Abstract. Some close binary star systems are able to form and retain planets, but the majority are not. The cause of this discrepancy is not known, and represents a key question in theories of planet formation. To test if there is a correlation between secondary star mass and planet occurrence, as predicted by some models of planetary system evolution, **I propose to construct a Markov Chain Monte Carlo fitting framework to accurately measure the physical properties of the components of very close, spectrally unresolved binary stars.** Using this fitting framework, I will explore the relationship between binary properties, especially secondary mass and planet existence, to explore different theories of planet formation.

Background and Motivation. The majority of solar-type stars exist in binary systems (Duquennoy & Major 1991; Raghavan et al. 2010), but formation in a binary system drastically suppresses a young planet's chances of survival: A binary companion reduces the occurrence rate of both planets and disks by ~2/3 (Kraus et al. 2016; Cieza et al. 2009; Kraus et al. 2012). Some process is reducing *some* planet formation, while not entirely suppressing it. **This unknown physics presents a key to understanding the processes that affect planet formation.** Understanding the possible relationship between a binary star's properties and a planet's existence within a system may clarify why only some planets that form around binary stars survive. **Theoretical models make different claims about which stellar properties impact planet survival,** so exploring system properties and comparing them to planet existence may reveal a correlation between stellar parameters and planet survival.

For example, an intermediate mass binary companion might perturb a circumstellar disk due to tidal forces, inhibiting planet formation and causing fewer planets to occur around binary stars with moderate mass ratios. A very low mass companion would not perturb a disk, whereas an equal-mass companion's tidal forces would be balanced by the planet host. An equal mass secondary could externally irradiate a circumstellar disk around the primary star in a system, possibly reducing the formation rate of planets by photo-evaporating mass in the disk. **These two scenarios can be separated by studying whether an equal-mass companion reduces the planet host rate in binaries, or whether a lower-mass companion has a greater effect.**

Determining the physics governing the connection between system properties and planetary survival rates requires techniques to accurately measure the physical parameters of the individual stars in the binary. However, with current analysis methods it is difficult to characterize the individual stars in very close binaries (<10 AU separation). These systems, identified by radial velocity measurements or high-resolution imaging, are unresolved in most observations, meaning that for two stars in a system we only measure one spectrum, or one set of composite colors. Thus, observational barriers limit our understanding of exoplanet host systems. Precise stellar properties are also needed to infer planet properties: uncertainties in the host star radius directly propagate to the planetary radius, and thus its density and bulk composition.

Project Design and Intellectual Merit. Large planet-search surveys like *Kepler*/*K*2 and TESS, with sophisticated planet detection mechanisms and extensive moderate-resolution spectroscopic follow-up, provide a laboratory for examining the effects of different binary star properties on planet survival rates. The light curves produced by these missions have allowed identification of planet-hosting binary stars, and the spectroscopic follow-up carried out by their collaborations provide a rich data set for analysis of stellar properties. Few estimates of close companion properties have been carried out at any level of robustness. **I will accurately**

determine planet host system properties to accurately explore relationships between different system properties and planet existence for the first time.

To understand whether stellar properties like secondary mass impact planet survival rates, I will select a sample of *Kepler/K2* and TESS stars which are a) confirmed binary stars and b) have spectroscopic follow-up. I will study systems both with and without planets, to construct a control sample alongside the planet host systems. I will initially select systems that already have spectroscopic observations available. If necessary, I will follow up on additional systems using the spectrographs installed on multiple telescopes at McDonald Observatory.

I will fit the observed data using a model consisting of the sum of the spectra of two stars, where the model parameters are temperature (and thus color and spectral lines) and relative brightness, which establishes the weighting between the two spectra. I will also be able to fit for surface gravity and extinction, although these parameters are less relevant for most nearby exoplanet host systems. To fit the model to observations, I have already begun developing a Markov Chain Monte Carlo (MCMC) routine. After I retrieve the stellar parameters, I will use stellar evolution models to infer their masses from their luminosities and temperatures. **Then, I will correlate the secondary masses with planet existence and properties, to test if there are systematic effects of different secondary masses on planet survival.**

My first paper will describe my analysis technique and introduce initial analysis of a few close binary systems that have been analyzed previously, to validate those results and demonstrate the utility of my technique. My second paper will study the binary populations of the TESS and Kepler/K2 planet hosts. My third paper will examine variation between different star forming regions, and will present any additional data I have taken at McDonald Observatory.

Broader Impacts. The methods I am developing will be useful to many subfields of astronomy, not only the field of planet formation. Some potential additional uses are 1) better understanding of young star population statistics via more accurate binary classification and 2) studying the effects of binaries on protoplanetary disks.

My second-year project at UT has focused on simulating a population of stars and manipulating it by adding binary stars and/or extinction, and trying to retrieve the population parameters. The goal of the project is to understand the systematic effects that are introduced to population statistics because of measurement uncertainties or observational error. **One possible way to extend my proposed project is to analyze young binary star populations to derive single star mass functions, and compare to the results from my second year project,** which makes predictions about which systematics should be present in observations if there are remaining observational biases. Thus, I can identify if young star forming regions have a significant population of remaining unidentified binary stars.

Another impactful project would be to apply this MCMC technique to potential binary systems that only have photometry (from WISE, 2MASS, or other surveys), but we have identified as possible binaries using *Gaia* or by placing the photometry on an HR diagram and identifying systems with photometric excess. This would allow exploration of many additional systems that do not have spectroscopy, and provide a large sample of deconvolved close binary stars at large distances, which are extremely difficult to identify and study.

References: Cieza et al. 2009, ApJL, 696, 84; Duquennoy and Major 1991, A&A, 248, 485; Kraus et al. 2012, ApJ, 757, 141; Kraus et al. 2016, AJ, 152, 8; Raghavan et al. 2010, ApJS, 190, 1