



Australia's National Science Agency

Polarimetry with BIGCAT

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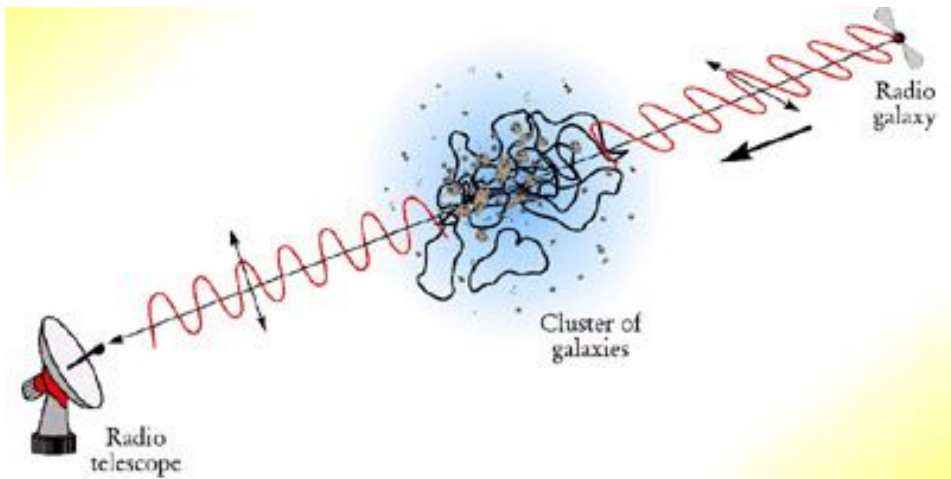
BIGCAT workshop

12 March 2021

Revealing cosmic magnetism

Broadband radio probes the origin & evolution of cosmic magnetism

- Radio polarimetry is an excellent tracer of magnetism
- Large samples of Faraday Rotation Measures (“RM Grids”) probe foreground magnetism and associated thermal material, and inform population studies



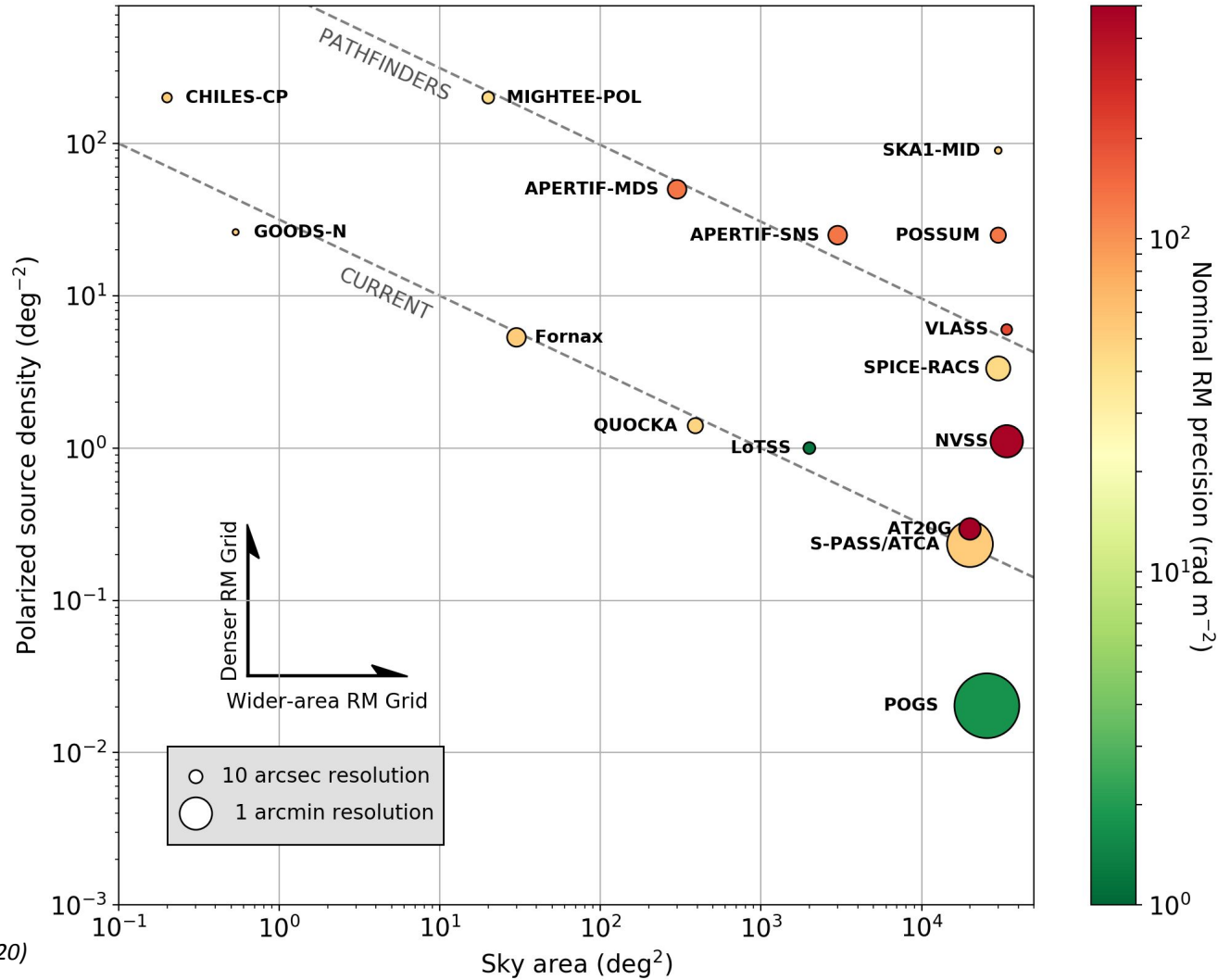
RM Grids - current and future

Current state of the art: NVSS @ 1.4 GHz, ~30,000 RMs

Upcoming in the future:

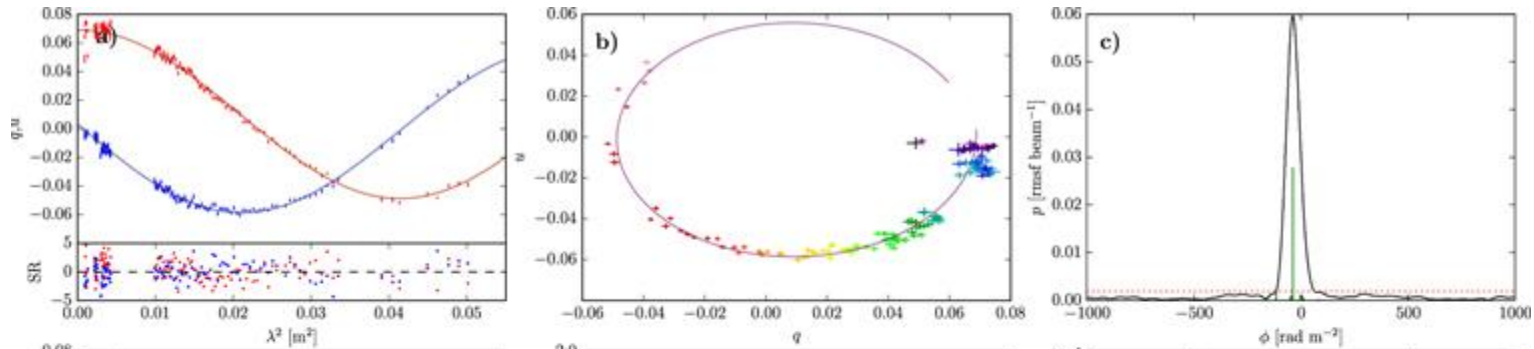
- Low frequency surveys with LOFAR and MWA -- ***precise RMs***
- Mid frequency surveys with VLA and ASKAP -- ***dense RM coverage***
- SKA survey(s) with SKA1-MID (and SKA1-LOW?) -- ***paradigm shift***

ATCA (with BIGCAT) plays an important role in this evolution



A “simple” polarized source ...

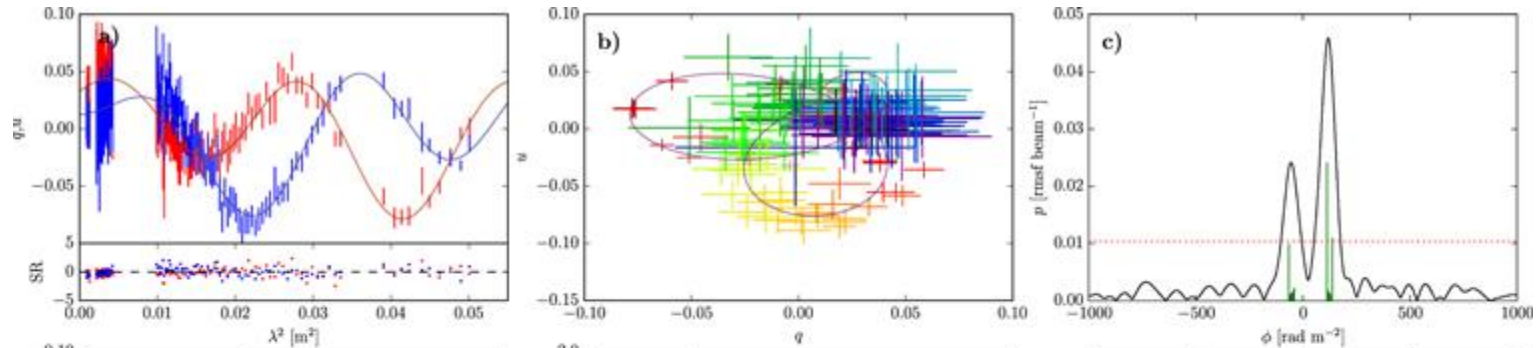
... shows sinusoidal variation in $Q, U(\lambda^2)$ and a single Faraday peak



Anderson et al (2016)
ATCA, 1.3-10 GHz, 36 sources

A “complex” polarized source ...

... shows complicated variation in $Q, U(\lambda^2)$ and multiple Faraday peaks



Anderson et al (2016)
ATCA, 1.3-10 GHz, 36 sources

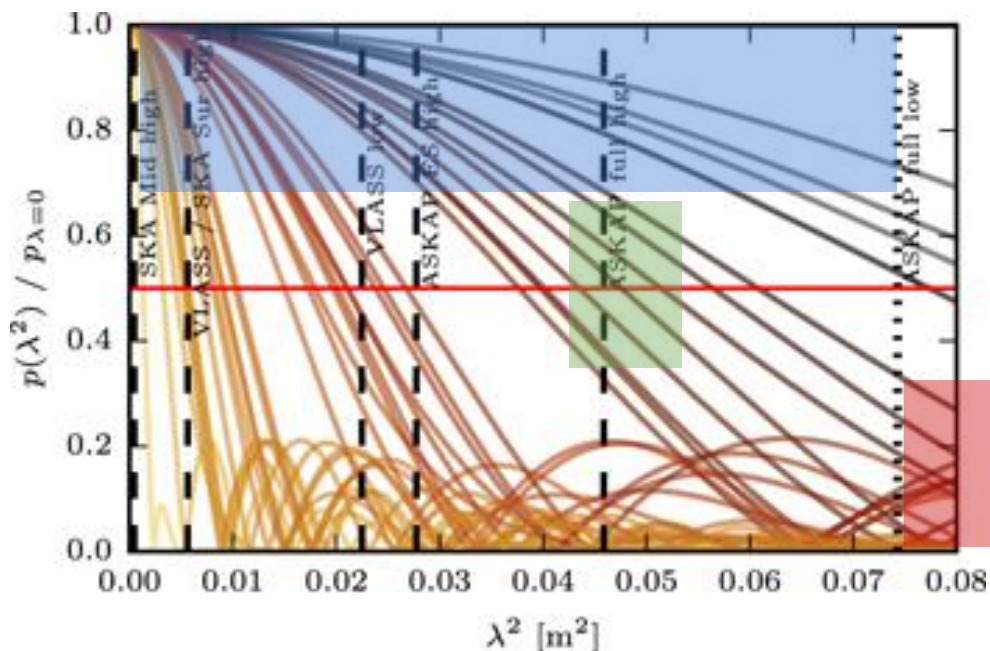
Complementarity between ASKAP and ATCA

ATCA 16cm+4cm: $\lambda^2 = 0.0012\text{-}0.074 \text{ m}^2$ (e.g. the QUOCCA project)

ASKAP MID+LOW: $\lambda^2 = 0.043\text{-}0.053$ and $0.076\text{-}0.14 \text{ m}^2$

Together:

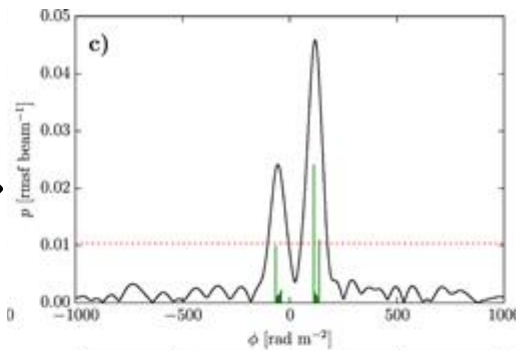
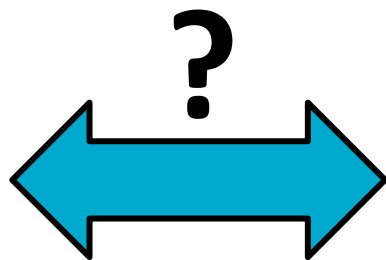
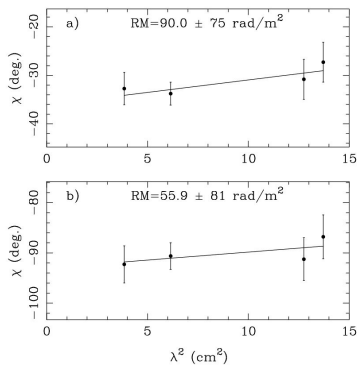
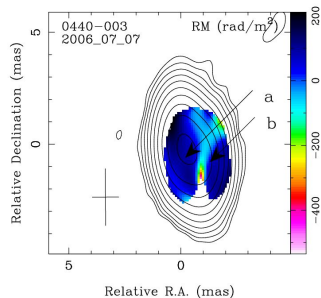
- Precise RMs
- Distinguish Faraday simple/complex
- Study detailed magnetic structure



QUOLL: an LBA survey (Kaczmarek+)



VLBI observations (e.g. MOJAVE) have shown extraordinary polarized structures on mas scales, within arcsec-scale radio sources



Anderson et al (2016)

Randomly selected example from MOJAVE webpage: <https://www.physics.purdue.edu/MOJAVE/>

Southern sky (and ATNF telescopes) FTW

QUOLL



High-res
structure

QUOCKA



Faraday
classification

POSSUM



Up to 1M polarized sources
Reveal the southern sky
Limited bandwidth

Important observational considerations

- Broad frequency coverage
- Avoidance of gaps in frequency coverage
(but still need to exclude RFI where/when it occurs!)
- Ultimately, *nearly everything* will be analysed in λ^2 not ν
- Calibration: quality, stability and frequency continuity
(Need to implement XY-phase calibration in BIGCAT too)
- Software consideration: broadband deconvolution is a real ongoing challenge! (not adequately addressed in any package)
- Zoom bands: 18.5 kHz may be enough already (?)
 - In 16cm band, this allows RMs up to $\sim 480,000 \text{ rad/m}^2$
(cf GC magnetar $\sim -67,000 \text{ rad/m}^2$, FRB xxx $\sim 150,000 \text{ rad/m}^2$)

Polarimetry wishlist

- Must have: retain capability for excellent polarization calibration
- Broadband VLBI
- Online flagging would be great
- Flexible averaging: bin into λ^2 channels?
(creating a metadata challenge?)

