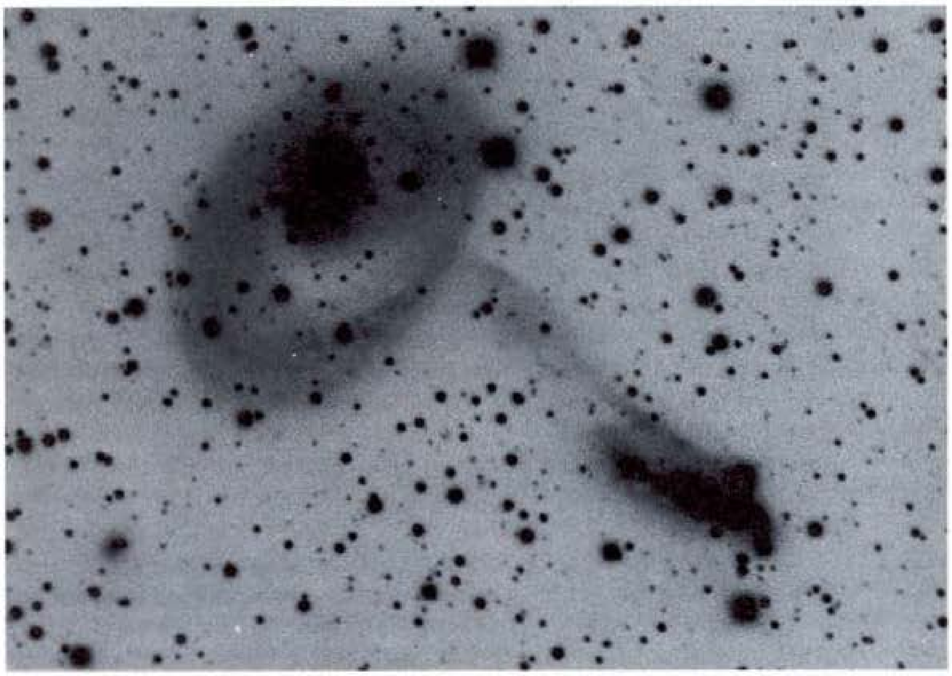
Towards a bigger Milky Way?

Opposites may attract, but with the hold of gravity it's a case of like attracting like. This phenomenon extends into the realms of the large-scale structure of our universe.



Two far distant galaxies just after a collision — a thin tendril of gas, dust, and stars connects the two.

Stars are gravitationally bound to one another in individual galaxies, which themselves appreciate the company of others and group together in clusters of up to a thousand galaxies. These clusters, in turn, congregate in even larger aggregations to form superclusters.

Our earth circles an average sort of sun set in one of the outer spiral arms of an average sort of galaxy — the Milky Way — that is part of a collection of galaxies forming a cluster rather affectionately termed the Local Group. 'Local', however, is a bit of a misnomer, because our 200-odd neighbours span a stretch of the universe more than 6 million light years in extent. Even the nearest galaxies — the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC) — are separated from us by the enormous distances of 160 000 and 200 000 light years respectively.

These two wispy, ill-defined balls of light are named after the Portuguese explorer, Ferdinand Magellan, who first brought them to the attention of Western man in the official report of his circumnavigation of the globe. Although the Clouds are visible in the lower latitudes of the Northern Hemisphere, they are most prominent in the southern skies, putting Australian astronomers in a good position to study them.

The Magellanic Clouds provide the best opportunity for studying galactic structure and composition. Both contain a wide variety of stars, nebulae, and star clusters, with some of the objects — particularly those in the LMC — having an astonishing size when compared with those found in the Milky Way. One giant star cluster, the 30 Doradus or Tarantula Nebula, contains more than 100 supergiant stars shining with such brilliance that, if they were in the position of the Orion Nebula (some 1200 light years away), they would cast easily visible shadows on earth. One of these supergiant stars, S Doradus, is a million times more luminous than the sun, and has a diameter larger than the earth's orbit.

An Australian focus

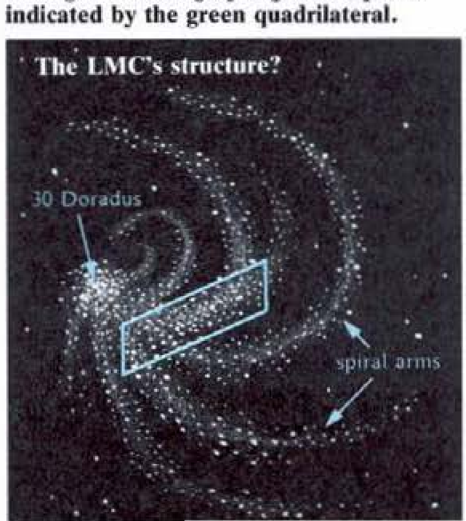
Two Australian groups — one based at the Australian National University's (ANU) Mt Stromlo observatory, the other in the CSIRO Division of Radiophysics — have provided the bulk of the observations made on the Magellanic Clouds. Among their continuing concerns, the astronomers are trying to unravel the structure of the Clouds and their relation to each other and to our own Milky Way.

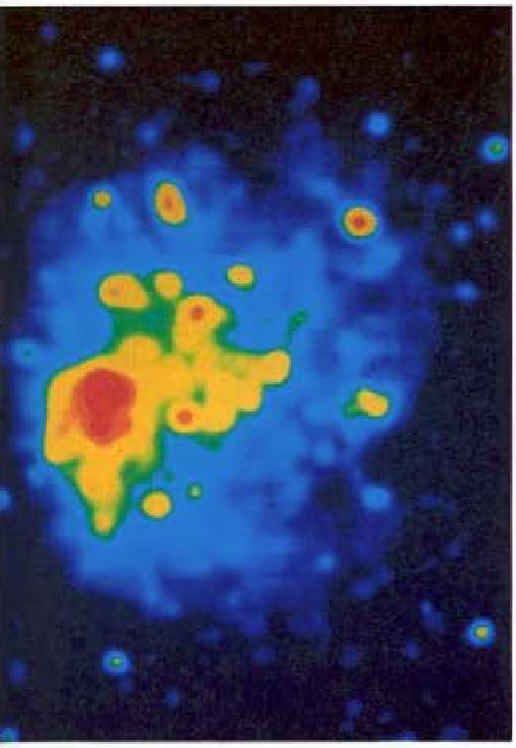
Optical astronomy provides a fairly general picture, but radioastronomy, in recording the noise generated by the fluctuations in the atoms and molecules circulating within the galaxies, helps reveal the finer detail. Pioneering studies by Dr Frank Kerr, Dr Brian Robinson, Mr Jim Hindman, and Dr Dick McGee, of CSIRO, revealed that the Clouds are embedded in an extensive envelope of hydrogen and they showed later that a bridge of gas links the two. More detailed CSIRO surveys of both Clouds by Mr Hindman, Dr McGee, Ms Janice Milton, and Dr Lynette Newton, helped flesh out the radio-picture.

The ANU group, consisting of Professor Don Mathewson, Dr Vince Ford, and Dr Philip Schwarz, have concentrated on providing the optical link, first through the Mt Stromlo telescopes, and then through the larger Siding Spring telescopes in northern New South Wales. However, they have also done some radioastronomy, with the highlight being the discovery by Professor Mathewson and Ms Martha Cleary, in collaboration with Mr John Murray of CSIRO, of the Magellanic Stream — a long trail of hydrogen gas apparently drawn out from the Clouds and possibly moving towards the centre of the Milky Way. The knowledge garnered by the two groups has led to some tantalizing theories on the evolution and interactions of the Clouds with one another, and with our own Milky Way.

According to Professor Mathewson, the Magellanic Clouds are quite small when compared with the Milky Way. The LMC has a diameter about half, and a mass about one-tenth, of the Milky Way's. The SMC is even smaller; its diameter is about one-third that of the Milky Way, and it only contains about one-fortieth of the mass.

Recent research suggests that the LMC has a spiral structure with the arms emanating from 30 Doradus. The bar of stars, prominent in the photograph taken through the Siding Spring telescope, is indicated by the green quadrilateral.





This computer-transformed radio-photo of the Large Magellanic Cloud gives some idea of its structure. The brightest region appears red.

About two billion years ago — long after our own galaxy coalesced into a regular galactic structure — the Magellanic Clouds were still largely gaseous. But we know from the age structure of stars in the LMC that something happened around that time to trigger off a bout of star-forming activity. And it might well have been that a close approach to our own galaxy provided the gravitational impetus to create stars out of gas. Most of the visible stars in the LMC and the main body of the SMC were formed during that time.

The structures that have since evolved have perplexed astronomers for many years. Galaxies can generally be dumped into one of two groups: the wonderful pinwheel shapes of the spiral galaxies, or the more diffuse structure of the elliptical galaxies. The blobs of light that constitute the Magellanic Clouds defied such classification and they were pushed into the 'too hard basket' by being labelled 'irregular' galaxies.

In the early 1960s Dr McGee completed an accurate radio survey of the hydrogen distribution in the LMC and suggested that it could be classified as a barred spiral — or a spiral galaxy that has arms of gas, dust, and young stars emanating from a central bar of stars, with the whole mass rotating. However, Dr McGee's suggestion was the subject of some dispute.

If the structure of the LMC was a difficult topic, that of the SMC was simply baffling. Estimates of the velocity of the hydrogen gas in the Cloud — achieved by measuring the Doppler shift in the radiation from the Cloud — led one early researcher to conclude that the galaxy contained separate expanding shells of gas, but this added little to any understanding of the Cloud's structure, since the origin of these shells was a complete mystery.

A high-quality photograph, taken through the Siding Spring telescope, of the Large Magellanic Cloud. The proposed centre of the galaxy — 30 Doradus — is the bright red/white region at the left.

Some structures?

Only in recent years have Australian astronomers been able to advance plausible explanations of the structure, history, and fate of the two Clouds.

A major reason for this new understanding is recent technological improvements. According to Dr Ray Haynes of the CSIRO Division of Radiophysics, most of the theories about the Magellanic Clouds are based on the surveys performed by Dr McGee and Professor Mathewson more than 20 years ago; meanwhile, instrument sensitivity and enhanced-image-processing techniques have shown remarkable advances.

Exploiting this new technology, Dr Haynes and Mr Murray — together with two West German collaborators from the Max Planck Institute for Radioastronomie, Dr Uli Klein and Dr Richard Wielebinski — focused CSIRO's Parkes radiotelescope onto the LMC once again. This time, though, improvements to the telescope's receiving equipment, and computerized image-processing, made their new survey approximately four times more sensitive than earlier studies. And their results suggest a bit more order in that diffuse — at least to the naked eye — blob of light hovering over our Southern Hemisphere.

The photo (left) of the LMC shows a fairly irregular pattern that the diagram on page 24, derived from the radio-survey, helps resolve. This work could yet see the LMC being classified as a spiral galaxy, but with the qualification that it is an asymmetric spiral since its putative centre — 30 Doradus — is way out on one edge of it. Why the galaxy's centre — where large numbers of stars are being formed — is so out of kilter with both its apparent centre of mass and its centre of rotation remains a mystery.

Worlds in collision?

Several explanations for the asymmetry of the 30 Doradus region have been advanced. One suggests that it is an intrinsic feature shaped by the internal structure of the galaxy. Another suggests that the galaxy's disk is warped and, through our line of sight, the centre of star-forming activity appears to be displaced. A third postulates that tidal interactions between the SMC and the LMC cause the distortion.

Because the scientists observed a conspicuous extension of radio emission from the SMC towards the LMC, they favour

If you were able to see the radio-emissions from hydrogen, and were transported to a point behind the Magellanic Clouds, this is how the Clouds, the associated Magellanic Stream, and our own Milky Way would look.

the last suggestion. And while such tidal interactions occur over almost incomprehensible distances, they are common features in the evolution of any cluster of galaxies.

In fact the baffling structure of the SMC may be explained through the rather startling suggestion by Professor Mathewson and Dr Ford that, some 200 million years ago, the Magellanic Clouds nearly collided, with the impact of the close encounter splitting the SMC in two. When we look at the SMC we may actually be getting a view of two galaxies, superimposed along our line of sight. The 'true' SMC lies closest to us, but behind it is what the two scientists have named the Mini-Magellanic Cloud.

That continuing interaction between our galaxy and the Magellanic Clouds is occurring is evidenced by the presence of a long ribbon of hydrogen gas, termed the Magellanic Stream, that stretches across 120 degrees of the sky. This gas apparently has its origins at a point in between the two Clouds and, while not visible to the naked eye, is readily detected by its radio emissions.

Among a number of theories about the origin of the Magellanic Stream, the most popular is that a close encounter between the Milky Way and the Magellanic Clouds raised tides within the Clouds and drew out the plume of gas. Other theories, most notably those developed by Professor Mathewson's group at the ANU, suggest that the Stream is a consequence of the Magellanic Clouds' movement through the 'halo' that surrounds our galaxy.

The halo has resulted from the regular supernovae explosions that occur among the hundred billion stars in the Milky Way. A supernova is the final death-throes of a supergiant star many times more massive than our own sun, which, under the influence of its own huge gravity, implodes and then rebounds with almost unimaginable violence, scattering starstuff all around the neighbourhood. Some of this matérial, especially when the explosion takes place on the outer edge of a spiral arm of the galaxy, moves far away from the plane of the galactic disk to create a diffuse gas, or 'halo', through which the Magellanic Clouds now move.

As the Clouds move through the halo the particles exert pressure on their gas, and either this pressure draws some of it away from the main body of the galaxy to form the hydrogen ribbon, or else the galaxies perturb the halo, forming eddies that act as gravitational centres, attracting matter in the near vicinity. Either way the Magellanic Clouds lose energy as they move through the halo.

The Magellanic Stream is now the subject of intense study because, given its gravitational interaction with our galaxy, accurate measurements of its movements in relation to both the Clouds and the Milky Way will help define the extent and mass of the Milky Way's halo and provide a better estimate of the mass in our galaxy. Since our Milky Way is an average sort of galaxy these findings could be extended to the rest of the universe and help determine whether the universe is open — and will continue expanding for ever — or has enough mass for gravity to force it to close back upon itself before it undergoes another 'Big Bang' cycle.

These sorts of studies in our own galactic backyard have far-reaching implications whose effects will not be obvious for eons. Of more immediate interest is the speculation that the friction associated with the Clouds' passage through the Milky Way's halo will influence their orbit, and eventually the Milky Way may capture its neighbours. Some astronomers believe that this capture has already taken place and that, in another two billion years, gravity will have its way and the Magellanic Clouds will collide with our galaxy.

Such a collision would not be as explosive as one would think: the greater mass of our galaxy will see most of the gas in the Clouds being stripped away, eventually being committed to the formation of a new generation of stars in a bigger Milky Way. Most of the stars would pass through the plane of our galaxy unscathed, and be left to continue scattered, lonely orbits around our newly enlarged galaxy.

Such cannibalism is not unusual; isolated orbiting groups of stars, the possible remnants of similar encounters, have been observed around other galaxies and there is a suggestion that the Milky Way might have already cannibalized one other companion galaxy in its younger days. The galaxies in our Local Group obviously have a big attraction for one another and, in billions of years time, who knows what part of the universe will eventually attract our very own Milky Way?

Wayne Ralph

More about the topic

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