S1.4

Supernova Remnants in the Multi-Messenger Era:

A View from the CTA Perspective

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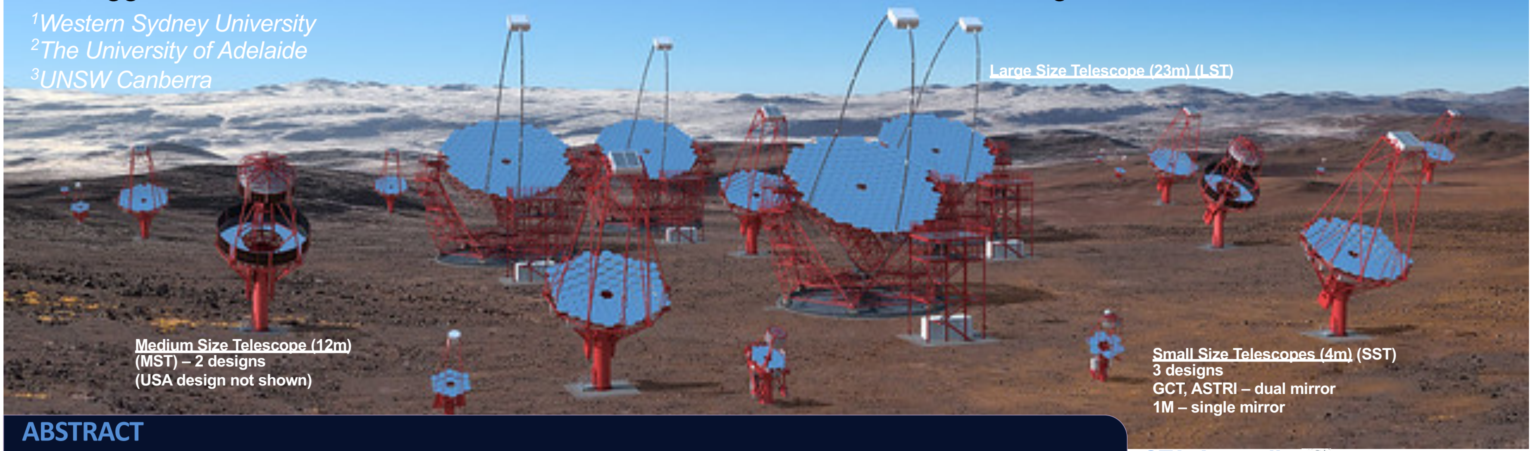

ABSTRACT

This is an exciting time for the discovery of supernova remnants (SNRs) in our and other nearby galaxies. SNRs reflect a major process in the elemental enrichment of the interstellar medium (ISM). The study of this interaction in different domains including gamma-ray, radio, optical, IR and X-ray, allow a better understanding of these objects and their environments. Nearby galaxies offer an ideal laboratory, since they are near enough to be resolved, yet located at relatively well-known distances.

CTA-Australia

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1. The role of Supernova Remnants?

SNRs heat and ionise the ambient interstellar medium (ISM) and distribute the chemical elements that were processed in the progenitor's interior and in the supernova into the ISM. In addition, electrons and nuclei are accelerated in the shock waves to highly relativistic energies and are responsible for a considerable fraction of the energy density in the Universe. The emission from non-thermal MeV to GeV electrons makes SNRs bright radio sources, while non-thermal X-rays have been confirmed for a number of young Galactic SNRs indicating the existence of TeV electrons. Similarly, highly relativistic particles have been detected in superbubbles (e.g., 30 Dor C), which are interstellar structures created by the combination of stellar winds of massive stars and their supernovae. However, the underlying physics such as particle injection, magnetic field configuration and amplification, and the escape of particles from the shock regions requires further investigation. Magnetic fields in SNRs and superbubbles are most likely a complex mixture of interstellar magnetic fields, relic fields of the progenitor, fields modified and enhanced by turbulence in the shock regions, and fields excited by relativistic particles. Therefore, various high spatial resolution, high sensitivity, and high spectral resolution observations are necessary to address these issues.

2. From ASKAP/MWA via eROSITA and CTA to KM3NeT

We are currently carrying out observational studies of SNRs and superbubbles using today's multi-messenger telescopes and will continue our efforts with upcoming telescopes like eROSITA, CTA, KM3NeT and the SKA precursors, including synergistic programmes such as ASKAP. SKA pathfinders' observations in radio at low frequencies with high sensitivity will detect new SNRs in our Galaxy and the MCs, which are either old and too faint, young and too small, or located in a too confusing environment and have thus not been detected yet. In addition, the SKA pathfinders' observations will also allow high-resolution polarimetry and are key to the study of the energetics of accelerated particles as well as the magnetic field strength and configurations. Gamma-ray studies provide answers to the long-standing question in high energy astrophysics: Where do cosmic rays come from? The gamma-ray emission seen from some middle-aged supernova remnants (SNRs) is now known to be from distant populations of cosmic-rays (probably re-accelerated locally) interacting with gas, but there is still much work to be done in accounting for the Galactic cosmic-ray flux. Young PeV gamma-ray supernova remnants require different techniques to address the question of cosmic-ray acceleration. The CTA will allow us to do this.

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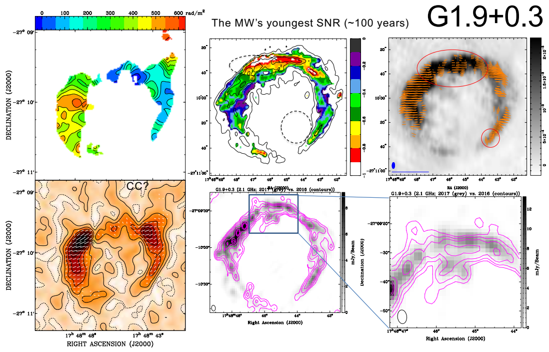

K. Luken, in prep.

Signs of interaction, including brightening (?) → more to come

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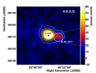
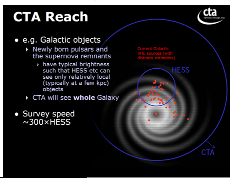
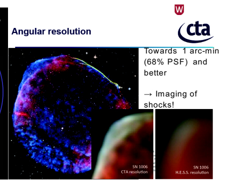
3. CTA Science and SNRs



Main Themes

1. Cosmic Particle Acceleration
2. Probing Extreme Environments
3. Physics Frontiers: Beyond Standard Model

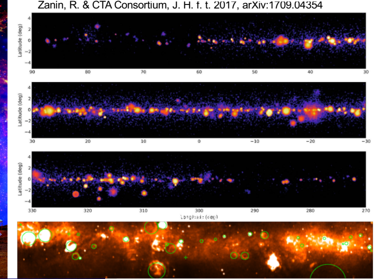


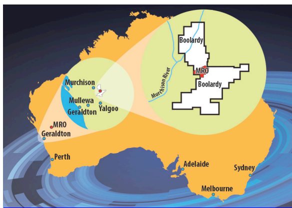


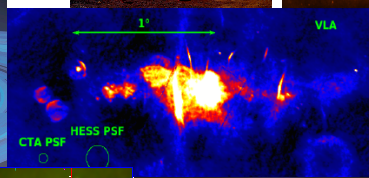
Key Science Projects & SNRs

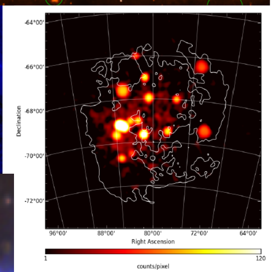
– Galactic Plane Survey
– Galactic Centre Survey
– Large Magellanic Cloud Survey
– Extragalactic Survey
– Transients?
– Cosmic-Ray PeVatrons
– Star-Forming Systems

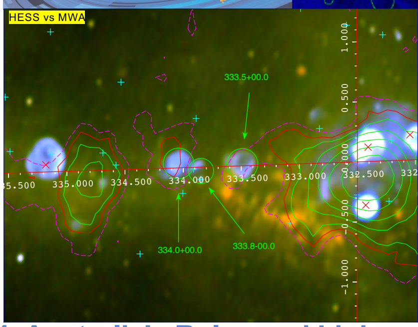
Zanin, R. & CTA Consortium, J. H. t. t. 2017, arXiv:1709.04354

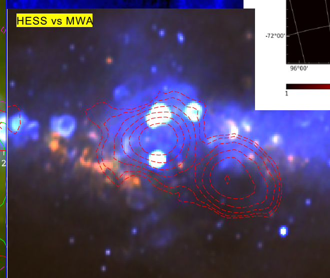


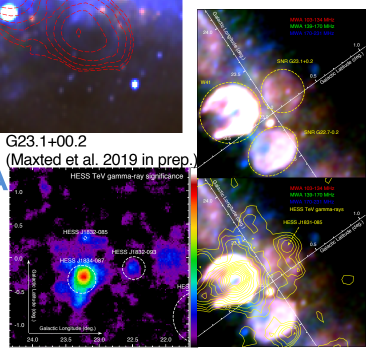












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(Maxted et al. 2019 in prep.)

4. Australia's Roles and Linkages with CTA

- SST hardware (camera Si-PMs, software etc)
- Performance optimisation at >10 TeV energies
- Multi-wavelength support
- ISM surveys for CTA's Galactic Plane Studies [Mopra, Parkes, ATCA, ASKAP]
- Radio continuum surveys [MWA, ASKAP, SKA]
- Shocked & ionised gas (optical, radio lines)

Alsaberi+ 2019

SUPERNOVA REMNANTS II
AN ODYSSEY IN SPACE AFTER STELLAR DEATH
3-8 June 2019, Chania, Crete, Greece

For further information about CTA: www.cta-observatory.org