Using the Five hundred metre Aperture Spherical Telescope to detect the highest energy cosmic rays

Research Field
Particle physics/radio astronomy

Project Suitability
PhD
Honours (as appropriate)

Project Supervisor
Dr Clancy James
Clancy.james@curtin.edu.au

Co-Supervisors
Prof Jaime Alvarez-Muniz, Prof Xiang-Ping Wu
University of Santiago de Compostela, Spain; National Astronomical Observatories, China

Cosmic rays are the highest-energy particles in nature, impacting the Earth with energies more than a million times higher than can be achieved with the Large Hadron Collider. Yet we don't know where they come from. This is because cosmic magnetic fields deflect cosmic ray trajectories during propagation. As cosmic ray energy increases, this deflection may become small enough to trace cosmic rays back to their origin – but the highest-energy particles are very rare, arriving at a rate of one per square kilometre per century.

How to detect enough of these 'ultra-high' energy cosmic rays? The 'lunar technique' is a method for solving this problem. When a cosmic ray interacts, it gives off a burst of radio-wave radiation, lasting a few nanoseconds. By pointing a ground-based radio-telescope at the Moon, cosmic rays hitting the lunar surface might be detected. And the largest single-dish radio telescope in the world – the Five hundred metre Aperture Spherical Telescope (FAST) - has just been completed in Guizhou Province, China. However, to use FAST to detect lunar signals, the effect of the rough lunar surface on the signal shape needs to be modelled. Solving this problem will be the aim of the project.

Aims of project:

(i) Model the rough lunar surface.

(ii) Apply surface-transmission equations to model radio emission from cosmic ray cascades.

(iii) Determine whether current radio telescopes can observe these signals – and then go and discover them!

The results of this investigation will inform not just a planned experiment with FAST, but also proposed lunar missions such as LORD (Russia), and potential ground-based radio observations with the Parkes and Effelsburg telescopes (Australia and Germany, respectively). An honours project would target aims (i) and (ii), while a PhD student may have the opportunity of participating in observations, extending their results to experiments searching for neutrinos underneath the Antarctic ice, and potentially visiting international collaborators such as Prof Jaime Alvarez-Muniz in Spain.

(Right) The Five hundred metre Aperture Spherical Telescope (FAST). This instrument will be used to search for cosmic rays hitting the Moon.
(Below) Bootprint of an astronaut on an Apollo mission. Data from these missions will be used to model the lunar surface.