S-PASS & Future Prospects



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Outline

- Radio polarisation surveys
- Why S-PASS at 2.3 GHz?
- S-PASS: project and results.
- Future prospects



Radio unpolarised emission – total magnetic field



Polarised radio emission







Jodrell-Bank 250-feet + Effelsberg 100-m + Parkes 64-m

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Why 2.3 GHz? Low frequency: obscured polarised emission



- Signal mostly obscured at low frequency
- Signal gradually reappears at high frequency





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S-PASS: S-band Polarization All Sky Survey

- To survey the polarized emission of the entire southern sky at 2.3 GHz
 - Dec < 0°;</p>
 - PARKES (64m): 2.3 GHz ;
 - 224 MHz BW (100+ ch);
 - 8 MHz channels
 - (0.5 MHz originallly)
 - FWHM = 8.9';
 - σ_{beam} < 0.9 mK;
 - ~2000 h
 - 175 nights in 2.5 yrs (!)



- Started Oct 07, completed in January 2010, survey paper submitted
- Goals:

synchrotron emission, Galactic magnetic field, CMB foregrounds.

Mapping: long AZ scans

small area basket weaving: not an option for S-PASS

- ground emission contamination (EL dependant)
- high speed requires significant overhead for short scans (10°-20°)
- short scans: mean emission on area scale is lost

- non-standard scanning strategy has been developed for S-PASS
 - AZ scans
 - Long AZ scans at South Pole EL to cover all Dec each scan (~115°)
 - Sky rotation to observe all RA 24 hrs.
 - Each night a zig-zag track is observed in the sky
 - one zig-zag per night: accurate start timing is required







S-PASS and other data sets

S-PASS Q



1.4 GHz (DRAO + Villa Elisa)

SHASSA: H_{α} WMAP 22.8 GHz



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Science Results



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Science Results

- S-PASS science is diverse
- Milky Way, galaxy clusters, cosmic web, CMB
 - Galactic Magnetic field
 - Fermi Bubbles and Galactic structure
 - ISM turbulence
 - ISM clouds, cavities, and supershells (e.g. Gum Nebula)
 - ICM of galaxy clusters
 - Extragalactic source properties
 - Synchrotron Cosmic Web
 - RM catalogue
 - CMB foregrounds
 -

Science Results

- **16 papers,** to date (and counting)
- A selection



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6. S-PASS and Synch Cosmic Web

• Search for Synchrotron Cosmic Web

Brown et al., 2017, MNRAS, 468, 4246

- from Cosmic Web filaments (B field and CRs)
- S-PASS ideal: S-PASS beam matches well filament cross-section
- Statistical search: cross-correlation S-PASS and cosmic web tracers (simulation reproducing the real cosmic web)
- New deep upper limit: Synch emission <0.04 μ Jy/arcsec² (3 σ)
 - B < 30 nG (3 σ) => primordial MF < 1 nG



7. S-PASS bright polarisation sources catalogue

Lame'e et al., 2016, ApJ, 829, 5

- Polarisation properties of compact Extragalactic sources
- Bright sample of 533 sources with
 - Stokes I > 420 mJy
 - Dec > -40°
 - Counterpart at 1.4 GHz (NVSS)
- Depolarisation(D) between 1.4 and 2.3 GHz
- Correlation with a number of properties (L, z, pol frac, RM, ...)
- Major outcomes:
 - Flat spectrum sources are neither depolarised nor repolarised (on average)
 - Depolarisation depends on the source env, not on the Galactic screen
 - First (weak) evidence of z-evolution of D => magnetic field evolution with z

10. S-PASS and CMB foregrounds

Synchrotron component

Krachmalnicoff et al., 2018, A&A

Several sky cuts (|b| > 20 deg => |b| > 50 deg)

SEE NICOLETTA's TALK



13. S-PASS Compact Source RM Catalogue

- Polarisation compact source catalogue (Dec < 0°)
- Sample of ~5000 pol sources identified in S-PASS maps
- Follow-up with ATCA, 1.1-3.1 GHz, broad band
- Filled the Southern Hemisphere gap of Taylor et al. (2009)
- Large Scale magnetic field modelling, EGS magnetic field analysis, ...



Schnitzeler et al., 2019, MNRAS, arXiv:1902.09556



14. S-PASS survey description paper

Carretti et al., 2019, MNRAS, submitted

- Survey description:
 - observations, calibrations, scanning strategy description
 - Maps. DR1 with all channels binned together
 - Q, U cube subject of DR2 at a later stage



N.B.: S-PASS follows the IAU convention on Polarisation Angle

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Work in progress

15. Advance diagnostic to study linearly pol em

Herron et al., 2018, ApJ, 855, 29

Robitaille et al., 2018, A&A, 617, 101

16. New Local ISM cavity with outflows into the halo

17. Large radio loops

18. New SNRs

19. ζ Oph region

20. Combination GMIMS-S-PASS (RM-synthesis (Faraday Tomography) on 300-2400 MHz)

21. And counting...



Future Prospects



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Future Prospects (1)

- S-PASS Faraday spectrum with internal S-PASS Q, U spectral cube
- Combination S-PASS GMIMS data:
 - Frequency range 0.3-2.4 GHz
 - Faraday spectrum cube (signal distribution in the RM space)
 - Galactic Faraday tomography, to study and characterise the ISM and its features.
 - RM map.
- In progress



Future Prospects (1)

- To efficiently clean CMB from foregrounds we will need to map the sky as much as possible up to 15-20 GHz and combine all data.
- S-PASS + C-BASS (+WMAP? +Planck? Low S/N)
- RM map of diffuse emission => PA angle correction to extrapolate to CMB frequencies. It might still need higher freq map to have the lambda=0 angle right.
- Frequency spectrum extrapolation:
- S-PASS + C-BASS ok, but likely another survey at higher frequencies needed to capture the slope steepening because of electron aging.



Future Prospects (2) S-PASS North

- Sardinia Radio Telescope (SRT)
- Nearly a Parkes twin: 64-m dish, latitude = + 39°
- S-band array (7-beam) under development 3.0-4.5 GHz (see Alessandro's talk)
- Considering a lower signal at 3 GHz (0.45x)
- Finer beam (7' => 0.75x)
- 7 beams
- => same S/N in ~2000h (same observing time)
- Larger BW can help => but lower signal at higher freq. Trade-off.





Future Prospects (3) C-Band Cryo-PAF at SRT

- Identified as one of the highest priority developments for SRT (review of Italian telescope receivers)
 - 3-8 GHz,
 - cryogenic,
 - 50+ formed beams dual pol;
 - Learning ground for higher frequency PAFs (20 GHz, 100 GHz)
 - Several science goals. For this audience:
- Fast C-band continuum/polarisation surveys, especially in the GP: improve res 60' => 2.5'. Essential to beat depolarisation on the Galactic plane.
- 2. CMB foregrounds at 5 GHz at res of at least 10'.
- 3.

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Take home messages

- S-PASS: absolutely calibrated polarisation maps.
- Polarised signal detected down the Galactic disc
- **Diverse science**: Galactic, Extragalactic, galaxy clusters, cosmology
- Analysis for CMB B-Mode foregrounds (See Nicoletta's talk)

• Future prospects:

- Combination with other surveys
- At higher and lower freqs
- S-PASS NORTH => SRT
- SRT C-Band PAF

THANK YOU!



