Chapter 9

Summary and Future Work

Here we briefly summarize the major findings of the previous chapters and discuss projects for future study.

9.1 Summary

This thesis presents data from the H I Southern Galactic Plane Survey. We have surveyed the H I and 21-cm continuum emission in the Galactic plane between $l = 253^\circ - 358^\circ$ and $b = \pm 1^\circ$ at an angular resolution of $2'$ and spectral resolution of 0.8 km s^{-1}. The survey constitutes over an order of magnitude improvement in angular resolution and sensitivity over previous surveys of this region. The general goals of the survey are to understand the structure, dynamics and thermal distribution of the neutral hydrogen component of the ISM. We have full polarization information that we are using to study the magnetic field structure of Milky Way and magneto-ionic medium. The SGPS has taken its place among three very large surveys of the Galactic Plane that form the International Galactic Plane Survey. This collaboration seeks to survey the entire Galactic plane at an angular resolution of 1 arcminute, a spectral resolution of 1 km s^{-1} and to a sensitivity limit of 1 K.

In this work we have focused on presenting the survey goals, observations and analysis procedures and some of the results of the survey. In particular, we have studied H I shells in the Galaxy. In Chapter 1 we described the survey goals and outlined some of the immediate projects underway with these data. In Chapter 2 we explained the Parkes portion of the survey. We described the observing method and the data reduction strategy. Because some characteristics of the data reduction are non-standard, in particular our treatment of frequency-switched data, we explained these in detail. The chapter summarizes the tools developed and fully explains how to use them. We concluded the chapter with a summary of the ten $14^{\circ} \times 22^{\circ}$ data cubes that were produced and will be made public.

In Chapters 3 and 4 we carefully examined two pairs of large H I shells discovered in the SGPS Parkes data. Chapter 3 presents the outer Galaxy chimneys, GSH 277+00+36 and GSH 280+00+59. Both shells are extremely large, $R_{sh} \approx 305$ pc and 215 pc, respectively, and appear to be chimneys that have opened to the Galactic halo. These shells are located on the edge of the Sagittarius-Carina spiral arm. In Chapter 4 we presented GSH 304-00-12 and GSH 305+01+24, two shells behind the Coalsack nebula. GSH 304-00-12 is particularly large in angular diameter, covering $29^{\circ} \times 20^{\circ}$, and expanding from the Sagittarius-Carina spiral arm into the interarm region. Using a simple numerical model of a stellar wind-blown bubble, we show that GSH 305+01-24 is associated with the Centaurus OB1 association.

Chapter 5 is a catalog of large shells in the SGPS region. We presented fifteen additional new shells and discussed their individual properties. We found that one, GSH 337+00-05 is associated with an OB association, Ara OB1, that another, GSH 298-01+35 is a chimney candidate, and that many shells are joined. We discussed the radius and expansion velocity distribution and compared those with catalogs compiled from other galaxies. We also began to explore H I shells at high resolution. We showed that all shells have very thin, dense, walls and suggest that these may help to distinguish pressure-driven shells from shells caused by gravitational instabilities (Wada et al. 2000). These high resolution observations open the door to studies of instabilities in shells, and will hence allow us to probe the physical conditions of shell break-out much more accurately.

Chapter 6 began our discussion of the ATCA survey. In this chapter we described the observing technique for this survey, the largest mosaicing survey completed to date. We explain the process of calibration and solutions developed for problems with survey data. We elaborate on techniques for combining single dish and interferometer data and finally present selected images from data cubes of the full survey region.

In Chapter 7 we presented an analysis of the SGPS Test Region ($325\overset{\circ}{.}5 \leq l \leq 333\overset{\circ}{.}5$; $-0\overset{\circ}{.}5 \leq b \leq 3\overset{\circ}{.}5$). The objective of this chapter was to elucidate possible uses of the SGPS data, particularly distance estimates from continuum absorption and direct comparisons of the continuum and H I emission. The analysis focused on the interaction of massive stars with the ISM. In particular, we examined the ISM around H II regions, supernova remnants (SNR) and small H I shells. We presented absorption spectra towards two SNR that provided new distances to these remnants. These results serve to show that a wealth of information about the morphology of H II regions and SNRs can be obtained from observations of the surrounding medium.

Finally, in Chapter 8, we presented the distribution of H I shells in the Galaxy, in particular with respect to spiral structure. By examining the distribution of SGPS shells in l-v space and with respect to the Taylor & Cordes (1993) model for the spiral arms we find that many large shells are in interarm regions. We included the Heiles (1979, 1984) shells and found that many of those shells are also between the spiral arms. In addition, we confirmed that the largest shells are at large galactocentric radius. Using spiral density wave theory we showed that shells expanding into interarm regions may experience exaggerated expansion down a density gradient that extends from the arm into the interarm region. Additionally, the timescale and several generations of massive stars involved in the formation of a large shell may lead to a spatial offset of the shell away from the leading edge of the spiral arm.

9.2 Future Work

This dissertation asks as many questions as it answers. But, of course, the Southern Galactic Plane Survey is just beginning and therefore the scientific opportunities available through this data set are just now revealing themselves. Some of the questions that this project was designed to answer remain unanswered: what role do H I shells have in the energy budget of the Galaxy? what is the porosity of the Galaxy due to H I shells? Other questions appeared along the way and proved intriguing to solve. We hope that the SGPS may help us to answer some fundamental questions about the structure and dynamics: where are the spiral arms? what is the large scale density distribution of the neutral medium? Perhaps most important is that the SGPS will provide a resource for astronomers of all varieties.

It will also be particularly interesting to expand the shell catalog throughout the Galactic plane and include small shells. With a statistically complete Galactic shell catalog we should be able to determine what percentage of shells are between the spiral arms and if there is a higher probability of finding small shells in the arms and large shells in interarm regions. An expanded sample will also allow us to study shells in a variety of evolutionary states.

In Chapter 5 we initiated a discussion of the high-resolution properties of supershells. Clearly, we have only just begun to explore these opportunities. Small-scale Rayleigh-Taylor instabilities will allow us to study the density and pressure structure at the shell walls and how shells interact with one another. As suggested, the density structure of the shell walls may allow us to distinguish pressure driven shells from those created by gravitational instabilities. However, in order to confirm this suggestion we need to expand the high resolution Galactic shell catalog and search explicitly for shells created by gravitational instabilities.

Follow-up observations of the outer Galaxy chimney GSH 277+00+36 are underway as part of a project to study how chimneys supply gas to the halo and how they evolve. We will obtain high resolution ATCA data on the chimney break-out of GSH 277+00+36 and higher sensitivity Parkes data to search for condensations of expelled interior gas. These data should help us to understand the relationship between supershells and chimneys; probe the disk-halo interaction through a study of the process of chimney formation; and determine whether shells on the trailing edges of spiral arms experience a break-out process into the inter-spiral arm region which is physically similar to break-out away from the plane. In the ATCA data we hope to see evidence of instabilities at the shell caps, shearing along the chimney walls, dissolving or recombining H I density enhancements in the chimney interiors, and polarization structures that explore the layers of ionization and magnetic fields in the shocks. All of these clues will help us understand the external density gradient, the energy requirements for break-out, and the age of the objects. The role of magnetic fields in the transport of matter from the disk to the halo may also be significant. Magnetic fields may form unstable configurations, such as Parker instabilities, through which energy stored in the fields may move additional matter out of the disk. Similarly, the role of magnetic fields in break-out or containment of shells expanding into interarm regions has yet to be explored. Contemporaneous full polarization continuum observations will allow us to explore the polarization structure of chimneys at high resolution for the first time.

The next several years will be an exciting time for Galactic H I studies as the new surveys are analyzed and their many results revealed. I look forward to being a part of this major undertaking.