Magnetic stars with Australian radio facilities

Recent results and future steps

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Image credit:: NRAO/AUI/NSF; Dana Berry / SkyWorks

Coherent stellar radio bursts: Solar-like or auroral activity?

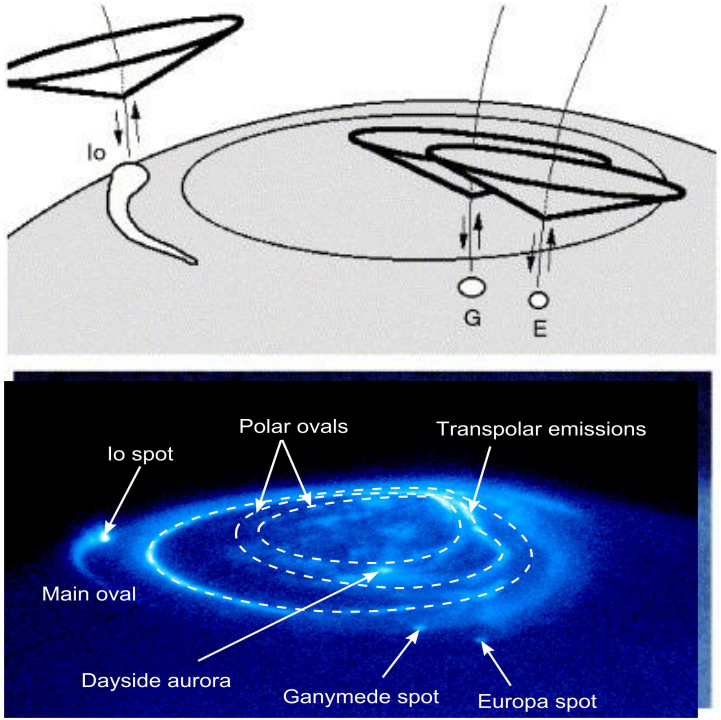
Magnetically-active stars produce **powerful bursts** across the EM spectrum, including at low radio frequencies

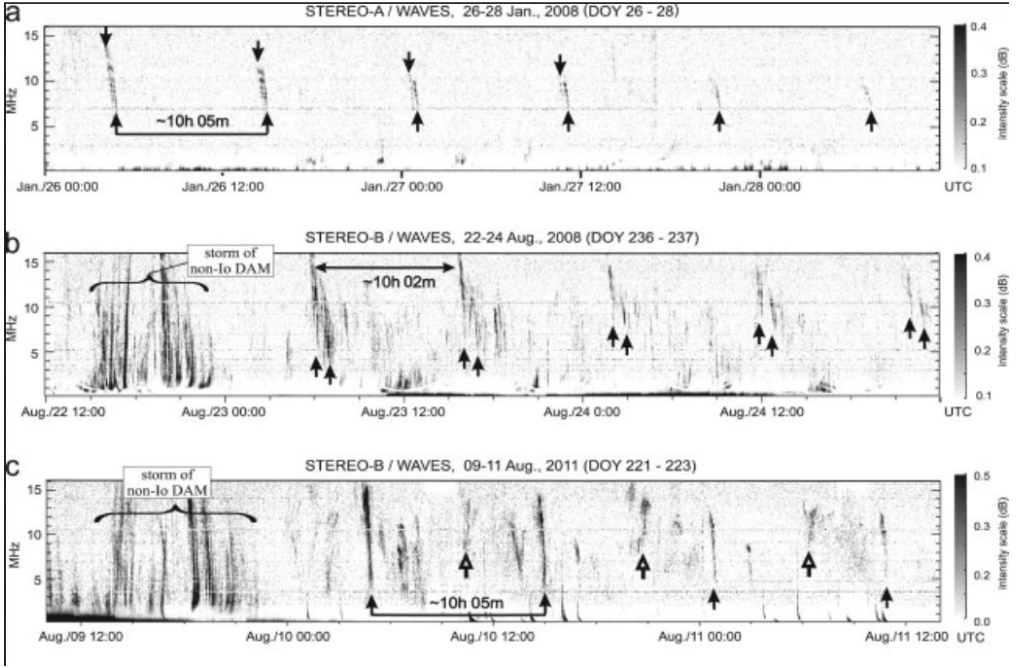
Low-frequency bursts from these stars are unlike those of the Sun:

Sun	**M-dwarfs**
Sometimes highly polarised	Consistently highly polarised
Can be clearly identified as Type I, II, III, IV, V based on morphology in dynamic spectra	No unambiguous identifications of Solar burst morphologies
Associated with flares at other wavelengths	No clear multi-wavelength correlation

Could they be explained by ***auroral*** activity seen from magnetised planets (Jupiter, Earth…), ultra-cool dwarfs, and hot magnetic stars?

Auroral radio emission - the electron cyclotron maser





Periodic Jovian decametric bursts; Panchenko+ 2013

Jovian aurora; John T. Clarke (U. Michigan), ESA, NASA; Zarka 2007

Key questions

Is the low-frequency activity of magnetically active stars powered by **auroral** or **solar-like** processes?

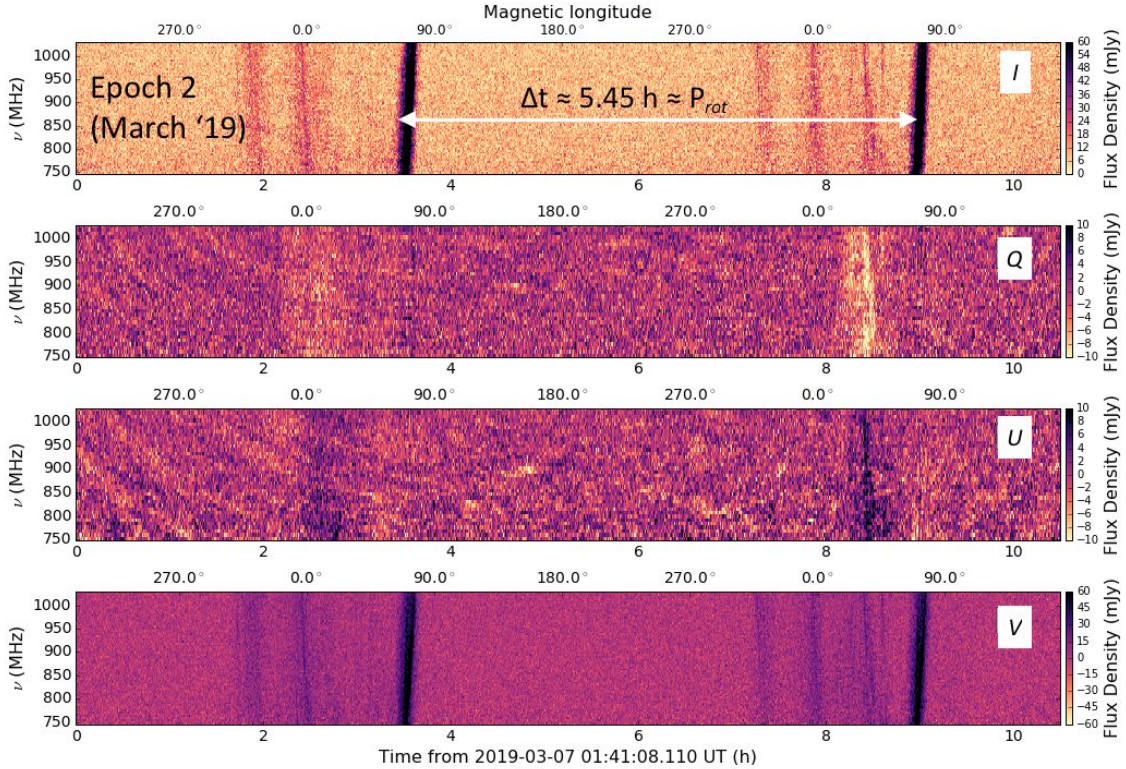
Can we detect **space weather events** from these stars? What implications does this have on habitability of close-in planetary companions?

What is the population of radio-active stars? What can **population trends** reveal about the operation of different kinds of magnetic activity?

What does low-frequency emission reveal about **stellar magnetospheres**?

Recent results

ASKAP dynamic spectroscopy of UV Ceti



Zic et al. (2019)

Two ASKAP ~10-hour observations at 888 MHz

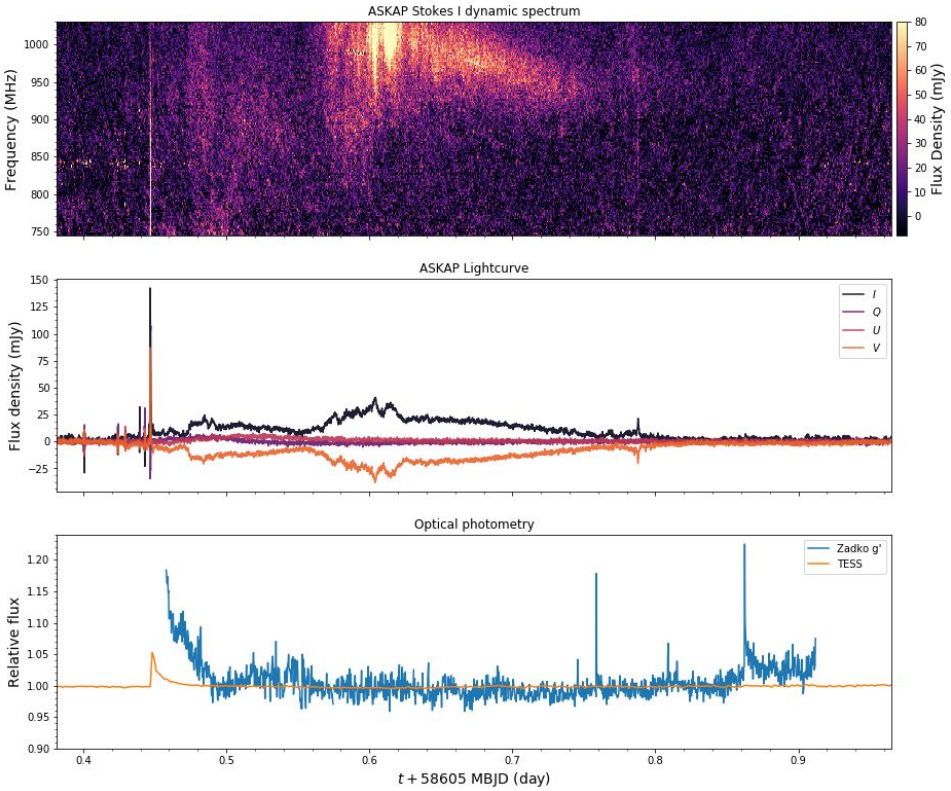
Question: can auroral processes operate in active M-dwarfs?

Answer: yes

Elliptical polarisation: emission produced in **extremely rarefied** auroral cavities

n_e <~ 41 cm^{-3} (expected around 10^8 - ^{9} cm^{-3})

Multi-wavelength space weather monitoring of Proxima Centauri



Zic et al. in prep

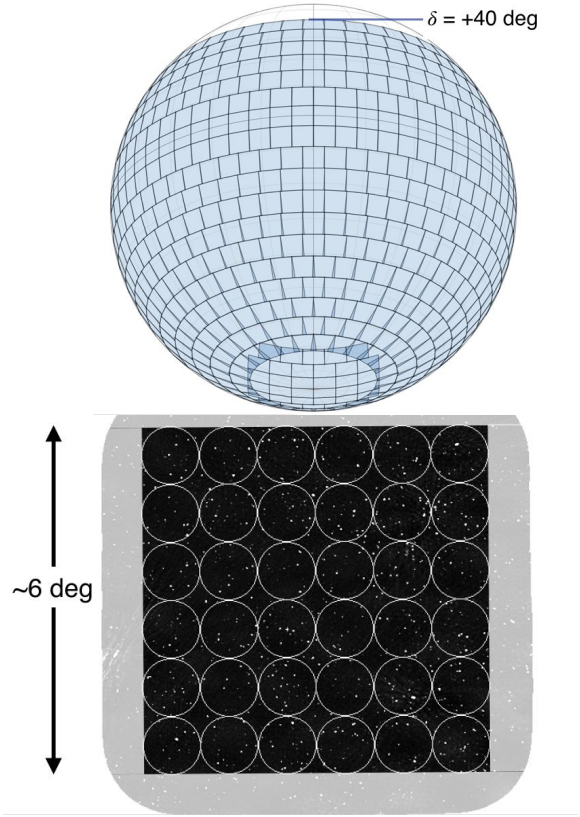
11-night multi-wavelength campaign (MWA, ASKAP, Parkes, ATCA, Zadko, ANU 2.3m, TESS)

Short, bright radio burst peaks at onset of large optical flare.

Most other optical/radio activity uncorrelated: **mechanisms are decoupled**

Long-duration emission likely ECMI from ongoing particle acceleration in large-scale magnetic field **(auroral process)**

Circularly polarised sources in RACS



Rapid ASKAP Continuum Survey (RACS):

Baselines	22-6400m (36 antennas)
Angular resolution	15”
Frequency	888 MHz (288 MHz bandwidth)
Polarisations	Full Stokes (*I*, *Q*, *U*, *V*)
Typical RMS noise	~250 μJy
Sky area	-90° < δ < +40°
Pointings	903 tiles
Integration	~15 minutes per tile

https://atnf.csiro.au/content/racs

Circularly polarised sources in RACS

RACS is unique: **first all-sky Stokes V survey** at these frequencies

Following on from the work of Lenc et al. (2018) at 200 MHz with the MWA

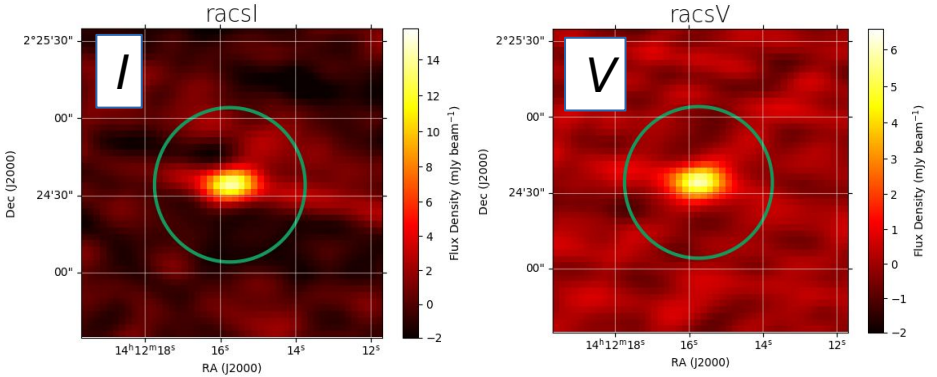
Problem: AGN make cross-matching radio sources to stars very tricky

Solution: Exploit Stokes *V* – cross match Stokes *V* to Stokes *I*

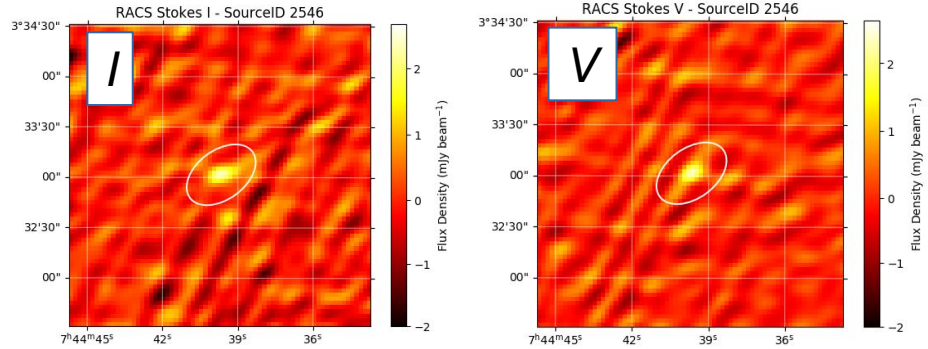
Inspect results, rule out artefacts and leakage sources (off-axis leakage worse)

Early results are promising! Detected known radio stars, and some new ones (Pritchard et al. in prep)

Magnetic B-type pulse: CU Virginis



Active M-dwarf burst: YZ CMi



Prospects for Australia-India collaboration

With full ASKAP surveys coming up, many more new detections of magnetically active stars to come in the near future.

These detections will need follow-up! **uGMRT presents an attractive option**: wide bandwidth, mid-low frequency, good sensitivity, good instantaneous *uv*-coverage

Case study:
Lenc et al. (2018): Detection of Bp star HD 142990 in MWA Stokes V survey
Das et al. (2019): uGMRT follow-up confirms periodic pulsation from this star

This example **highlights mutual benefit** which could arise from an Australia-India partnership on stellar magnetic activity.

Concluding note: the ASKAP Variables and Slow Transients Survey (VAST) is an open collaboration. Email tara.murphy@sydney.edu.au if interested in joining