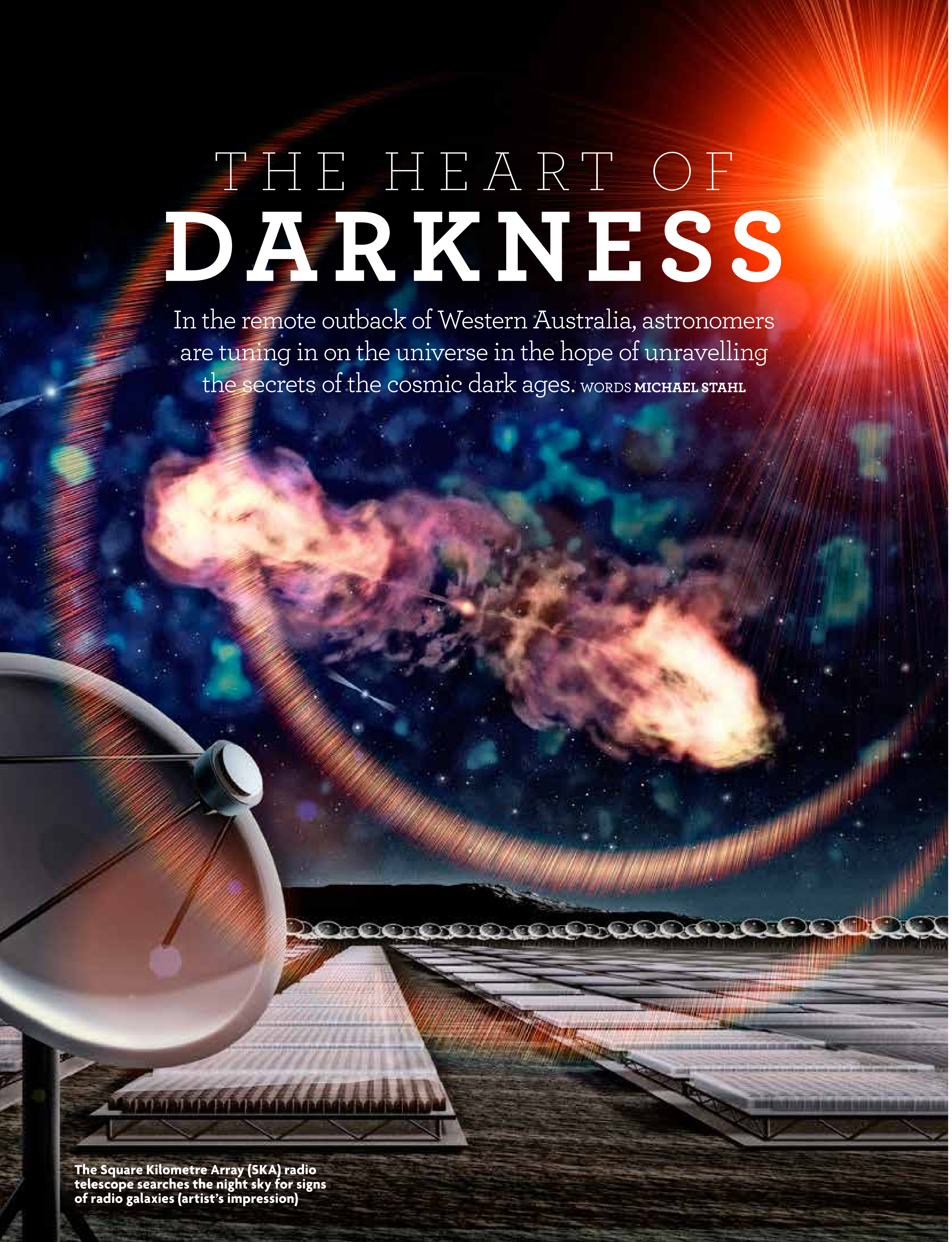
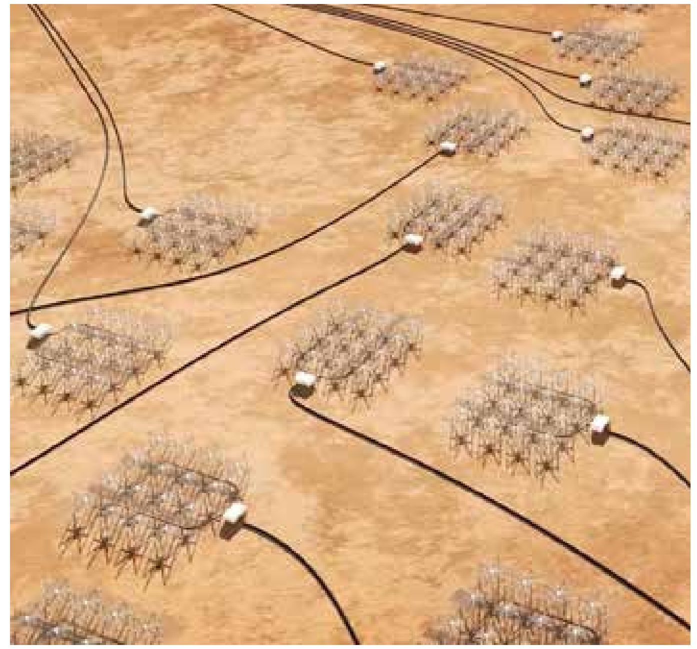
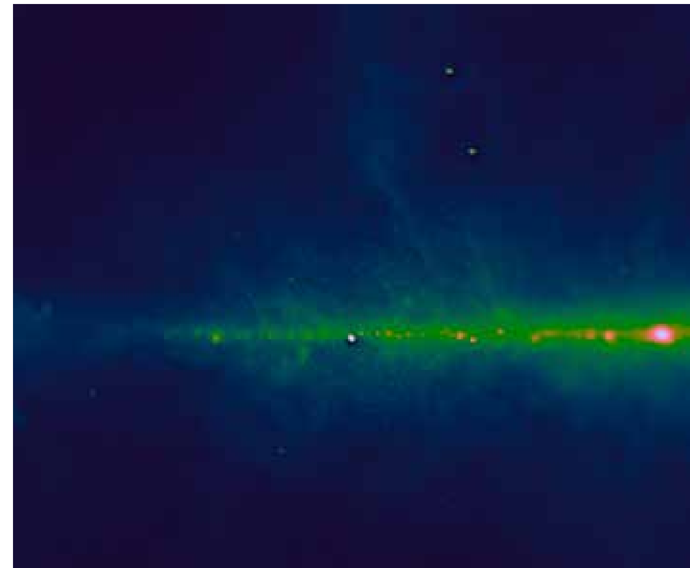
THE HEART OF DARKNESS

In the remote outback of Western Australia, astronomers are tuning in on the universe in the hope of unravelling the secrets of the cosmic dark ages. WORDS MICHAEL STAHL



The Square Kilometre Array (SKA) radio telescope searches the night sky for signs of radio galaxies (artist's impression)





Murchison Widefield Array image of The Milky Way, showing exploded stars; MWA "tiles" (left)

PHOTOGRAPHY: COURTESY MURCHISON WIDEFIELD ARRAY; SKA ARTIST'S IMPRESSION: GETTY IMAGES

FROM THE AIR it resembles an outback mustering of spidery, silver aliens or a network of sensors reading Earth's thoughts. Both illusions hint at the truth, for the Murchison Widefield Array (MWA) radio telescope in remote north-western Australia marks a dramatic step in mankind's ability to discover the origin of the universe.

Situated 350km north-east of Geraldton, Western Australia, the MWA has already pushed the known boundaries of radio telescope design and data processing. The joint project between the US, Australia, India and New Zealand is seen as a precursor to the even more ambitious (and international) Square Kilometre Array (SKA) radio telescope.

The $1.9b SKA project, scheduled to begin construction in 2016, will be spread across several sites in southern Africa and Australia, with operational headquarters in the UK. Several thousand radio telescopes, of three different types, will bring an unprecedented sensitivity to the search for the faint radio signals emitted before the first planets were formed almost 13 billion years ago.

The MWA may be on a much smaller geographical scale, being scattered across a 3sq km site in the Murchison shire, but its widefield array format has already been instrumental in prompting breakthroughs in hardware and software design – even before it commenced its maiden observations.

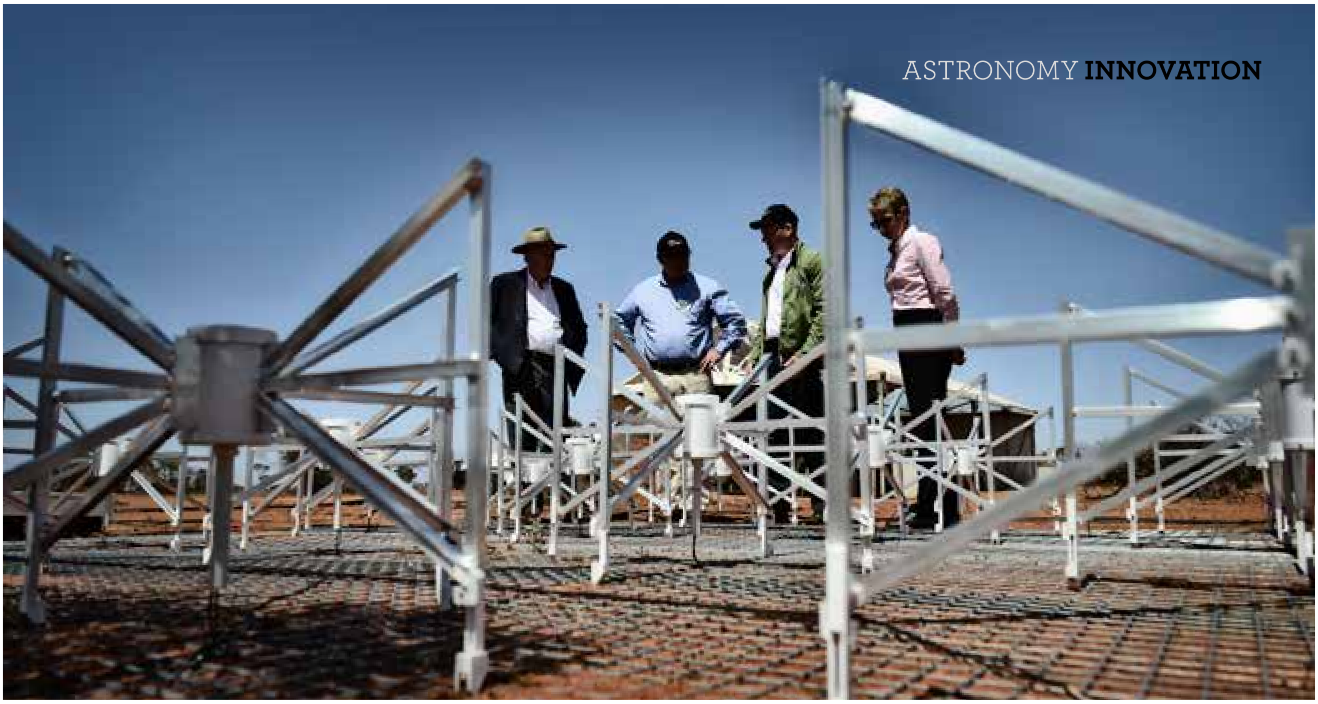
The MWA radio telescope comprises 2048 aluminium-legged antennas, called dipoles, each occupying about one cubic metre. The dipoles are arranged in blocks of 16, referred to as tiles. The dipoles are fixed, facing upwards, each listening for very low-frequency radio transmissions across the entire sky. Hence its middle-of-nowhere location in the 41,000sq km Murchison shire.

"We're looking for whisper-faint signals from the other side of the universe," says Steven Tingay, director of the MWA and professor of radio astronomy at Perth's Curtin University. "Murchison shire has an area close to the Netherlands and a population of 100 people. No mobile phones, no cars, no industry, no nothing."

Radio telescopes are scaled according to the size of the waves they are trying to collect. The familiar, moveable parabolic dish, for all of its complexity in size, materials and maintenance, remains the most viable type of telescope for detecting the high-frequency signals within our own galaxy.

Tingay explains that the low-frequency waves targeted by the MWA are "the signature" of the earliest days of the universe. The cosmic dark ages are a billion-year void immediately after the Big Bang, 13.7 billion years ago, and before the expansion and cooling of the universe caused gases to collapse and create the very first stars and galaxies.

"The atoms and molecules that we know of make up five per cent of the universe," Tingay says. "The other 95 per cent is made up of dark matter and dark energy. Both of these substances have no theory within physics for what they are. We literally have no understanding of what 95 per cent of the universe is." ›



Dipole discourse (left to right): WA minister for science and innovation John Day, federal member for Brand Gary Gray, director of the MWA project Steven Tingay, Curtin University vice-chancellor Jeanette Hacket

The low-frequency target lends itself to the MWA's innovative array of fixed dipoles, rather than an array of small, moveable parabolic dishes of 10m to 15m diameter. (Australia's best-known single parabolic radio telescope, at Parkes, NSW, measures 64m and is second in size to the 70m dish at Tidbinbilla, near Canberra). "It's a very brute-force, mechanical method of collecting the radiation," Tingay says of the parabolic dishes used for the past half-century.

Moveable dishes provide the capacity to focus on a particular area of the sky, but over time they become increasingly expensive to maintain. That's where the MWA already provides a window to the future of radio astronomy. The focusing isn't done by the antennas themselves, but by digital skewing of the combined mass of signals collected across the MWA site.

"We're pushing all the cost and complexity of our antennas away from the concrete and steel, into the signal processing," Tingay says. "We can make up for having very simple antennas by having a very sophisticated, high-capacity supercomputer on the back end. And as time goes on, computers get cheaper and more powerful."

Even IBM, which is working with Tingay and Curtin University on both projects, has had to push itself hard to meet the demands being imposed on data. IT architect Indulis Bernsteins jokes, "I can't even keep track of my MP3s and photos, so how are scientists going to be able to trawl through petabytes of data?"

Among the innovations Bernsteins and his team have already made are data processing on the fly, and a system that will detect events and direct scientists' attention to a particular area of the sky – "to wake them up if the sky does anything interesting".

Tingay sheepishly admits that the field data-processing boxes for each of the MWA's 128 tiles have at their core a souped-up graphics processor co-opted from a games console. "If we, as astronomers, were to sit down and develop that from scratch, well, we never could. But the gaming industry, over 20 years, has produced this thing that is amazing for radio astronomy.

"We can take that and say to IBM, it would be great if we could tweak it like this – and so we've got it to the cutting edge. They get to make better products and we get the computer we want."

Tingay says that it may be possible to build a no-moving-parts telescope for high-frequency observation, ultimately replacing the mechanical dish, but the computing power needed is still perhaps 25 years away. When the SKA's third and final phase of construction is complete, probably approaching 2028, it will cover the radio spectrum with a combination of sparse, single-dipole antennae, grouped MWA-style tiles and thousands of moveable parabolic dishes about 12m in diameter.

Tingay thinks that the SKA's $1.9b price tag is cheap, especially compared with Switzerland's Large Hadron Collider (LHC), which cost about $4b. The two instruments are rivals in a common quest. "The question of dark matter is one the LHC is trying to figure out by smashing things together, trying to re-create the conditions of the Big Bang. Astronomers are trying to look back 12 billion years, to the dark ages; same problem, different directions and scales."

He believes the unravelling of dark matter and dark energy could occur within the next 20 years. "And that's going to completely overthrow the current laws of physics. I predict 100 to 200 years after that, that will be turned into technology we can't even imagine now."

Kim Steele, a 20-year-old radio astronomy student at Curtin who helped assemble the MWA dipoles, has been sitting in on the conversation in Tingay's office. "If my *Star Trek* history is up to scratch," she says, "I think we came up with warp drive in this century."

Her professor grins. "Maybe it will be just like *Star Trek*."