Chapter 9

Thesis Summary

My thesis research focused primarily on identifying and characterizing pre-main sequence (PMS) stars in nearby star-forming regions. I carried out wide-field ($\sim$150–250 deg^2) optical photometric and spectroscopic surveys in and near the nearby Taurus and Upper Scorpius associations. These two regions represent very different star-forming environments. Known members of Taurus are primarily very young (1–2 Myr-old) and very low mass ($M >1$ M$_\odot$). The intermediate-age, $\sim$5 Myr-old region of USco is a massive OB association. The spatial coverages of my optical surveys in both Taurus and USco were chosen specifically to extend to regions well beyond areas previously explored in a similar manner.

In Taurus, the aim of my optical photometric/spectroscopic survey was specifically to probe for a distributed population of intermediate-age PMS ($\sim$5–10 Myr-old) stars outside of the young subclusters that are known to contain most of the young Taurus population. Because stars continue to move with the velocity of their parent cloud after they are born, in 3–10 Myr, the intermediate-age PMS stars could have traveled significantly far from their birth sites. The area I surveyed was sufficient to detect stars of $\lesssim$10 Myr old that originated in the current young regions of Taurus and subsequently drifted away.

From this work I found tens of young ($\sim$1–3 Myr) and intermediate-age ($\sim$5–10 Myr) stars both near the known Taurus population and to the east, but relatively few PMS stars of any age to the west. Based on this result and assessment of the proper motion distributions, I argued that the new PMS stars identified far from

Taurus cannot have originated from the vicinity of the 1–2 Myr-old subclusters. I proposed instead that they comprise a new, previously undiscovered region of recent star formation which *may* have formed out of a different part of the same molecular cloud that is forming the current Taurus population. Because the new PMS stars exhibit a range of ages from 1 to ∼10 Myr, if they do share a common parental cloud with Taurus, this new population would provide definitive evidence that the Taurus cloud has been forming stars for at least 10 Myr.

In USco, the aim of my optical photometric/spectroscopic survey was to probe beyond previously explored regions to identify large numbers of intermediate-age, 5 Myr-old low mass stars which had not yet been uncovered due to the inherent challenges of surveying an association that spans >200 deg^2 on the sky. From the spectroscopic data I have discovered 145 new low mass members of USco and over-doubled the number of previously known 5 Myr-old brown dwarfs. I used photometry and spectral types to derive effective temperatures and luminosities, and placed newly identified association members onto a theoretical HR diagram. These data were combined with pre-main sequence evolutionary models to derive a mass and age for each star. Using Monte Carlo simulations I showed that, taking into account known observational errors, the observed age dispersion for the low mass population in USco is consistent with all stars forming in a single burst ∼5 Myr ago. I also derived the first spectroscopic mass function for USco that extends into the substellar regime and compared these results to those for four other young clusters and associations. For the five regions considered, I find the low mass IMF to be dependent on environment in that associations that contain a significant number of O- and B-type stars produce more very low mass stars and brown dwarfs.

As follow-up to the optical surveys in USco, together with my collaborator John Carpenter, I have completed a program to measure mid-infrared photometry using *Spitzer* for 27 new substellar members. I have compared my 3.6–8 μm IRAC photometry for brown dwarfs in Upper Sco to similar observations by Carpenter et al. (2006) for higher mass stellar association members and find from this comparison that the frequency of brown dwarfs with disks at 5 Myr is indistinguishable (∼15%) from the fraction of 5 Myr-old low mass stars with disks. Thus, these observations add to the growing evidence that substellar formation and early evolution must proceed through very similar physical processes as those that form and shape low mass stars. I have additionally compared my *Spitzer* IRAC results to those from similar studies in the younger regions of IC 348, Chameleon I, and Taurus. I found a disk frequency of ∼40% for brown dwarfs from 1 to 3 Myr, declining sharply by 5 Myr. Thus, assuming environmental factors do not play a large role in the lifetimes of disks around the lowest mass stars and brown dwarfs (which does not have to be true), the evolution of circumstellar material must proceed rapidly around such objects between 3 and 5 Myr.

In total, my thesis worked produced two published papers on the photometric and spectroscopic surveys in USco (Slesnick et al. 2006a) and Taurus (Slesnick et al. 2006b), and I anticipate an additional two papers to be submitted by the fall. One will present the additional spectroscopic data in USco (chapter 5 and §8.1), and will include the analytical discussion of the age distribution in USco and the low mass IMF (chapter 6). The other paper will discuss results from *Spitzer* observations discussed in chapter 7. In addition to the papers that have (or will) come out of the surveys in USco and Taurus, I undertook two separate projects early during my time at Caltech, both resulting in publications. I completed a near-infrared spectroscopic survey in the ONC and derived the first spectroscopic substellar mass function for this cluster (Slesnick et al., 2004). Discussion of this work was given in chapter 6. I also worked on a project to characterize the star formation history and mass function of the high mass population in h and χ Persei (Slesnick et al., 2002). Results from this work are presented in appendix A.