Brown Dwarfs
IAU Symposium, Vol. 211, 2003
E. L. Martín, ed.

Very Low Mass Stars and Brown Dwarfs in Taurus

Russel White

McDonald Observatory, R.L.M. Hall 15.308, Austin, TX 78712-1083

Gibor Basri

Department of Astronomy, University of California at Berkeley, Berkeley, CA 94720-3411

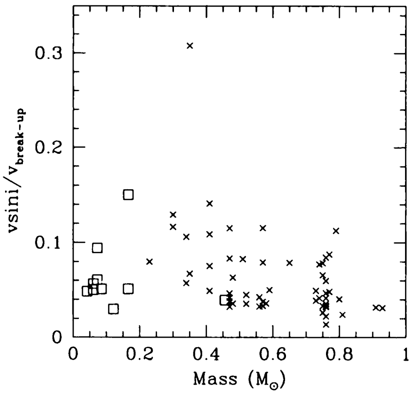
Abstract. We present high resolution optical spectra obtained with the Keck I telescope of low mass T Tauri stars and brown dwarfs in the Taurus star forming region. Based on the inferred photospheric and circumstellar properties, we conclude that objects in Taurus with masses as low as 50 Jupiters form and evolve in the same way as higher-mass T Tauri stars, but with smaller disks and shorter disk lifetimes.

1. Highlights

High resolution optical (6390 - 8700 Å) spectra of 7 low mass T Tauri stars (LMTTs) and brown dwarfs were obtained with Keck I telescope using the HIRES spectrograph at a resolving power of 33,000. The presence of Li I 6708Å absorption, low surface gravity signatures, and radial velocities confirm that all are members of the Taurus star forming region. Four of the seven targets observed appear to be T Tauri brown dwarfs. Of particular interest is the previously classified "continuum T Tauri star" GM Tau, which has a spectral type of M6.5 and a mass just below the stellar/substellar boundary.

These spectra, in combination with previous HIRES observations of LMTTs (White et al. 1999; Basri & Marcy 1995), are used to understand the formation and early evolution of objects with masses near and below the stellar/substellar boundary. None of the LMTTs in Taurus are rapidly rotating (vsin$i$ < 30 km/s; Figure 1), unlike low mass objects in the Orion star forming region or in the field. Many of the slowly rotating, non-accreting stars and brown dwarfs exhibit prominent Hα emission (EWs of 3 - 36 Å), indicative of active chromospheres. We demonstrate empirically that the full-width at 10% of the Hα emission profile peak is a more accurate indicator of accretion than either the equivalent width of Hα or optical veiling: 10%-widths > 270 km/s are classical T Tauri stars (i.e. accreting), independent of spectral type. Although LMTTs can have accretion rates comparable to that of more typical, higher-mass T Tauri stars (e.g. K7-M0 spectral types), the average mass accretion rate appears to decrease with decreasing mass (Figure 2). A functional form of $\dot{M} \propto M$ is consistent with the available data, but the dependence is difficult to establish because of both selection biases in the observed samples, and the decreasing frequency of active

https://doi.org/10.1017/S0074180900210462 Published online by Cambridge University Press



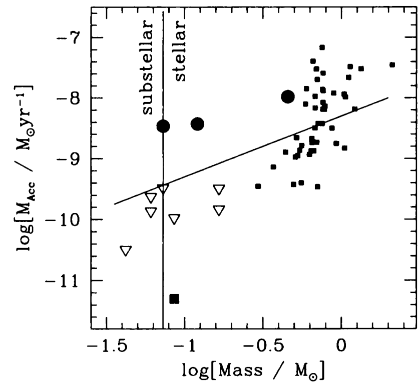


Figure 1. *Left Panel* - Rotational velocities ($v\sin i$) expressed as a fraction of the break-up velocity plotted versus mass. The large squares are new measurements presented here and the small x's are from Clarke & Bouvier (2000). The distribution of rotational velocities appears to be mass independent.

Figure 2. *Right Panel* - Mass accretion rates versus mass. The large circles and triangles are new measurements presented here; triangles are upper limits. The large square shows the mass accretion rate derived for V410 Tau Anon 13 by Muzerolle et al. (2000) and the small squares are mass accretion rates for classical T Tauri stars from White & Ghez (2001). The mass accretion rates appear to decrease toward smaller masses. The function form $\dot{M} \propto M$ is shown for comparison.

accretion disks at low masses (M < 0.2 $M_\odot$). The diminished frequency of accreting disks for LMTTs, in conjunction with their lower, on average, mass accretion rates, implies that they are formed with less massive disks than higher-mass T Tauri stars. The radial velocities, multiplicity, and circumstellar properties do not support the suggestion that many of the lowest mass members of Taurus have been ejected from higher density regions (e.g. Reipurth & Clarke 2001). Instead, LMTTs appear to have formed and are evolving in the same way as higher-mass T Tauri stars, but with smaller disks and shorter disk lifetimes.

References

Basri, G., & Marcy, G. W. 1995, AJ, 109, 762

Clarke, C. J., & Bouvier, J. 2000, MNRAS, 319, 457

Muzerolle, J., Briceño, C., Calvet, N., Hartmann, L., Hillenbrand, L., & Gullbring, E. 2000, ApJ, 545, 141

Reipurth, B., & Clarke, C. 2001, AJ, 122, 432

White, R. J., Ghez, A. M., Reid, N. I., & Schultz, G. 1999, ApJ, 520, 811

White, R. J., & Ghez, A. M. 2001, ApJ, 556, 265

https://doi.org/10.1017/S0074180900210462 Published online by Cambridge University Press