Techniques and tools for weak lensing with the SKA

Michael ‘Jimmy’ Tarr
Collaborators:

- David Bacon - ICG Portsmouth
- Bob Nichol - ICG Portsmouth
- Wendy Williams - Hertfordshire
- Jose Sabater - IfA Edinburgh
- Ian Harrison - Manchester
Weak Lensing:

- Unbiased measure of matter distribution
- Decades of optical work (statistics) to build on
- SKA-1 weak lensing will be very competitive with DES
- Cross correlation will particularly powerful, see Pourtsidou talk
- Large scale mass maps will be extremely useful for many areas:
  - Galaxy bias
  - Identifying Large Scale Structures
  - Cosmological parameters
  - Modified gravity
Resolution and baselines:

- Need to preserve ellipticity information
- Requires scales up to several effective radii
- Also need small scales to well sample shape (sub-arcsecond at least)
- Large scales (short baselines) will be well covered by requirements of the ‘Pulsar Timing’ group
- Smallest scales will push the limits of SKA
- Maximum baselines (150Km) at 1GHz will provide a resolution 0.5’’; sensitivity trade-off
Images vs Visibilities

Images are non-unique models of the data, and include assumptions about the sources and correlated noise across pixels.

Images are good for:
- Well sampled data
- Simple morphologies (features much larger than the resolution)
- Accurate positions
- Reducing the number of parameters

Not so good for:
- High fidelity, unbiased shapes with well understood noise
- Features at the resolution limit
Fourier domain estimators

- Shapelets
  - Chang+ 2004, Patel+ 2010
- Bayesian Fourier Domain
  - Bernstein+ 2015, Rivi+ 2016
- FILM
  - Tarr+ 2016
FILM: Fourier Inspection of Lensing Modes

- A weak lensing ‘map’ estimator
- Infers a shear field for a ‘patch’ of visibilities
- Does not return individual ellipticities
- Difficult to remove some galaxy characteristics
- Less parameters to constrain
- Need to model a large amount of data
- Still requires some information from image plane i.e. positions

\[
4\pi^2 \sigma_g^2 \gamma_1 \langle \mathbf{u} \rangle_1 - 8\pi^2 \sigma_g^2 \gamma_2 \langle \mathbf{u} \rangle_2
\]
Results
Results
Simulations:

- Created my own simulations (right) based on Wilman+ 2008 (0.2’’ resolution)
- End to end simulations will be vital for everyone
- This is a big job, but whose?
- How can these help people develop bespoke tools and methods for SKA
- Would an open simulation interface be a good idea?
Summary requirements:

- Sensitivity: Flux limit of approx. 1µJy for cosmologically interesting depth
- Frequency: Less extended emission at high frequencies, but lower resolution at low frequencies
- Resolution: sub-arcsecond needed (0.2” would be great)
  - Except for intensity mapping (Pourtsidou)
- Gridded and calibrated visibilities
  - See lensing ECP request
- Bespoke algorithms
  - And tools to help them be developed