Transient science with the Square Kilometre Array

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Radio surveys have given us a largely static view of the sky.

A figure of merit for transient detection is

\[ A \Omega \left( \frac{T}{\Delta t} \right) = \text{large} \]

\( A = \) collecting area
\( \Omega = \) solid angle coverage
\( T = \) total duration of observations
\( \Delta t = \) time resolution

The SKA and pathfinders will allow us to explore transient phenomena in an unbiased way, for the first time.
What causes transient phenomena?

1. Explosions
   - e.g. supernovae, gamma-ray bursts, orphan afterglows

2. Propagation
   - e.g. Extreme Scattering Events, intra-day variables

3. Accretion
   - e.g. neutron stars, black holes, quasars, X-ray binaries

4. Magnetospheric
   - e.g. magnetars, flare stars, planetary variability

5. Unknown
   - e.g. known unknowns, unknown unknowns...
SKA Science
SKA: Gamma-ray bursts

- Long: collapse of massive star
- Short: merger of two neutron stars (or black hole)
- Trace cosmic star formation to high redshift
- SKA can observe large fraction of GRB afterglows
- Detect orphan afterglow emission

Burlon et al. 2015, arXiv:1501.04629
SKA: Supernovae

- Determine true CCSN rate in local Universe
- Bridge the gap between Type IIBc SNe and GRBs
- Determine progenitor scenario for Type 1a SNe

Pérez-Torres et al. 2015, arXiv:1409.1827
SKA: Active galactic nuclei

- Intrinsic variability: flares, shocks around SMBH
- Extrinsic variability: scattering in ISM, IGM
- SKA will allow monitoring of $\sim 10^5$ sources

Bignall et al. 2015, arXiv:1501.04627
SKA: Tidal disruption events

- Tidal disruption of stars by supermassive black holes:
  - Can discover quiescent supermassive black holes
  - Can study early stages of jet formation in AGN

Donnarumma et al. 2015, arXiv:1501.04640
SKA: Novae and symbiotics

- Interacting binary star systems
- Hot white dwarf orbits a main-sequence/red giant star.
- Thermal emission traces outflows
- Can determine mass, kinetic energy

What will the SKA see?

Metzger, Williams, Berger (2015, 1502.01350)
Current Results
MWA 128T transients surveys

Image credit: David Kaplan
MWA survey results

- Cadences from 4 seconds – months
- Searching for pulsars (Bell), FRBs (Tingay, Trott, Rowlinson)
- Blind searches (Bell, Rowlinson)

Image credit: Antonia Rowlinson
Radio emission from exoplanets?

Murphy et al., 2015
Interplanetary scintillation

Kaplan et al. 2015, *in prep*
The ionosphere: direction field

Loi et al. 2015, submitted
First results from BETA

150 sq deg to 1 mJy in 12 hours

Credit: Bannister & Heywood (CASS)
Intermittent pulsar PSR J1107–5907

Hobbs et al. 2015, *in prep*
First results from UTMOST

Image Credit: Ravi, Bailes et al
Future Challenges
Technical challenges

- Source finding (Hancock et al.)
- Source classification (Lo et al., Farrell et al.)
- Transient detection pipeline (Murphy et al.)
- Characterising rates and detection statistics (Trott et al.)
- Data storage and processing

- ‘Real time’ processing
- Triggering and follow-up
Summary: what we have learnt so far

▶ Large scale transients surveys open us new parameter space
  . . . but increases the data/technical challenges

▶ Commensal surveys will produce great science
  . . . however ability to do targeted follow-up is important

▶ Rapid processing and follow-up is critical
  . . . follow-up on slower timescales than the events is limited

▶ Australia is leading lots of the scientific and technical efforts
  . . . need to make sure this feeds into SKA