My undergraduate research focused on T Tauri stars, which are the precursors of stars like our sun. These slowly contracting stars have strong magnetic fields and a circumstellar disk. Many have large, stable starspots on the photosphere that create periodic variability in the star's luminosity; this variability establishes the stellar rotation rate. Recent studies (Herbst et al., 2002) have revealed a bimodal period distribution in some cluster populations. Higher-mass T Tauri stars ($M > 0.25\,M_{\rm sun}$) have a period peak of slow rotators at about 8 days, while lower-mass T Tauri stars do not exhibit this period peak. The slow rotators are unusual; due to contraction and accretion torques, these stars should be spinning with periods of about 0.5 days. The magnetic disk braking model (Königl, 1991) suggests that the magnetic field interacts with the disk and transports enough angular momentum from the star to the outer disk to prevent these stars from spinning up. Both the bimodal period distribution and magnetic disk braking remain controversial.

Led by Dr. Ann Esin at Harvey Mudd College, our group chose to tackle this scientific question by looking at other T Tauri star populations for a bimodal period distribution. I spent summer 2002 working with two other students acquiring optical photometry of the young open cluster Berkeley 87. We used the 1-meter Pomona telescope at the JPL Table Mountain Observatory. We designed a six-week observing plan that maximized coverage of the cluster in relevant filters while retaining enough time resolution for well-sampled lightcurves. During observations we tackled a number of software problems with focusing and tracking, as well as hardware problems with our liquid nitrogen-cooled CCD camera. I also reduced and analyzed using IRAF routines for aperture photometry and fitting point-spread functions. In addition, during the winter I participated in a few nights observing isolated T Tauri stars in the near-infrared. The observations did not provide any useful data, but I learned a lot about the techniques (and frustrations) associated with infrared photometry.

In addition to observing duties, I pursued my interest in the theoretical problem of the slow rotators. I developed a model based on calculations by Wang (1997) and applied it to the T Tauri population of the Orion Nebula Cluster. I assumed that the stars with periods of 8 days were magnetically coupled to their disks. To achieve "torqueless accretion", I balanced magnetic and accretion torques. By using a stellar evolution model (D'Antona & Mazzitelli, 1994), I determined the required surface magnetic field strengths as a function of stellar mass, accretion rate, age, and period. I found that magnetic disk braking requires surface field strengths of about 1 kG, consistent with observations (Johns-Krull, Valenti & Koresko, 1999), but I could not identify any mechanism that would prevent disk-braking from occurring in low-mass T Tauri stars. I presented preliminary results at the 205th American Astronomical Society meeting in January 2005. I wrote my thesis on the topic of magnetic disk braking and received the Thomas Brown Award for senior thesis research. Dr. Esin and I have written a paper on this research that will be submitted to the Astrophysical Journal by the end of the year. My research will also be used as the foundation for another senior thesis project comparing the period distribution of known T Tauri populations of different ages.

During my undergraduate senior year, I designed and executed an observing project of Algol, an eclipsing binary with a drop in luminosity of over one magnitude in optical filters. I used a 0.3-meter telescope on campus and wrote a script to take short exposures in three colored filters during the transit. Using this data, a geometric model I developed, and the instrument response, I was able to constrain the spectral class (and therefore the temperature) of the secondary given the spectral class of the primary star. I was unable to observe the secondary eclipse, but assuming a circular orbit, I was able to constrain the inclination angle.

I also worked for Dr. Donald Hoard at the Spitzer Science Center on cataclysmic variables (CVs). Our goal was to expand the population of CVs with known colors, thus allowing us to distinguish between evolutionary models that predicted different populations of white dwarf companions. I used POSS1, POSS2, and 2MASS data for known white dwarfs and looked for CV candidates. Using DS9 software I determined an astrometric solution for the candidates and created finding charts for follow-up observations using the Spitzer Space Telescope.

I have started graduate research at Cornell with Dr. James Lloyd on extrasolar planetary transits across low-mass, cool dwarf stars. These stars are particularly good candidates for planet searches. Most stars in the local solar neighborhood are low-mass dwarfs. Their smaller size makes it far more likely to detect an Earth-like planet in a habitable orbit around a low-mass dwarf than existing surveys of sun-like stars. These star-planet systems should also have a lower contrast ratio, which make them the best candidates for direct imaging of planets. I am evaluating the photometric stability of near-infrared filters for the purposes of detecting a planetary transit around a low-mass star. I am determining the variability effects as a function of stellar spectral types, atmospheric water vapor concentrations, infrared filter, and telescope and camera response. To do this I must convolve observed spectra for M, L and T dwarfs, near-infrared filter transmission profiles, atmospheric transmission provided by the MODTRAN model, and the telescope and camera response for the Palomar 60-inch robotic telescope, the Palomar 200-inch Hale telescope, and the Mauna Kea Observatory. By identifying the best filter for infrared differential photometry for these low-mass stars, I will pave the way for future extrasolar planet transit photometry surveys. These results will also shape infrared instrumentation currently under development. Results should be submitted for publication in mid-2006.

Selected Publications:

R. S. Yamada and J. P. Lloyd, "Infrared Photometric Stability in Searches for Extrasolar Planets around Late-Type Dwarfs" (in preparation)

R. S. Yamada and A. A. Esin, "Modeling Disk Braking and Torqueless Accretion in T Tauri Stars" (in preparation)

R. S. Yamada "Magnetic Braking and T Tauri Stars: Some Theoretical Considerations". Senior Thesis, Harvey Mudd College. [2005]

R. S. Yamada and A. A. Esin, "Modeling Period Distribution of T Tauri Stars." poster, 205th AAS meeting. [2005]