The SuperCLASS Radio Weak Lensing Survey

Ian Harrison @itrharrison
on behalf of the SuperCLASS collaboration (~30 people)

53rd Rencontres de Moriond
La Thuile
21 March 2018
The SuperCLuster Assisted Shear Survey
Radio Weak Lensing Survey

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Radio Weak Lensing Timeline

Stage IV
- Euclid
- LSST
- SKA2

Stage III
- DES
- KiDS
- HSC
- SKA1
- WFIRST-AFTA
- CFHTLens

Stage II
- FIRST
- COMBO-17
- HST-COSMOS
- (V-DECS)
- (e-MERLIN+)

Stage I
- SuperCLASS
- VLA-COSMOS-3GHz

Stage 0
- HDF-N

Year
- 2000
- 2010
- 2020
- 2030
- 2040

Total Galaxies
- $10^9$
- $10^8$
- $10^7$
- $10^6$
- $10^5$
- $10^4$
- $10^3$
- $10^2$
SuperCLASS
The Survey

- Aiming for first solid detection of weak lensing signal in the radio waveband
- ~1 galaxy arcmin$^{-2}$ for shape measurement
  - Detected
  - Resolved
  - High redshift
- ~1 deg$^2$

Full survey forecast from N-body simulations
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The Survey

• Radio shear:
  – e-MERLIN (1.4 GHz)
  – JVLA (1.5 GHz)

• Optical shear, photo-zs:
  – Subaru (BVRIz)
  – CFHT (near-IR)

• Source classification, RM-synthesis:
  – GMRT (325 MHz)
  – LOFAR (150 MHz)

• Source classification:
  – Spitzer (3.6, 4.5 um)
  – SCUBA-2 (submm)
  – AMI (15 GHz)
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The Survey

- Currently have
  - e-MERLIN
    (Northern half only)
    - ~95% taken
    - 50% reduced
  - JVLA
    - 100% taken
    - 100% reduced

- DR1 in April 2018
  - ~0.26 deg$^2$ to ~7 uJy
  - Survey description paper
  - Radio x Optical lensing paper – detection possible
  - Radio-only lensing paper – detection unlikely!
SuperCLASS
Scales of Interest

e-MERLIN
UK Midlands

JVLA
New Mexico desert

Real space telescope positions

People’s heads here.
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Scales of Interest

e-MERLIN
UK Midlands

JVLA
New Mexico desert
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Scales of Interest

- Combination of e-MERLIN and JVLA baselines gives access to relevant spatial scales

- Ideally, would combine data in Fourier space, then image
  - This is hard due to real world foibles with the data

![Image of graph showing 1.4 GHz Angular size in arcsec vs. log10 Baseline length in meters with Shear Signal, JVLA, and e-MERLIN data]
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Scales of Interest

e-MERLIN

Real space PSFs

JVLA
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Scales of Interest

e-MERLIN

JVLA

Real space PSFs
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Scales of Interest

Real space PSFs

e-MERLIN vs. JVLA
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Scales of Interest

e-MERLIN

JVLA

Fourier plane coverage
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Scales of Interest

e-MERLIN

JVLA

Fourier plane coverage

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SuperCLASS e-MERLIN Data

- 49 pointing mosaic to target sensitivity
  - ~400 hours of data
  - 2 years of effort by Bob Watson to reduce
  - Pushed the limits of wide-field imaging with e-MERLIN

- Source classification via Zooniverse visual inspection (AGN or SFG)

- Raw $n_{\text{gal}} \approx 0.2 \text{ arcmin}^{-2}$
- $n_{\text{gal}} \approx 0.1 \text{ arcmin}^{-2}$ for DR1 WL sample
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JVLA Data

• Mosaic of full field (1.75 deg$^2$) to target sensitivity
  – ~24 hours of data
• Raw $n_{\text{gal}} \sim 1$ arcmin$^{-2}$
  – JVLA sensitive to diffuse flux which is hard to detect in e-MERLIN
• $n_{\text{gal}} \sim 0.1$ arcmin$^{-2}$ for DR1 WL sample
  – Defined on e-MERLIN area
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Example Sources

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Optical Data

- High-quality optical BVri imaging (0.4” – 1.3” seeing) from Subaru Suprime-Cam

- E-mode power spectrum detected at 9.3σ
- Consistent with expected signal for supercluster region

B-mode power spectrum consistent with zero
• Developed full end-to-end pipeline for simulation of radio observations
  – Source populations
  – Sky model (galsim)
  – Full telescope+noise model in visibility plane
  – Imaging
  – Source finding

• Quantify shear biases in pipeline
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Constraints on Source Profiles

• Simulations of ‘smooth’ (Sersic) starforming galaxy source profiles do not match rea detection rates
  – Sources seem to contain more compact structure than expected
  – Desire: deep observations with very good UV coverage to learn about SFG source profiles
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Source Properties – e-MERLIN

Source size

Source flux

Source position angle

All sources

Resolved sources

Source ellipticity

(Preliminary)

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Source Properties – JVLA

(Preliminary)
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ToDo List for DR1

• Source catalogue pretty much ready
• Create radio shear catalogue
• Create radio-radio, radio-optical shear power spectra

SuperCLASS – I. The Super CLuster Assisted Shear Survey: Project overview and first data release

SuperCLASS – II. Radio shapes of weak lensing sources

SuperCLASS – III. Weak lensing from radio-optical cross-correlations
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Goals for DR2

• Fourier plane combination of data from both telescopes!
  – Will allow combined imaging, combined fitting
• Well motivated source models from deeper surveys
• Analysed using prototype SKA SDP pipeline
• Automated source classification
• Squeezing the $n_{\text{gal}}$ up towards 1 arcmin$^{-2}$
SuperCLASS Summary

- Observing $\sim 1 \text{ deg}^2$ supercluster region to detect weak lensing shear signal in radio data
- Combining e-MERLIN, JVLA to access relevant spatial scales
- Built simulation pipeline to quantify systematics
- First results imminent..!
- **Pathfinder** for excellent weak lensing cosmology constraints with SKA
  - SKA$x$Optical can beat WL systematics