THE AGE
National

Reach for the heavens

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What's out there?

JUST when astronomers think they have a handle on the universe, something turns up that makes them revise their theories – again. If it isn't the Big Bang or super massive black holes or dark matter, then it's galaxy clusters or large-scale voids or something even stranger.

Now astronomers at Swinburne University of Technology and Melbourne University believe Australia's newest radio telescope will throw light, so to speak, on some of the universe's many mysteries while providing insights into its very origins.

The $350 million Australian Square Kilometre Array Pathfinder, known as ASKAP, is under construction for the CSIRO at the Murchison Radio-Astronomy Observatory in the mid-west of Western Australia.

When the radio telescope is completed within the next few years, ASKAP will have 36 identical antennas, each 12 metres in diameter and all working together as a single instrument. But even before it begins its first scan of the heavens, a group of Australian theoretical astronomers, including Associate Professor Darren Croton from Swinburne and Dr Alan Duffy from Melbourne University, have made predictions about some of its discoveries.

In a paper published in the *Monthly Notices of the Royal Astronom-ical Society*, the researchers say the telescope will detect 700,000 new gas-rich galaxies further out in space and back in time than any astronomer has ever gazed before at this wavelength. After combining simulations on Swinburne's super computer with ASKAP's specifications, Dr Croton says surveys using the new telescope will locate more galaxies in the distant reaches of the universe and astronomers will be able to study them in more detail than with any other radio telescope.

Two surveys will be undertaken with the telescope, one dubbed Wallaby and the other Dingo. The Wallaby survey is predicted to discover 600,000 new galaxies by scanning 75 per cent of the sky but not as deeply or as far back in time as that of Dingo. Instead, Dingo will focus on a smaller portion, allowing for deeper penetration and the identification of 100,000 new galaxies.

"Dingo is more about the evolution of hydrogen gas in the galaxies over time while Wallaby is more like a census of what the gas is doing right now," Dr Croton says. "With the simulations we mimic these future surveys and mock up a virtual sky. The tool we use is called the Theoretical Astrophysical Observatory (or TAO for short) – a new virtual laboratory funded by the federal government. We use the observatory to take the simulation results and turn that into a virtual sky that looks like a particular survey."

He describes the computer simulation of ASKAP's potential discoveries as similar to testing a formula one racing car in a wind tunnel before using it on the track. "Astronomy has two main branches," he says. "One consists of astronomers who measure the universe – they are the observers – and the other are theorists like me who make predictions, who take the known laws of physics and try to interpret the observations.

"But one of the big challenges is that astronomy is cosmic archaeology where we only see pieces of the puzzle as we look back in time. And so far, for these galaxies, many of the observational pieces have been missing."

Trying to put the pieces together is like cutting a film of a movie into its different frames, throwing the bits on the ground then picking them up and trying to reassemble the movie by fitting the frames together again, Dr Croton says. But astronomers don't have all the missing frames so this is one of the major roles theorists play in predicting astronomical discoveries.

"Modern theorists use supercomputers to test the theories we come up with. A nuclear physicist or a biologist will test their theories in the lab before they take them out into the world but astronomers don't have that luxury so we use supercomputers to build virtual laboratories. And that is what we've done: we've taken everything we know about galaxies, how they are born, how they evolve, their different shapes and sizes – we take all that understanding to build models and make predictions for things we haven't yet seen."

Dr Croton says the models in the supercomputer are combined with what is known about the broad framework of the universe, the cosmology, and this is allowed to evolve. The computer then generates a virtual universe with tens of millions of galaxies spread over vast volumes of cosmic space and across cosmic time – larger volumes than can be observed and longer stretches of time than can be seen with existing telescopes.

With the advent of the ASKAP, the team of theorists customised models they had been developing over the past seven years and used the supercomputer to predict what astronomers would see with the telescope "before we even collect a single photon of data". These predictions will help astronomers using the telescope to decide on the best observing strategies in conducting the surveys.

Dr Croton says this highlights the important relationship between theory and observation, with each guiding the other so that as discoveries are made these are fed back into the computer. As well, when the data comes in the models will help astronomers interpret it.

Of course, the data that ends up in the computer doesn't tell the scientists anything: it has to be interpreted within the broader context of what has been newly discovered about the universe. So the models and theories work together by helping the scientists understand what they are seeing.

"And there's a flip side to this that to me makes it more exciting because there will surely be aspects of the model that are wrong, parts of our predictions will not be correct; areas where we thought we understood but we don't," he says.

"You might believe you understand something but then you get a new instrument that reveals new details, or something entirely different which opens up new areas to explore that may ultimately drive the construction of new telescopes and new surveys – each feeding into each other. Then again, if we don't see as many galaxies as predicted, then the universe is strangely different to our simulations."

* The pathfinder radio telescope will be an important test bed for the giant Square Kilometre Array, the future $2 billion international radio telescope that will be constructed over the next two decades to operate in Australia, New Zealand and South Africa. This will be the world's largest and most sensitive radio telescope when it comes online.

Astronomers say the SKA will enable them to see back to moments just after the Big Bang. Research based on the observations is expected to answer fundamental and unsolved questions about the universe such as how the first black holes and stars were born.

Although Australia, with New Zealand, competed with South Africa to establish the telescope in Western Australia, the non-profit SKA Organisation decided to split its operations between the three countries. The group, based in Britain, is expected to spend up to $US190 million a year to operate and maintain the telescope.

Members of the organisation include government departments, research councils and institutes from Australia, Canada, China, Italy, New Zealand, South Africa, the Netherlands and the UK, with India an associate member.