Chapter 8

Conclusions and Future Prospects

Throughout this thesis, three main themes have provided the underlying framework linking the various aspects of this study. These are:

1. The need to understand the instrumentation being used for astronomical observations to maximize the astrophysical returns.

2. The role that surveys play in enhancing the understanding of the Magellanic Clouds in particular and the Universe in general. Apart from the obvious statistical applications of surveys, they are a valuable means of identifying sources that are interesting in their own right, and which justify detailed follow-up studies.

3. The issues involved in the accurate, and justifiable, classification of sources, which often needs to be done with only limited observational data.

Concluding remarks and thoughts about future areas of study following each of the three themes are discussed below.

Instrumentation and Astrophysics

A thorough understanding of the instrumentation and data analysis techniques being used is vital in order to maximize the scientific results of detailed studies of various astrophysical phenomena. This is particularly true when the instrumentation is new, when many "real-world" scenarios have yet to be tested on the unfamiliar instrument, such as was the case for observations with the Australia Telescope Compact Array reported here.

Detailed knowledge of the instrumentation of existing facilities is also important. An understanding of the limitations and strengths of the particular observing technique, and of the methodology used to obtain and present published catalogues, is necessary if meaningful comparisons are to be made with such data. Such understanding is important when the comparisons are within the same wavelength band such as radio, and is even more critical when comparing data from different bands such as radio and X-ray.

The convergence of instrumentation capabilities and scientific investigations is likely to continue with developments in millimetre wavelength and optical interferometry. Understanding of these different aspects of astronomy will be essential to design, construct and operate the next generation of radio telescopes such as the Square Kilometre Array (SKA). Scientists and engineers will continue to challenge each other to build improved instrumentation to allow current and new astrophysical questions to be answered.

Surveys and Sources

Radio surveys may seem, to some, a rather mundane and uninteresting area of astronomical research. However, the targeted survey of both the Small and Large Magellanic Clouds presented in this thesis provided a challenging and interesting environment in which to investigate the properties of the selected sources.

The observations undertaken in the Small Cloud targeted a known SNR, two known H II regions, four sources with marginal X-ray detections and a selection of other sources which appeared compact in the MOST 843 MHz survey images. As expected, most of these were background sources, but further observations of three sources, BKGS 32, 0021–742 and 0032–738, are required if these sources are to be classified with some certainty.

The known SMC SNR 1E 0102.2–7219 was observed as part of the initial SMC survey and its detailed structure was revealed for the first time in the ATCA 5 GHz image. These results led to a dedicated multi-configuration observational campaign to image this SNR at four radio frequencies to facilitate a more complete comparison with the existing optical and X-ray data. These ATCA observations, and their interpretation, led to this object being the subject of intensive study shortly after the launch of the *Chandra X-ray Observatory* which is able to image a source with angular resolution comparable to the current generation of ground-based radio interferometers. Such resolution at X-ray wavelengths was unheard of, and offers exciting scientific opportunities. The radio observations reported in this thesis and the corresponding X-ray results have rekindled interest in this source. Further dedicated ATCA observations are now warranted to improve the dynamic range of the current images, particularly at 8 GHz, and to attempt to determine the presence of any polarized emission. Such new observations would take advantage of significant improvements in the ATCA instrumentation since the observations reported in this thesis were obtained.

The LMC observations targeted 41 sources, all of which were relatively compact at 843 MHz and had flux densities greater than 200 mJy. An objective method of classification of radio sources was developed for this sample. Follow-up observations for ten of these LMC sources are warranted, as in many cases a compact source and some diffuse extended emission are located near to each other. Such observations should image both the extended region and compact object and may reveal that most of the compact sources are unrelated background objects. However, results from these observations may identify exciting sources for follow-up studies similar to those for SNR 1E 0102.2–7219 in the SMC reported in this thesis.

Source Classification

A number of issues involved in the classification of sources were highlighted in the analysis of the SMC sample. These included a consideration of uncertainties in radio flux density measurements and the impact this has on the accurate determination of the radio spectrum. Particularly important are possible calibration and baselevel offsets – relevant when comparing interferometer data with single-dish results – and the fact that an interferometer does not sample emission on large angular scales. This last effect can lead to an underestimate of the flux density and significant differences between the observed and the actual morphology.

The issues raised as a result of the analysis of the SMC data led to the development of a more structured and logical approach to classifying sources in the sample observed in the LMC. The "decision tree" presented in Chapter 5 was used to determine if the 5 GHz ATCA and catalogued Parkes flux densities could be reliably used in the determination of the radio spectrum and, in turn, if the spectral index could be used as a reliable metric from which an accurate source classification could be made. This approach has been shown to be successful, removing much of the ambiguity in the process and providing more reliable source classifications.

The study of 0101–7226 reported in Chapter 7 stands as a valuable reminder that source classification is an imperfect process. Such a source, which is quite different from the "typical" members of its class, could easily be misclassified on the basis of limited survey data even after a careful application of a decision tree process.

Source classification remains a difficult and challenging problem and is likely to continue to be so into the immediate future. Whilst the methodology presented in this thesis was developed to address a specific sample of sources, all located relatively close to each other, it would be interesting to apply this technique to other radio surveys at centimetre wavelengths.