Explainer: What is the Great Attractor and its pull on the Milky Way?

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An artist's impression of the galaxies found in the 'Zone of Avoidance' behind our Milky Way. Credit: International Centre for Radio Astronomy Research

Around four decades ago, astronomers became aware that our galaxy, the Milky Way, was moving through space at a much faster rate than expected.

At 2.2-million kilometres an hour, the speed of the Milky Way through the cosmos is 2,500 times faster than a cruising airliner; 55 times more than the escape velocity from Earth; and a factor of two greater than even the galaxy's own escape velocity!

But where this motion comes from is a mystery.

The Big Bang theory of our origin tells us that every point in the universe should be flying apart from every other point. Nevertheless, galaxies on either side of us should be moving at similar recession velocities, which should result in no net motion in the Milky Way's frame of reference.

Net motion can arise from nearby clumps in the distribution of matter, like a massive cluster of galaxies. The additional gravitational attraction of such a galaxy cluster can slow down, and even reverse, the expansion of the universe in its immediate vicinity.

But no such cluster is obvious in the direction of the Milky Way's motion. There is an excess of galaxies in the general vicinity, and an excess of radiation visible in X-ray telescopes. But nothing that in any way seems large enough to explain the results.

So are we seeing an over-density of pure dark matter? Or is the current theory of the origin of mass and motion incorrect? Astronomer Alan Dressler, of the Carnegie Institution, used the former explanation, famously dubbing the missing concentration of matter the "Great Attractor."

But another explanation may lie in the fact that the inferred direction of the missing matter is not too far away from the direction of the Coalsack nebula, which lies deep within our own Milky Way.

The hidden attractor

Could our own Milky Way be moving through space like an edge-on spinning disc, obscuring the very source of a distant gravitational attractor? Could there be a super-massive cluster of galaxies (it would need to be the equivalent of 10,000 Andromeda galaxies) that is somehow being missed because its being obscured by the dense layer of dust associated with the thin disc of the Milky Way?

With that in mind, in the late 1990s, our team began using an innovative instrument on the iconic Parkes telescope, in New South Wales, simply known as the Parkes multibeam receiver. The unique sensitivity and field of view of this receiver allowed us to make progressively more sensitive radio surveys of the sky.

These surveys were made by tuning the receiver to what is known as the 21cm line of neutral hydrogen. Although a weak line, the sensitivity of the receiver was such that thousands of galaxies could be detected in "blind" surveys.

Moreover, at radio wavelengths, radiation passes straight through the dust layer in the Milky Way. The Milky Way essentially becomes invisible.

The HI Parkes All-Sky Survey (HIPASS) provided the first shallow survey of the whole southern sky. In fact, HIPASS was the first sensitive sky survey for extragalactic hydrogen ever made by any telescope. But nothing unexpected was found behind the Milky Way.

Other shallow surveys by our team targeted the Milky Way itself. Only a mild galaxy over-density was seen.

But it was recognised that deeper observations were needed. Theoretical models (particularly the so-called Lambda-cold-dark-matter model) only come under suspicion if nothing is found within a distance of 200 million light years.

Therefore, a long series of deeper observations of the local universe behind the disc and bulge of the Milky Way was conducted, again with the Parkes telescope.

From out of the data

These finished in the mid-2000s. Due to the extra difficulty of analysing radio data in the Milky Way (there is extra noise created by cosmic rays in our galaxy) and the dispersal of our team, it took until last year for all the data to be fully analysed and submitted for publication.

Within five degrees of the Milky Way's disc, we found altogether 883 galaxies plus a further 77 in the two bits of the northern Milky Way, visible from Parkes. Only a small number of these galaxies had a previous optical redshift and therefore distance estimate.

But when we looked at data from new infrared surveys, combined with data from our own brand-new deep infrared survey (infrared or heat radiation passes much more easily through dust), we were able to confirm stellar counterparts for almost 80% of the galaxies. The rest are too deeply embedded in the Milky Way to be confirmed with any existing optical or infrared telescope.

The discovery of so many previously hidden galaxies created quite a bit of excitement. But given that we didn't find the Great Attractor, why all the excitement?

It would be nice to think that it was because the mystery has deepened even more. We did find new galaxies, clusters of galaxies and new strands in the cosmic web. Just not enough to explain our motion, so there is still the mystery of what is the "Great Attractor" that has this pull on our Milky Way.

I think most of the excitement was generated by the simple act of unveiling the universe a little bit more, like the early explorers completing maps of the blank southern hemisphere.

Further exploration

So what comes next? It just so happens that Australian astronomers are in prime position to further explore structure and motions in the nearby universe. Radio surveys such as CAASTRO's 2MTF survey, which also uses the Parkes telescope to calculate galaxy distances, are already making new contributions.

Better still will be the WALLABY survey, for which I am co-principal investigator with Dr Baerbel Koribalski, to be executed with the new CSIRO Australian SKA Pathfinder (ASKAP) telescope, starting later this year.

This will allow us to make massive inroads into the detailed exploration of the radio universe, as will the Square Kilometre Array (SKA) itself. At optical wavelengths, the Australian Astronomical Observatory and the ANU are leading a new survey, called TAIPAN, which will target elliptical galaxies to explore more distant regions.

Theorists are also exploring whether the space-time metric we use to describe the universe may no longer be valid, and whether general relativity itself may need modification on large scales.

It's early days yet, and major shifts in the cosmological paradigm require incontrovertible evidence. Nevertheless, the mystery behind the Great Attractor is an enduring one and may not be fully understood for a few more years.

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