CHAPTER VI

CONCLUSIONS AND FUTURE WORK

In this chapter a summary of the results obtained for this thesis are presented in Section 6.1, some conclusions in Section 6.2, and suggestions for future work are presented in Section 6.3.

6.1 Summary of Results

This thesis presents MERLIN spectral-line polarisation observations of OH and H_2O masers towards the star-forming regions, S140-IRS1 and W49 A. No emission was detected in the excited OH spectral lines at 6.0 GHz, but detailed results of observations of S140-IRS1 in the OH 1665 MHz and the H_2O 22 GHz spectral lines, and of W49 A in the 1612 and 1720 MHz OH maser satellite lines are presented. The OH masers in S140 are distributed in two distinct groups separated by $\sim$ 1 arcsec. Both groups have similar velocity patterns, and the overall number of spots is small. The magnetic field, deduced from measurements of Zeeman splitting, is uniform in its direction (towards us), with values ranging from –5.2 to –6.9 mG. The direction of the magnetic field and the location of the OH maser regions indicate that they may be associated with the CO outflow from S140-IRS1. The strongest water masers are associated with IRS1 and have a bulk proper motion towards the SE. However, their Doppler velocities are red-shifted, whereas the CO outflow is blue-shifted in this direction. A separate pair of masers, $\sim$ 15 arcsec to the WSW, appear to be expanding away from a common centre. Additional water maser components appear up to 30 arcsec from IRS1 with no obvious counterparts or alignments with any of the known outflows in the region. The OH and water maser results suggest that there are multiple excitation sources. Further interferometric observations are required to clarify the situation.

The results of the observations of the 1612- and 1720-MHz OH masers in W49 A are described and show agreement with closely matching velocities with those determined from previous observations with the Very Large Array (VLA) by Argon et al. (2000). New masers have been discovered in W49 N and W49 S, the distribution of the OH masers in W49 S showing a parabolic form with strong evidence for a bow shock. The magnetic field strengths deduced from Zeeman measurements are found to be strong enough to play important roles in the star-formation process. Evidence of field reversal in the cases of W49 N, W49 SW and W49 S can be used to constrain future theoretical models.

6.2 The Absence of OH Masers

6.2.1 1.6 GHz Ground State Lines

In S140-IRS1 only the 1665 MHz OH masers have been detected. In a detailed analysis of the pumping schemes for 1612-MHz masers (Gray et al., 2005; Gray, 2007), it has been found that this line typically requires a substantial flux of pumping radiation at 53 and 35 μm. Although these results have been derived in the context of evolved stars, the pumping mechanism probably has more general validity, and so the absence of 1612 MHz radiation would, on the basis of this Far Infra-Red (FIR) pumping scheme, result from a radiation field which is too cold (radiation temperature50 K) in the maser zone. The main-line masers can be pumped by a cycle involving radiative absorption of 119 μm radiation, followed by a collisional decay (Gray, 2007). However, this analysis ignores FIR line overlap, which is very similar for both 1665 and 1667 MHz. The need for abundant 119 μm radiation, in conjunction with low fluxes at 53 μm, suggests a pumping radiation temperature between 25 and 50 K. The absence of the 1667 MHz masers, if the pump is similar for both main lines, can be attributed to competitive gain, in which the 1667-MHz inversion is 'robbed' by the 1665-MHz maser arising in conditions of strong saturation. It would then follow that the S140 OH masers are strongly saturated. The 1720 MHz inversion is probably collisionally quenched at the densities which support the other lines (see, for example, Fig. 2a of Gray 1991).

6.2.2 6.0 GHz Excited State Lines

No OH emission was detected at 6.0 GHz from both sources. Using the maser modelling of Gray et al. (1992), an upper limit to the hydrogen density in the S140 regions is less than 2×10^7 cm^{-3}, the number density of OH is less than 100 cm^{-3} and the kinematic temperature is less than 75 K. In the case of W49 A, which is believed to be the most massive star-forming region in our Galaxy, the main reasons for the absence of OH masers are probably because 1) this region has very low declination and far away from Earth therefore maybe there are some structures unresolved by MERLIN in its narrow dimension (0.005 arcsec) 2) the masers vary with time. Baudry et al. (1997) found a change in the integrated flux density from 0.8 to 1.1 km s^{-1} in 11 months.

6.3 Future Work

- A study of the proper motion of the OH masers towards S140-IRS1 might confirm the existence of a Keplerian disc as mentioned in Chapter 4.
- In this thesis, the polarization properties of the satellite line OH 1720 MHz masers towards W49 A have been studied in particular. However, a full polarisation study of the other OH maser transitions (e.g. 1612, 1667, 1720 MHz) and the methanol (CH_3OH) 6.7 GHz transition should help to confirm and complement the results in this thesis.

- VLBI observations are required to detect the associated maser proper motions towards the W49 S region to confirm the velocity structure of the cometary HII region.
- A detection of the 6.0 GHz OH masers would have been very useful in constraining the OH maser pumping models. Additional more-sensitive observations to detect these masers, perhaps even using a large single-dish radio telescope, would be invaluable.
- The new data in this thesis should help in a further analysis of a conical outflow model for the S140-IRS1 region.