RMs from observations of resolved nearby galaxies and compared the results with the model parameters. We found that the average magnetic field strength is overestimated by a factor of about 2 when assuming energy equipartition. For edge-on galaxies, the RMs calculated from observations at 4.8 GHz and 8.4 GHz are indicative of the orientation of the large-scale magnetic field, but are no longer half of the Faraday depths indicating that edge-on galaxies cannot be seen through at these two high frequencies.

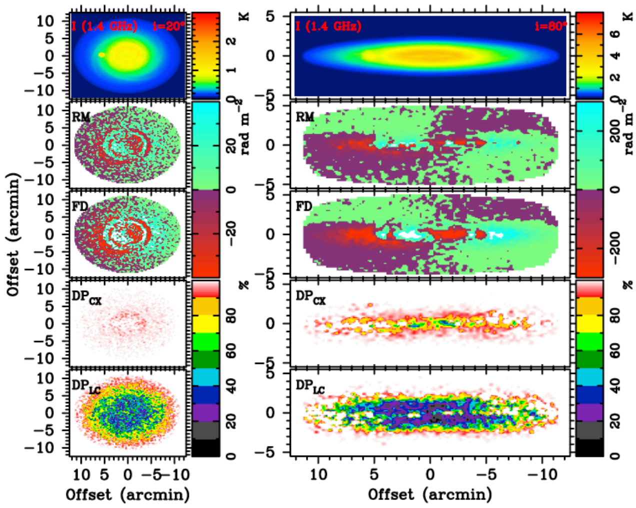

Figure 4: Images of the Milky-Way seen face-on and edge-on. From top to bottom: total intensity at 1.4 GHz, RM calculated from polarisation angles at 4.8 GHz and 8.4 GHz, Faraday depth, depolarisation between 4.8 GHz and 8.4 GHz, and depolarisation between 1.4 GHz and 4.8 GHz.

We also studied the statistical polarization properties of a large sample of unresolved Milky-Way-like galaxies that will be observed by future telescopes such as ASKAP.

Sun & Reich, 2012, A&A, 543, A127

Upcoming meetings

Magnetic Fields in the Universe IV: From Laboratory and Stars to the Primordial Universe

Playa del Carmen, Mexico, Feburary 4-8, 2013

http://metropolis.nucleares.unam.mx/mfu4

POSSUM/EMU/GALFACTS meeting

Penticton, Canada, May 20-24, 2013

Magnetic Fields throughout stellar evolution

Biarritz, France, August 26-30, 2013

http://iaus302.sciencesconf.org