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Hydrogen gas is telling tales on hundreds of galaxies once shielded by interstellar dust. **Wendy Pyper** enters the realm of dark matter, dark gas clouds, and the Great Attractor.

Seeking galaxies by gaslight

Galaxies, stars and mysterious perturbations of space have long tantalised our imaginations and inspired Hollywood directors. But thanks to the stars and dust in our own galaxy – the Milky Way – our view of the Universe and the secrets within, have been partly obscured. Now astronomers at the CSIRO Australia Telescope National Facility (ATNF) at Parkes in New South Wales have found a way to look through the Earth's galactic curtain.

'For the first time we've searched behind the Milky Way and found hundreds of new galaxies no-one has seen before,' ATNF astronomer, Dr Raymond Haynes, says.

The discovery came after ATNF astronomers designed a special radio wave 'receiver', for the Parkes telescope. Like a transistor radio, only more sensitive, the receiver picks up radio waves emitted by hydrogen gas, a basic building block of galaxies and stars. These radio waves can penetrate the dust and starlight of the Milky Way, enabling astronomers to detect faint, small or distant galaxies, which would otherwise remain hidden.

'In the past, astronomers have looked for galaxies by the starlight they give out,' Haynes says. 'That's fine for nearby galaxies, but as you go deeper into the Universe, the light from faint, small or distant galaxies is usually absorbed by interstellar dust. By looking at the hydrogen gas, rather than stars, we've been able to detect those galaxies.'

So far, the 'HIPASS' – HI Parkes All Sky Survey (HI for neutral hydrogen) – has unveiled more than 600 new galaxies behind the Milky Way, which obscures about 15% of the southern sky, and 900 new galaxies in the remainder of the southern sky and part of the northern sky.

HIPASS astronomers, including scientists from Australia, the UK, US, Mexico and the Netherlands, have also calculated the distance to these galaxies.

Because our Universe is expanding, (like the cloud from an explosion), the further a galaxy is away from us, the faster it recedes. As a result, radio waves emitted by distant galaxies are more stretched out than those emitted by galaxies closer to us.

'As with optical astronomy, we've been able to observe galaxies on the two-dimensional plane of the sky,' Haynes says. 'But we've also been able to determine the distance to each galaxy using the velocity information we gather from their radio emissions. So now we can effectively see out through space.'

This advance has enabled astronomers to draw the first three-dimensional picture of the distribution of galaxies in the southern sky. The survey has also been conducted 13 times faster than normal, thanks to the 'multibeam' design of the receiver.

'We've put 13 receivers on the telescope at once, so we can cover more of the sky in one bite,' Haynes says. 'So if we look at a given area in the sky, instead of seeing something that's 14 minutes of arc across (half the size of the moon) as we would observe with a single receiver system, we see 13 times that area simultaneously.'

In just over three years the astronomers have mapped the entire southern sky and part of the northern sky. This map

Pictures: Dick Bellby, Lochman Transparencies

The nearest galaxies to the Milky Way are the Magellanic Clouds, 180 000 light years away. Astronomers can now detect more distant galaxies, using radio waves emitted by hydrogen gas that can penetrate the dust and starlight of the Milky Way.

The Parkes telescope is attached to a 13-beam receiver that detects radio waves emitted by the hydrogen gas in stars and extra-galactic matter. The 13 beams enable more of the sky to be viewed at once. The receiver is cryogenically cooled to –250°C. This reduces the noise (free electrons) or interference within the receiver (by slowing the movement of electrons), enabling even weak radio signals from deep space to be detected.

will help them understand the structure, distribution and formation of stars, galaxies and extra-galactic matter and answer questions that have puzzled astronomers for decades.

One such question concerns the amount of matter in the Universe. Dr Lister Staveley-Smith, the project scientist in charge of the multibeam instrument, says one of the main aims of the survey was to put limits on the amount of 'dark matter' in the Universe.

Dark matter, as the name suggests, can't be seen, as it gives off no light, radio waves or any other kind of radiation. However, astronomers know it exists because it influences the rotation of galaxies.

'We can measure the mass of galaxies by looking at their size and rotation velocities,' Staveley-Smith says. 'But when we do that, we find there's more mass in many galaxies than we can actually see. This hidden mass is generally what's called dark matter.'

Staveley-Smith says there are a number of theories on what dark matter is, ranging from 'exotic new forms of physics, to theories that space is filled with planet sized objects that can't be seen because they're so dim'.

Whatever the answer, he says that by looking at the motion of galaxies and their distribution – information the HIPASS will provide – inferences can be made about the amount and distribution of dark matter.

Other forms of matter of interest to astronomers are dark gas clouds. Like dark matter, dark gas clouds give out no light, but are full of hydrogen.

'Dark gas clouds are interesting because they could be protogalaxies, (clouds of gas that haven't managed to form stars), or they could be debris from the formation of other galaxies,' Staveley-Smith says. 'By mapping these clouds, we'll have a better understanding of their distribution, their relation to other galaxies and their formation.'

How stars and galaxies form is another question that Dr Rachel Webster, the scientist in charge of HIPASS, hopes to answer. 'Looking at different types of galaxies might help us understand how they form,' she says. 'And we'll be able to look at the relationship between new stars and hydrogen gas, to see what sort of environment stars form in.

The survey will also help astronomers understand a mysterious entity called the 'Great Attractor', which is slowly but surely drawing galaxies towards it.

'Scientists have discovered that all the nearby galaxies are moving towards a centre,' Haynes says. 'We don't know what it is, but we assume it's a huge gravitational centre of attraction and the survey will help us locate precisely where it is in the Universe.'

It seems a more detailed analysis of the HIPASS data could finally reveal truths about our Universe that are stranger and more startling than Hollywood fiction.

What is a **galaxy?**

A GALAXY is a conglomeration of stars, gas, dust and planets. They begin life as immense clouds of gas (mostly hydrogen), from which stars condense. Initially, they have no specific shape or internal structure, but over millions of years their rotation (like the Earth around the Sun) moulds them into a 'spiral' or disc form.

Like a flying saucer, our spiral Milky-Way galaxy contains a central core of older stars from which radiate 'spiral arms' containing a lot of gas, dust and younger stars. Our sun lies in one of these spiral arms.

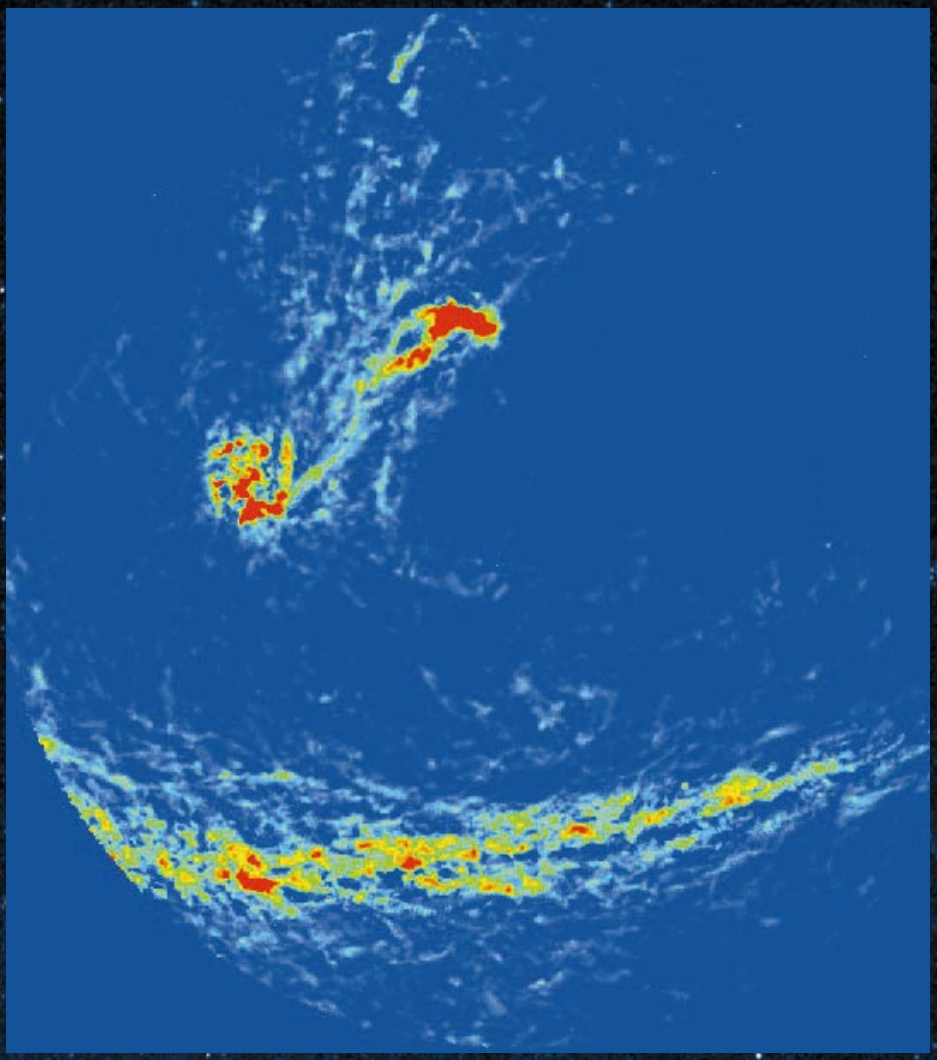
As well as spiral galaxies, astronomers have identified 'elliptical' and 'dwarf'-galaxies. Elliptical galaxies are thought to have formed by the merging of disk galaxies early on in the life of the Universe. They contain a large number of older stars and little or no gas and dust, which has been used up in the formation of stars. Elliptical galaxies may then form a sphere and eventually a black hole - a large gravitational centre.

Dwarf galaxies have a lower mass than spiral or elliptical galaxies. This means their internal spin is reduced so they tend to be 'blob-like' rather than disc shaped.

The nearest galaxies to the Milky Way are the Magellanic Clouds, 180 000 light years away (one light year is about 9500 billion kilometres). The Magellanic Clouds rotate around the Milky Way in much the same way that our moon rotates around the Earth.

Abstract: With a new radio wave 'receiver' linked to the Parkes telescope, astronomers are probing hundreds of galaxies once obscured by interstellar dust. The receiver picks up radio waves emitted by hydrogen gas, a basic building block of galaxies and stars. The 'HIPASS' – HI Parkes All Sky Survey has unveiled more than 600 new galaxies behind the Milky Way, which obscures about 15% of the southern sky, and 900 new galaxies in the remainder of the southern sky and part of the northern sky. The resulting map will help astronomers understand the structure, distribution and formation of stars, galaxies and extra-galactic matter and answer questions about 'dark matter', dark gas clouds and a mysterious entity called the 'Great Attractor'.

Keywords: galaxies, galaxy formation astronomy astronomical mapping, astronomical surveys, dark matter, gas clouds HIPASS (HI Parkes All Sky Surveys).



Left: The Large and Small Magellanic Clouds are the closest galaxies to the Milky Way. Seen here in the top left of the image, these dwarf galaxies are 180 000 light years from the Milky Way, which stretches across the bottom of the image. The different colours represent different intensities of the radio emission from hydrogen gas, which is being sucked out of the clouds by the gravitational pull of our own galaxy. The HIPASS survey will help astronomers understand how galaxies such as the Milky Way gravitationally interact with neighbouring galaxies.

Below: The HIPASS survey has enabled radio astronomers to map galaxies and gas clouds in the southern sky in three dimensions (latitude, longitude and into space). Because the Universe is expanding (like the cloud from an explosion), the further a galaxy is away from us, the faster it recedes from us. As a result, radio waves emitted by the hydrogen in galaxies and gas clouds, are more stretched out the further the objects are from Earth. The degree of stretching enables astronomers to work out the velocity and therefore distance of the object from Earth. This distance is recorded as different colours on the map, which covers the whole southern sky, from the south pole (bottom) to the celestial equator (top).