A Spectroscopic and Kinematic Survey of the Taurus Region

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Background and Motivation

The Taurus-Auriga star-forming complex is one of the most comprehensively studied star forming regions. While the census of Taurus members has been built and studied over the last 80 years, there remain peculiarities and questions about its completeness. The discovery of disk-free, member stars at large angular separations from clusters of stars with circumstellar material (e.g. Wichmann et al., 1996; Gómez de Castro et al., 2015) may be indicative of an older, distributed population. **An older population of stars in Taurus would affect derived disk fractions, inferred star formation history, and measurements of the IMF.** The inferred IMF of Taurus is suggested to be unusual (Luhman et al., 2017), showing an excess of stars with M = 0.7 − 1.0 $M_\odot$ and a deficit with M > 1 $M_\odot$. **As disk lifetimes depend on mass (Carpenter et al., 2006), any census missing disk-free (older) members will result in an inferred IMF biased towards low-mass stars.** Additionally, Gaia DR2 has shown that many known Taurus members are actually closer or further than the typically assumed distance of 145 pc. **With Gaia astrometry and our RVs, the 6D structure of the region will be studied in detail, and the relationship between the multiple sub-populations in Taurus (disk-bearing, disk-free, distributed, older) will be revealed.**

The Stellar Census – Spatial Distribution, Kinematic Structure, Age, and Distance

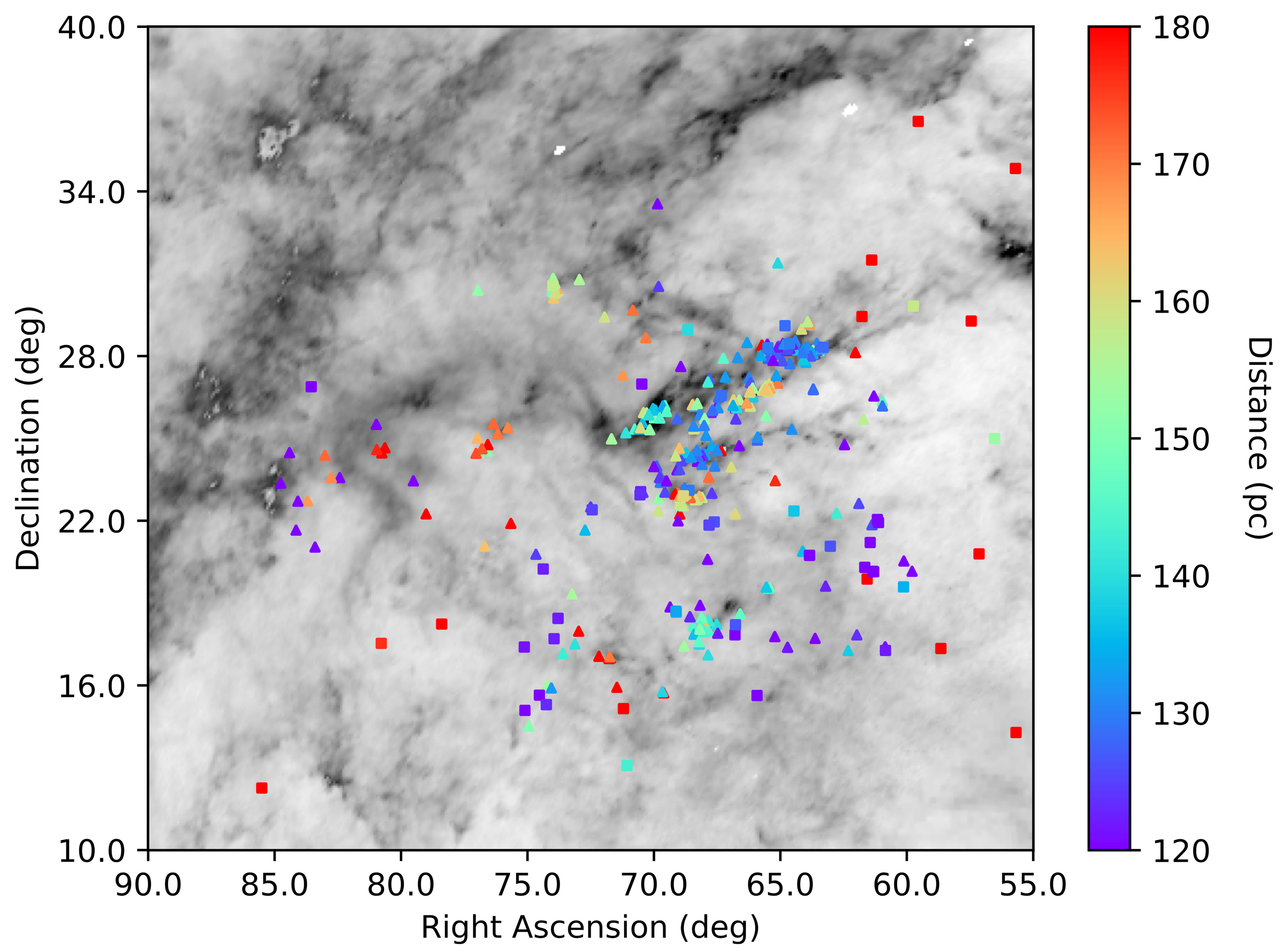

Figure 1: *The spatial distribution of known Taurus members as triangles and new UVW members as squares. Both new and previously known members have a range of distance from near 120 to upwards of 170 pc, challenging the typically assumed single distance to Taurus.*

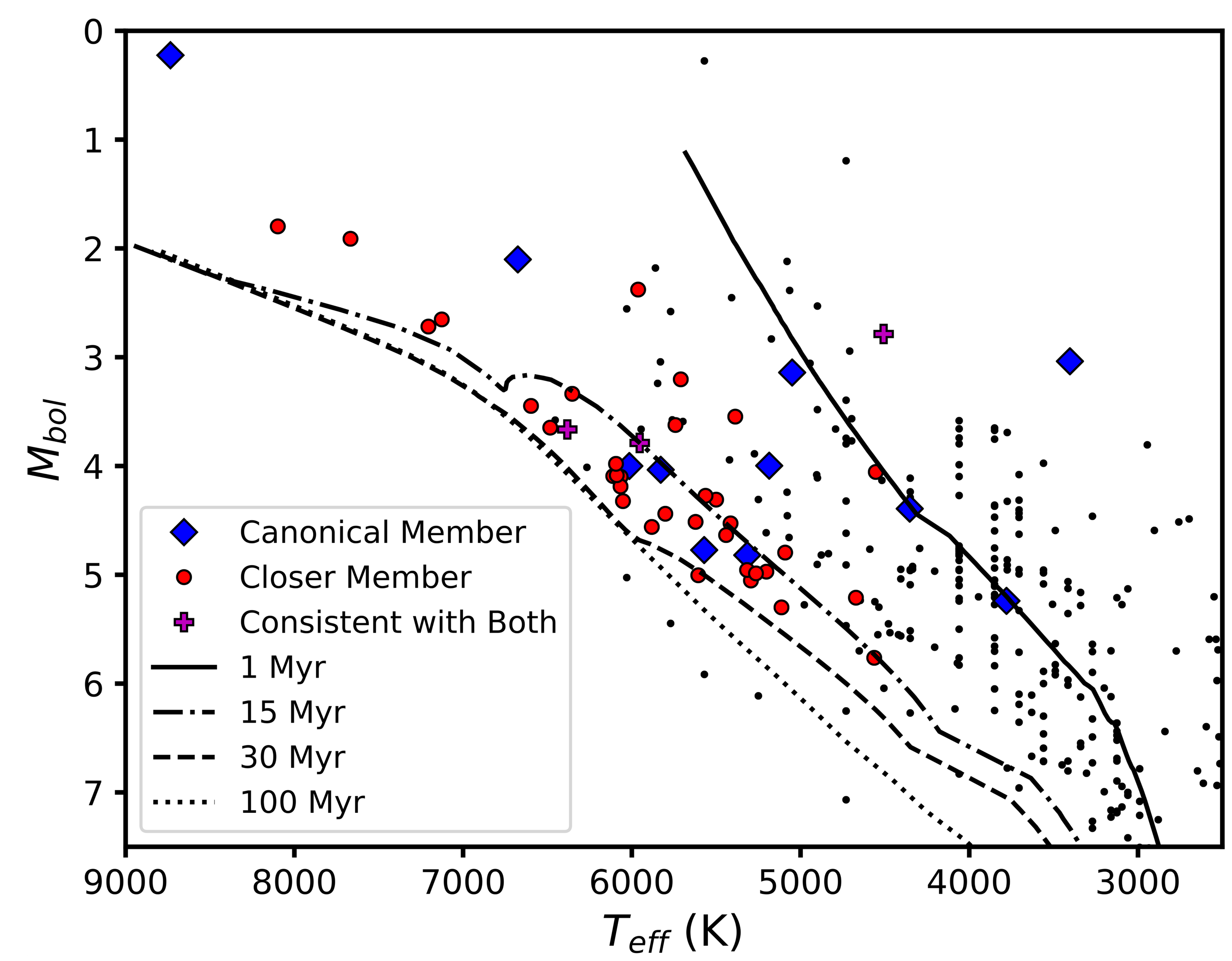

Figure 2: *An HRD for our new Taurus members. Previously known members are plotted as small black points. An age spread from 1 Myr to the ZAMS can be seen in both populations (the canonical and closer UVW groups), but the closer population sits nearer to the ZAMS. This is consistent with the thought that this population is older than canonical Taurus.*

Our group has undertaken a spectroscopic survey of Taurus to find new members and confirm likely members identified in Kraus et al. (2017). We use the Tull spectrograph on the 2.7-m telescope at McDonald Observatory to obtain spectra of our targets. The sample presented here is a subset of the larger survey, and is comprised of new candidate members from the TGAS catalog. The catalog was searched for stars with proper motions and parallaxes consistent with Taurus. Candidates were selected for agreement with one of two space velocities: the canonical Taurus velocity or an estimated space velocity of the closer population from Kraus et al. (2017). Zhang et al. (2018) have found new low-mass members that also appear older and more distributed than the canonical Taurus population.

The new members found in Taurus are preferentially found to the west and south (Figure 1), show a spread in age from 1-30 Myr (Figure 2), and in preliminary analysis show hints of kinematic substructure beneath their common bulk motion (Figure 3). Additionally, known Taurus members are found in Gaia DR2 to sit at a range of distances (Figure 1). The position and kinematics of a combined census will need to be studied in detail to determine the relation between these different groups of stars, and address the nature of the Taurus complex on a larger scale.

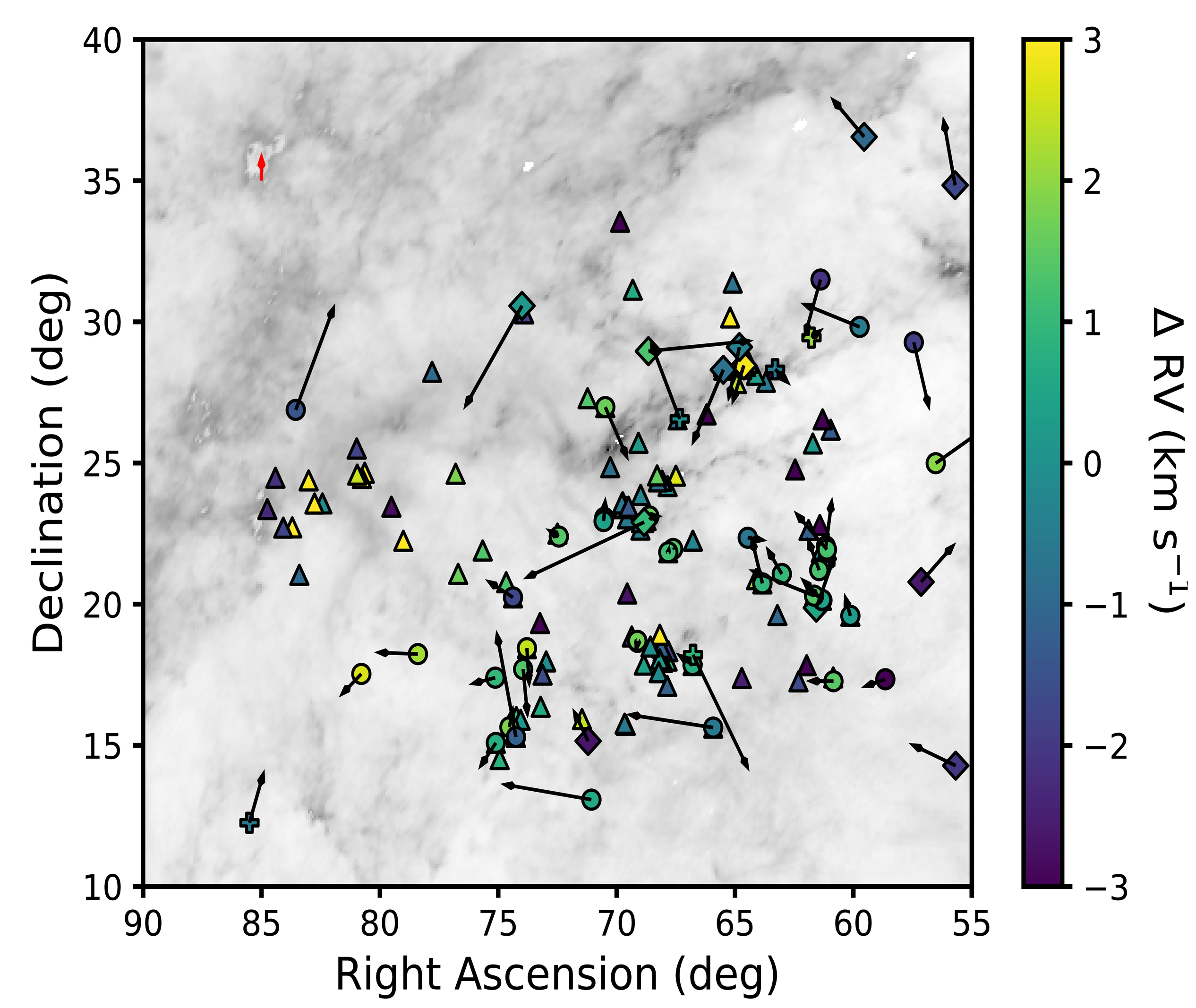

Figure 3: *Map of new Taurus members and the residual motion from the bulk UVW corresponding to their member population. Previously known members with RVs are shown without arrows as triangles. Some coherent substructure can be seen in small groups of stars. The kinematic substructure of the full census will be modeled to try to understand the connection between the populations and the orientation of the clouds from which these stars were formed. (Red arrow in upper left is 1 mas/yr)*

Future Work and Directions

- With *Gaia* DR2, kinematic clustering analyses will be performed on our sample of Taurus members to identify subpopulations. Various techniques will be used and compared: a two-point correlation function for the different populations, minimal spanning trees, and Gaussian mixture models.
- Traceback analysis, which requires precise stellar velocities, will be performed to determine kinematic ages of the identified subpopulations. Our derived sub-km/s radial velocities, in tandem with precise proper motions and parallaxes from *Gaia*, will allow us to perform such analyses. The median RV error (which we anticipate to decrease) is 0.4 km/s, corresponding to an introduced error of about 0.4 pc/Myr.