Pulsars & Fast Transient Science - LOVe-Merlin

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Pulsars are Key Science for the SKA! Fast Transients are not far behind.

e-Merlin+Lovell already does amazing slow transient science more to be done though as discussed in Mooley's talk.

Pulsar Timing Program

Unique monitoring of more than 800 pulsars/100 MSPs

A lot of science ONLY possible with long term study

- Long-term spin evolution: B-evolution, population studies.
- Glitches: large database, interior physics.
- Timing irregularities, transient phenomena.
- Crucial input to global projects (Search/GW/high-energy)
- International Pulsar Timing Array Verbiest et al. 2016
- Main Contributor to all Fermi Large Area Telescope Catalog of Gamma-Ray Pulsars - 2013, 2015 and 2017
- Main contributor to Gravitational Waves from Known Pulsars: Results from the Initial Detector Era - Abbott et al. 2016
- Time majority of newly discovered pulsars (AO/Parkes/ LOFAR)— get to the science.
- SKA /FAST era > 20,000 known pulsars how do we time them?

~16000 years of rotational history



~50 year binary - PSR J2032+4127





Pulsar Timing e-Merlin &/OR Lovell improving efficiency & sensitivity

- Enable pulsar timing mode for e-Merlin work started (Walker talk)
- Develops on beam forming work for LEAP, PAF, MeerKAT
- Provides ~64-m dish equivalent sensitivity small dishes alone.
 - * Useful in those times when Lovell not available
 - wider field of view allows for multi-beaming possibilities need more backends.
- * Combined with Lovell 110m dish equivalent
 - * Improved TOAs for MSPs for inclusion for EPTA/IPTA (> 2x)
 - Also very good addition to LEAP (> 20%)
 - improved robustness to RFI. (another 10-20%)
 - * Gives sensitivity to support MeerKAT, FAST and SKA discoveries





Pulsar Timing e-Merlin &/OR Lovell improving efficiency & sensitivity

- Increasing the field-of-view PAF
 - * Can take advantage of being able to time multiple pulsars at once.
 - * With Lovell alone, only need to time 3 pulsars at a time to get the benefit
 - Already more than 100 pulsars able to be observed in this way
 - Vastly increased numbers of pulsars in the inner Galaxy FAST, PALFA, MeerKAT etc...
 - Can do wide-field simultaneous timing with Effelsberg-PAF / APERTIF (PAFLEAP)
- Adding in the e-Merlin dishes same FoV but almost double the sensitivity.
- * A cooled PAF would be ideal for FAST/SKA
 - * Gives the sensitivity we need to be able to do more pulsars / better







Transients & Lovell - Current

- * Fast Radio Bursts (talks by Keane and Walker)
- * 5-10,000 sky/day! but still only ~20 known.
- * Lovell relatively narrow FoV so go for the many days
- * Piggyback on pulsar timing observations 200 days
- Near real-time processing done but more sophisticated analysis needs doing.
- * Upgraded Hardware Apollo + Pascal 1080 GPU
- Upgraded Software including greatly improved RFI removal
- * Builds on SKA NIP work 20 times faster in last 3 years!
- * Reprocess 200 days data in a couple of weeks
- * More sophisticated processing... more beams/telescopes.



Transients & Lovell + PAF - near Gen.

- * Talks by Keith and Malenta
- PAF greatly enhances the FoV
- Near generation processing capability would need just a handful of GPUs can process 9 beams (or more)
- Get detection rate for FRBs to that of Parkes and better, and have hundreds of days commensal observing
- Plus get "free" repeat monitoring.
- * Possible simultaneous with Eff.



Some of the most recent bursts from Champion et al. 2016

Transients & Lovell + e-Merlin - near Gen.

- Prototype system Talk Walker
- * Again utilise commensal observing.
- * e-Merlin increases FoV + sens.
- Crucially allows anti-coincidence
- Gives the vital localisation capability (transient buffers)
- Addition of a PAF would give even greater FoV.
- Potentially many highly localised FRBs
- * Possible simultaneous with Eff.



One FRB seen to repeat - AO FRB, also seen at higher frequencies - but still not localised! Spitler et al 2016

Conclusions

- Build on strong UK involvement in SKA Non-imaging processing - both hardware and software.
- Can play an even stronger role in PTA and Pulsar Survey science but also continue to lead the way in discovering new phenomena.
- * Become an even stronger player in fast transient science
 - * Look to a responsive mode for GW sources (et al.)!
- * Provide vital test bed for testing and improving new SKA high time resolution modes observing and processing!