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Astrometry in the Service of Planet Formation Studies: Disk Lifetimes in Nearby Star Forming Regions and a Planet Candidate around a Mature Brown Dwarf

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Abstract. We present preliminary astrometric results aimed at understanding the lifetime of circumstellar disks and potential for planet formation. We have obtained parallaxes to stars in the TW Hydrae, Upper Scorpius, and Chamaeleon I stellar associations. These enable new estimates for the ages of the stars. We are also performing the Carnegie Astrometric Planet Search of nearby low mass stars for gas giant planets on wide orbits. We have our first candidate around a mature brown dwarf.

Keywords. astrometry, planetary systems: formation, stars: pre–main-sequence

1. Introduction

Nearby young stars of age 5-10 Myr provide our best opportunity to study the late stages of star and planet formation with high sensitivity and spatial resolution. During this time period, the last gas-rich disks dissipate, and the onset of the debris disk phase occurs. Even for nearby star-forming regions, such as Chamaeleon I, Upper Scorpius or the more diffuse TW Hydrae Association, no distances exist to the numerous low mass members (K spectral type and later) because they were too faint for Hipparcos to measure. The luminosities for the H-R diagrams are calculated by using an average distance to the association. Overplotted with pre-main sequence tracks, and taken at face-value, the H-R diagrams appear to imply a wide range of ages within each association. To measure how long circumstellar disks last, a median age is read off that H-R diagram and plotted with disk fraction. We need distances to get more precise individual ages that would clarify the disk evolution within each cluster/association.

We use CAPSCam, a custom astrometric camera, on the 2.5m DuPont Telescope at Las Campanas Observatory. The instrument and basic data reduction techniques are described in Boss *et al.* (2009). The observations are made at z-band. We have embarked on a project to measure parallaxes for >60 K and M stars in the three aforementioned star-forming regions. We are also engaged in the Carnegie Astrometric Planet Search program (CAPS), which seeks to detect giant planets on wide orbits, if they exist.

2. Astrometric Planet Candidate Around a Field Brown Dwarf

We are surveying ∼100 low mass stars and brown dwarfs, and we have collected data since 2007. Systems with outer giant planets, like our own, could signal inner habitable

worlds. With CAPSCam, we have an astrometric accuracy of ∼0.3 mas, which should enable us to detect Jupiter-mass planets around nearby very low mass stars and brown dwarfs. Our first CAPS planet candidate is around an L5-type brown dwarf host.

In 13 epochs of data of this brown dwarf taken over four years (almost 2 orbital periods), we find astrometric motion with a orbital period of ∼800 d with a false alarm probability of <1%. The primary has a mass of ∼50 M_{Jup}, making the mass of the secondary ∼3 M_{Jup}. Given the painful history of claims and retractions of supposedly detected astrometric planets, we will attempt to confirm our astrometric detection with RV by combining Keck/NIRSPEC velocity measurements with our astrometry to refine the mass and orbital parameters of the planet.

3. Parallaxes and Ages in TWA, Upper Sco, and Cha I

The TW Hya Association (TWA) describes ∼30 stars identified from stellar activity (age) and common space motion searches. Disks in TWA range from 4 accreting, gas-rich proto-planetary to 7 traditional or debris disks to the majority of members with no detectable disks. We observed 14 primary TWA members plus 2 visual binary companions. Results were published this year in Weinberger *et al.* (2013). The Galactic space motions of the members are parallel and do not indicate convergence at a common formation point sometime in the last few million years. The median parallax is 18 mas or 56 pc. We analzyed the stars' absolute magnitudes on pre-main sequence evolutionary tracks and found a range of ages with a median of 10.1 Myr and no correlation between age and Galactic location. The TWA stars may have formed along an extended and filamentary molecular cloud.

Upper Scorpius is the smallest region of Scorpius-Centaurus star forming region. We are observing disk-bearing and disk-less stars, as determined from Spitzer spectral energy distributions (Carpenter *et al.* 2006). We have thus far obtained parallaxes to 22 K and M stars in Upper Sco: 10 disk-bearing, 9 disk-less, and 3 unstudied for disks. We use our distances to compute absolute magnitudes, and thereby to find the ages of the stars as they appear on evolutionary tracks by Baraffe *et al.* (1998). In our preliminary work, the disk stars have a median age of 14.4 Myr while the disk-less stars have a median age of 7.6 Myr. The whole sample has a median age of 10.8 Myr. At the two-sigma level, the disk stars appear older. This is contrary to expectation because older stars generally have a smaller disk fraction. However, the uncertainties are large in this preliminary work, and we are building a larger sample of parallaxes.

Chamaeleon I is a relatively compact region of recent low-mass star formation with no well-determined distance. We have thus far obtained parallaxes to 7 K/M stars in Cha I, and preliminary results are presented here. The average distance to these stars is 6.5 ± 0.4 mas or 153 ± 10 pc. The mean age of these stars, as determined by their positions on the evolutionary tracks by Baraffe *et al.* (1998) is 5.8 Myr, confirming that Cha I is younger than Upper Sco. Our sample so far includes one transitional disk, three Class II and two Class III T Tauri stars.

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