The Effects of Starspots on Spectroscopic Mass Estimates of Young Stars

Christian Flores[1], Michael S. Connelley[1], Bo Reipurth[1], & Gaspard Duchêne[2]

[1]Institute for Astronomy, University of Hawaii, [2]Astronomy Department, University of California, Berkeley.

Motivation

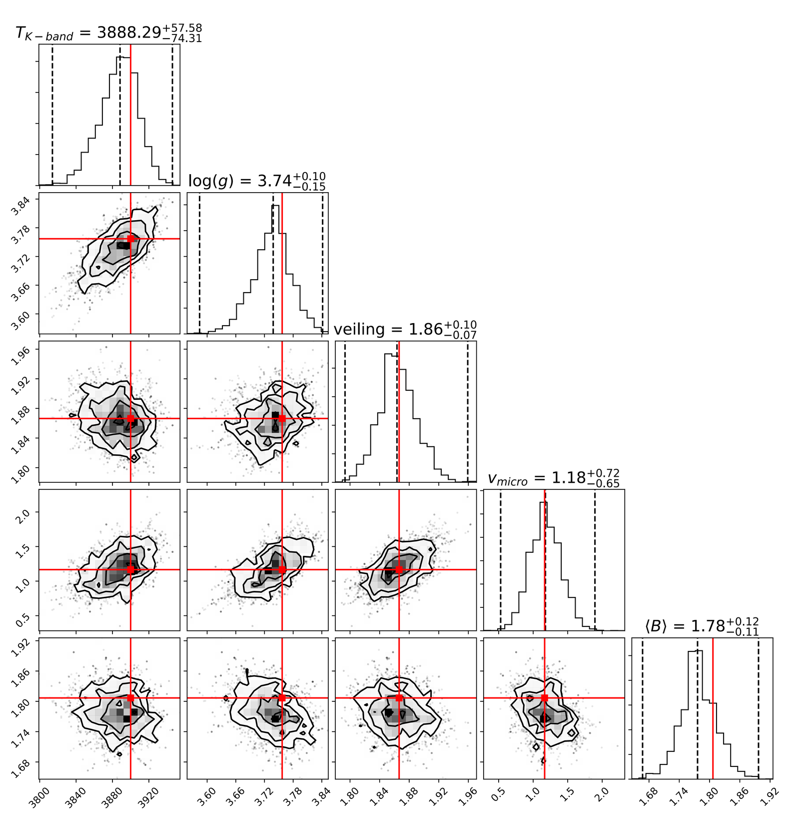
Magnetic fields and mass accretion processes create cold and hot spots on the surface of young stars. These thermal inhomogeneities affect the global temperatures measured on the stars. Although previous studies have reported this problem on individual sources, a large-scale study has not been performed yet.

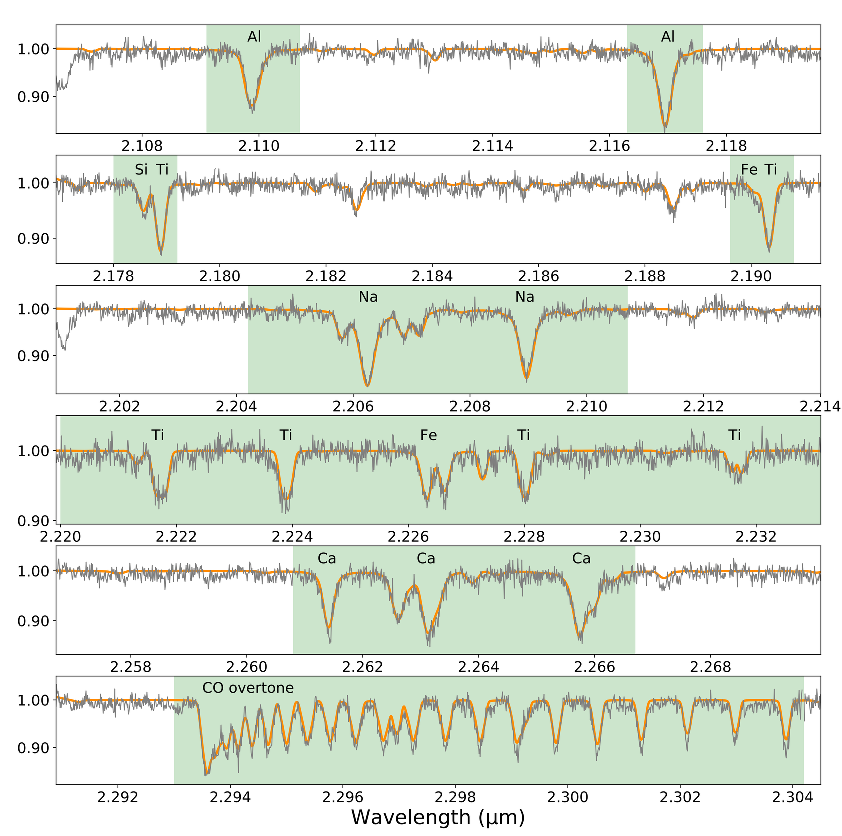
We present a large iSHELL high-resolution K-band spectroscopic survey of 42 young stars in Taurus-Aurigae and Ophiuchus star-forming regions.

Using these observations, we aim to:
1) Understand the temperature effects of starspots on young stars and
2) Determine whether optical or IR temperatures are better suited to derive stellar masses from stellar evolutionary models.

Methods: stellar parameter determination

We use the MoogStokes magnetic radiative transfer code (Deen 2013) to measure stellar properties such as the infrared temperature and the magnetic field strength.

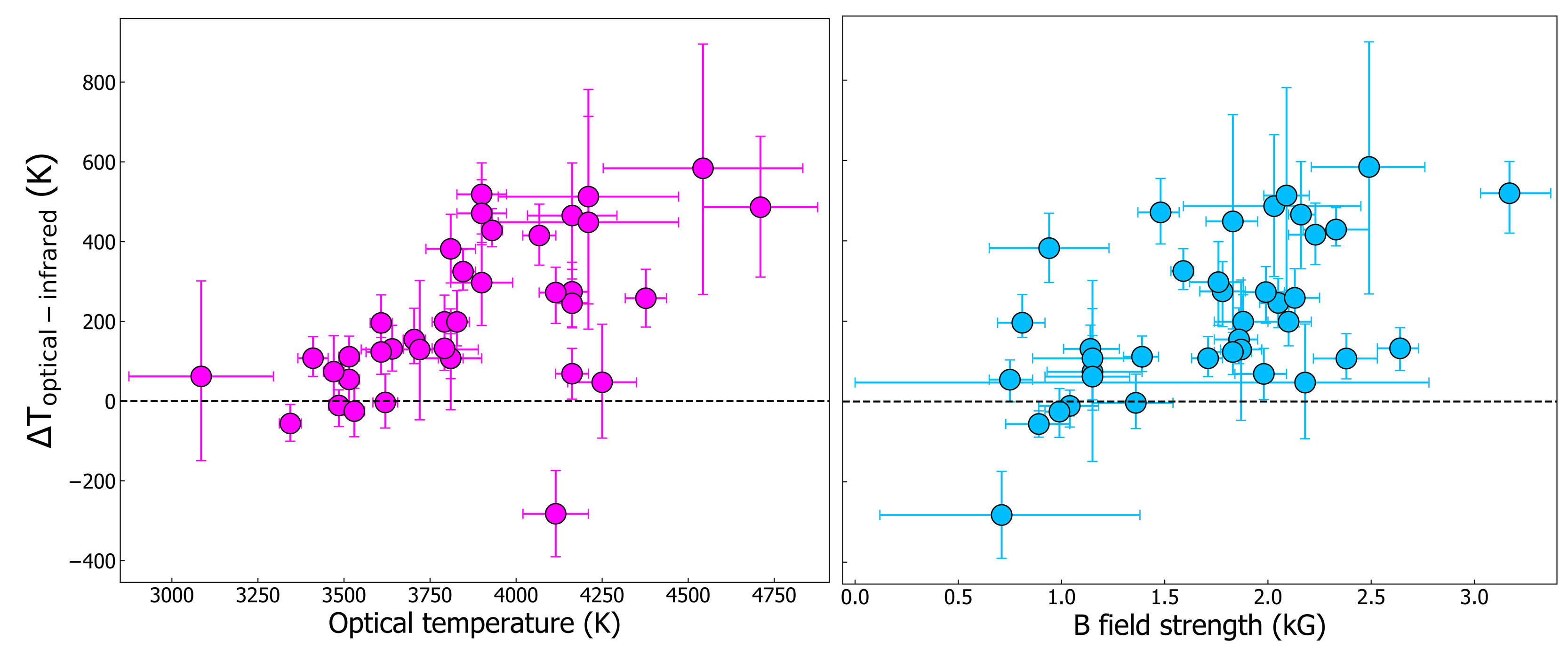




As an example, we show the parameters derived for CI Tau. Left figure shows the corner plot, and the right figure the spectrum of CI Tau overlaid with the best fit model.

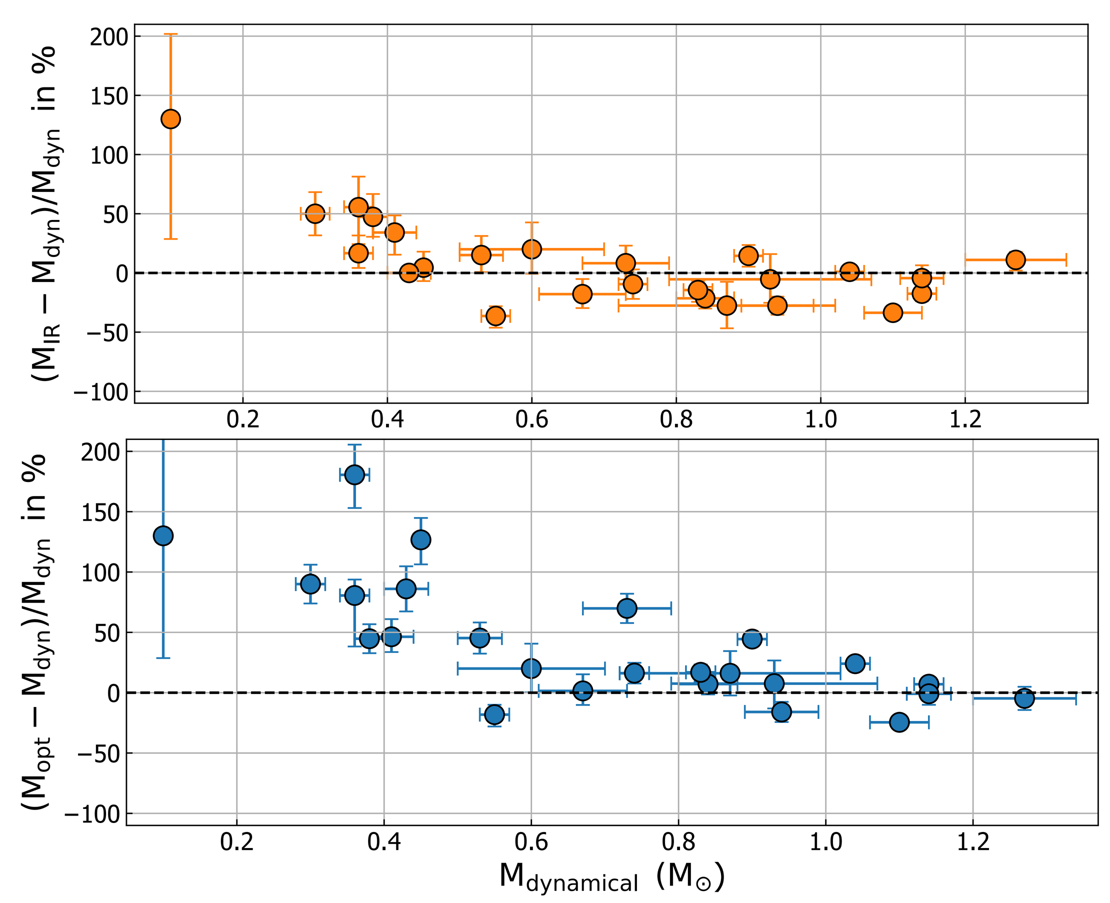
Results

We combined our infrared observations with optical measurements obtained from the literature and found significant temperature differences between optical and IR values. The measured temperature differences increase with the stellar temperature but also with the magnetic field strength of the stars.



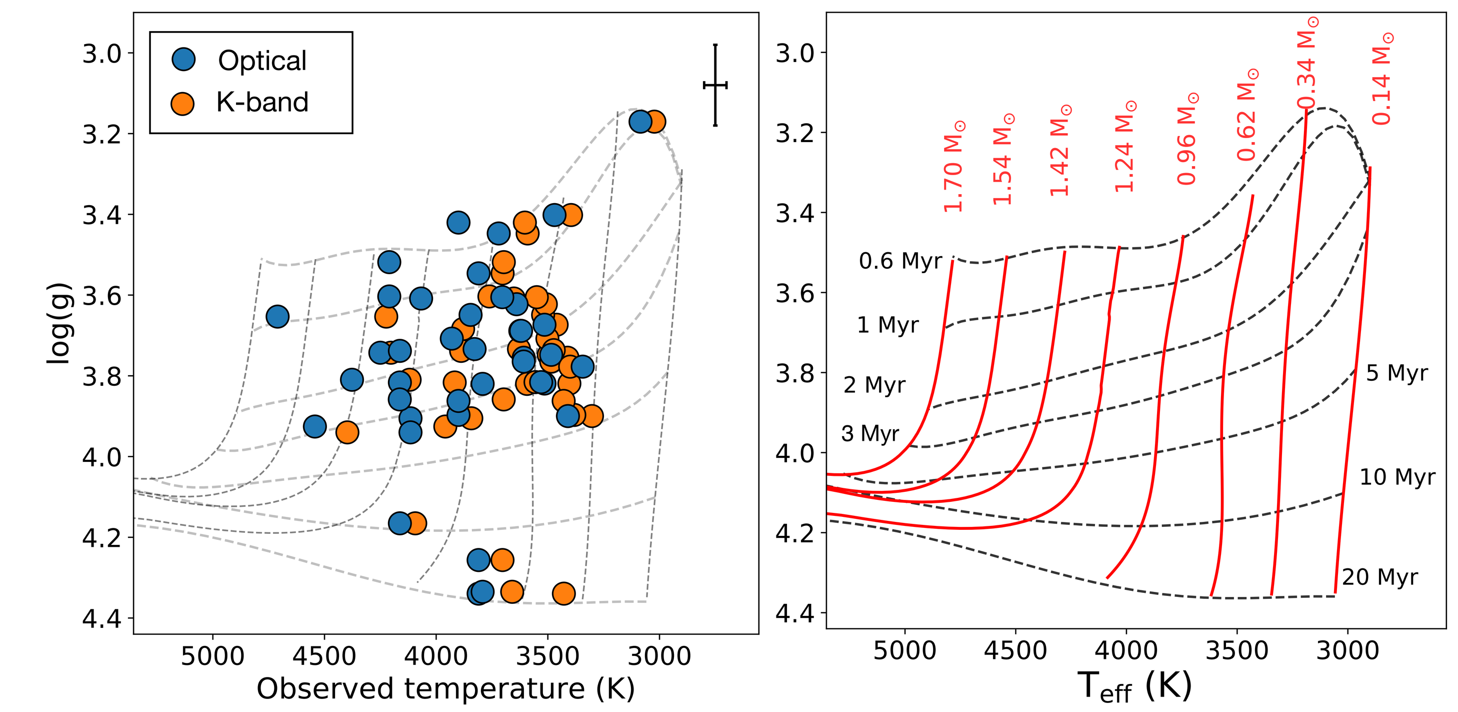
These results suggest that thermal inhomogeneities on the surface of the young stars (i.e., starspots) produce the observed temperature differences.

To understand which temperature (optical or infrared) is better suited to derive stellar masses from evolutionary models, we analyzed a sub-sample of 25 stars with dynamical masses measured from ALMA (Simon et al. 2019).



The mean percentage difference between IR-derived and measured dynamical masses is 8 ± 6 %. The difference between optically-derived and dynamical masses is 40 ± 8 %.
On average, the IR temperatures provide more precise and accurate stellar masses than optical values in the range of 0.3 $M_\odot$ to 1.3 $M_\odot$.

Methods: stellar mass estimates



We used our derived stellar parameters (and literature optical temperatures) along with the Feiden (2016) magnetic evolutionary models to derive stellar masses.

Summary and future work

1) We demonstrated that there is a significant temperature difference between optical and IR measurements of young stars. And we interpret that these are caused by starspots on their surfaces.

2) We showed that infrared temperatures provide more accurate and precise stellar masses than optical temperatures when combined with magnetic evolutionary models from Feiden (2016).

3) We encourage a study that compares optical and infrared derived masses against dynamical masses for young stars in the range of 1.2 $M_\odot$ to 2.0 $M_\odot$

References

1. Deen, C. P. 2013, AJ, 146, 51.
2. Feiden, G. A. 2016, A&A, 593, A99.
3. Simon, M., Guilloteau, S., Beck, T. L., et al. 2019, ApJ, 884, 42.

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caflores@hawaii.edu